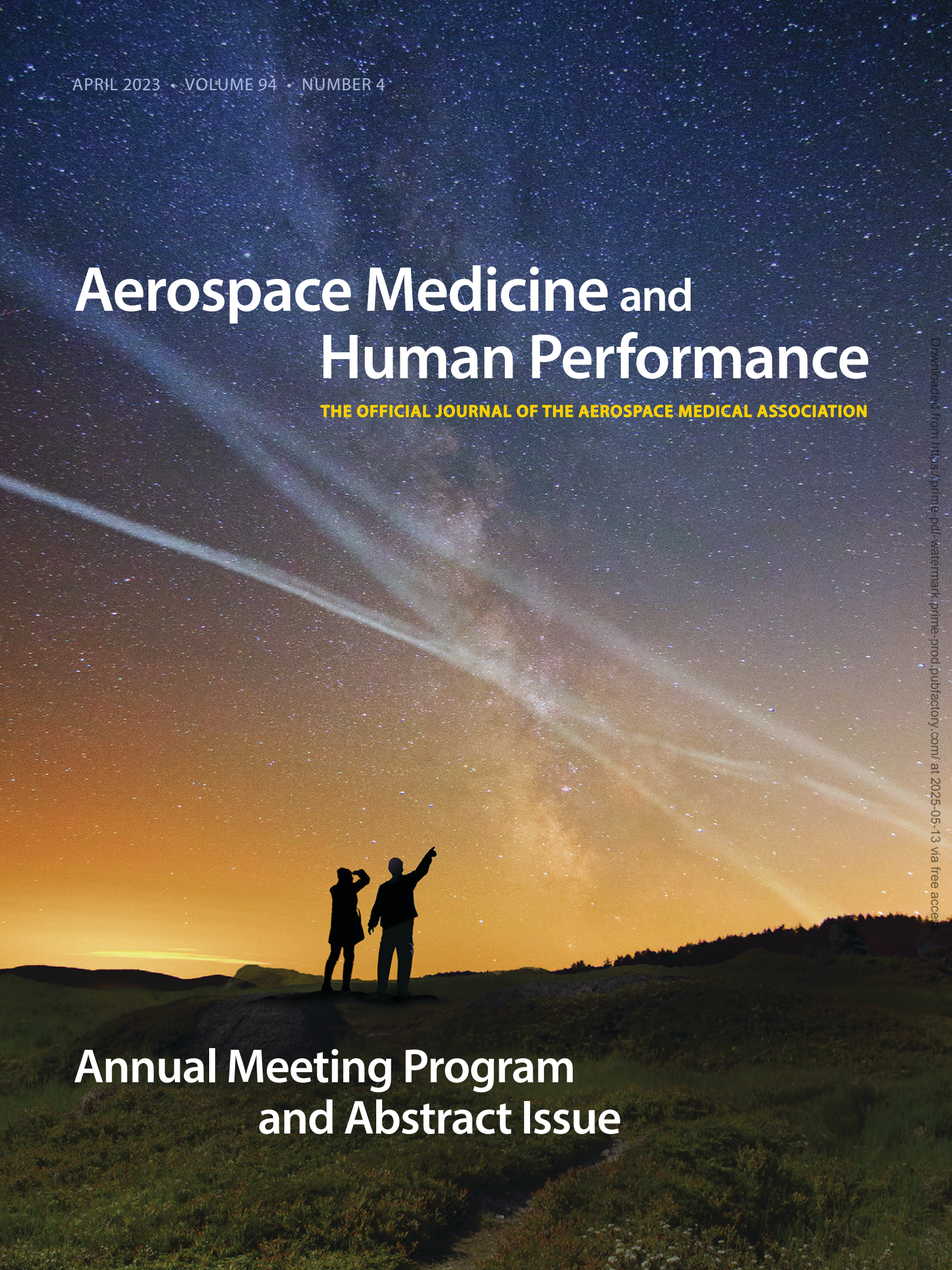
APRIL 2023 • VOLUME 94 • NUMBER 4

Aerospace Medicine and Human Performance

THE OFFICIAL JOURNAL OF THE AEROSPACE MEDICAL ASSOCIATION



Annual Meeting Program and Abstract Issue

Aerospace Medicine and Human Performance

April 2023 VOLUME 94 NUMBER 4 [ISSN 2375-6314 (print); ISSN 2375-6322 (online)]

This journal, representing the members of the Aerospace Medical Association, is published for those interested in aerospace medicine and human performance. It is devoted to serving and supporting all who explore, travel, work, or live in hazardous environments ranging from beneath the sea to the outermost reaches of space.

AEROSPACE MEDICAL ASSOCIATION is an organization devoted to charitable, educational, and scientific purposes. The Association was founded when the rapid expansion of aviation made evident the need for physicians with specialized knowledge of the flight environment. Since then, physicians have been joined in this Association by professionals from many fields and from many countries, all linked by a common interest in the health and safety of those who venture into challenging environments.

AEROSPACE MEDICINE AND HUMAN PERFORMANCE, formerly *Aviation, Space, and Environmental Medicine,* is published monthly by the Aerospace Medical Association, a non-profit charitable, educational, and scientific organization of physicians, physiologists, psychologists, nurses, human factors and human performance specialists, engineers, and others working to solve the problems of human existence in threatening environments on or beneath the Earth or the sea, in the air, or in outer space. The original scientific articles in this journal provide the latest available information on investigations into such areas as changes in ambient pressure, motion sickness, increased or decreased gravitational forces, thermal stresses, vision, fatigue, circadian rhythms, psychological stress, artificial environments, predictors of success, health maintenance, human factors engineering, clinical care, and others. This journal also publishes notes on scientific news and technical items of interest to the general reader, and provides teaching material and reviews for health care professionals.

MEMBERSHIP—The Aerospace Medical Association welcomes members interested in aerospace medicine and human performance. Membership applications may be obtained online at www.asma.org or from the Aerospace Medical Association's headquarters at 320 S. Henry Street, Alexandria, VA 22314, or phone the Membership Department at (703) 739-2240; skildall@asma.org.

SUBSCRIPTIONS—*Aerospace Medicine and Human Performance* is provided to all members of the Aerospace Medical Association (in print, online, or both). Subscriptions and changes of address should be sent to the Subscription Department, *Aerospace Medicine and Human Performance*, 320 S. Henry Street, Alexandria, VA 22314, at least 90 days in advance of change. Institutional Subscription Rates (including online version; other options available): U.S.-$330, Canada-$345, Other countries-$380 (includes air delivery); Agent Disc. $20. Individual Subscription Rates (Print and Online): U.S.-$270, Canada-$300, Other countries-$320 (includes air delivery). Single copies and back issues: $30+P/H ($7.50 U.S./ $25 International Air). NOTE TO INTERNATIONAL SUBSCRIBERS: Please add $50 for bank handling charges on checks not drawn on U.S. banks.

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Aerospace Medicine and Human Performance

APRIL 2023 VOLUME 94 NUMBER 4

AsMA 93rd Annual Scientific Meeting Program and Abstract Issue
Sheraton New Orleans Hotel, New Orleans LA
May 21–25, 2023

NEW ORLEANS, LA

ADVANCE REGISTRATION FORM
AEROSPACE MEDICAL ASSOCIATION
93rd ANNUAL SCIENTIFIC MEETING

MAY 21 – 25, 2023

- **Early Bird Registration runs January 1 – 31 (Mail registrations must be postmarked with a January date)**
- **Advance Registration runs February 1 – May 12.**
- **NO CANCELLATIONS OR REFUNDS AFTER MAY 12. *A $50 ADMINISTRATIVE FEE IS APPLIED TO ALL CANCELLATIONS***

WE STRONGLY ENCOURAGE ONLINE REGISTRATION:

https://www.asma.org/scientific-meetings/asma-annual-scientific-meeting/registration

You **MUST** be an active member of **AsMA** in order to register at the member rate. **Registration fee does not include membership dues.**

Fax registration form with credit card information to: (703) 739-9652

NAME			DEGREE/CREDENTIALS
ORGANIZATION		TITLE	
STREET ADDRESS	CITY	STATE/COUNTRY	ZIPCODE/MAIL CODE
EMAIL	TELEPHONE NUMBER	MOBILE PHONE NUMBER	FAX NUMBER

☐ **Please indicate if this is an address change to your AsMA Membership Record**

First time attendee, or new member? YES ☐ NO ☐ Special dietary requirement: _____

If you are being funded by the U.S. DoD please indicate Branch: ☐Army ☐Navy ☐Air Force ☐Coast Guard

By registering to attend an Aerospace Medical Association (AsMA) conference, you grant permission to AsMA to take and use your photo in AsMA marketing and promotional pieces for an indefinite period of time. Marketing and promotional pieces include, but are not limited to, printed brochures, reports, postcards, flyers, and materials, as well as online uses such as postings on the AsMA website, online newsletters, and e-mail blasts. AsMA shall own all rights, including copyrights in and to the photos.

You also grant permission to AsMA to use, encode, digitize, transmit, and display the video/audio of your session, presentation, or workshop given at the AsMA conference, singularly or in conjunction with other recordings, as well as to use your name, photograph, biographic information, and ancillary material in connection with such video/audio for commercial, promotional, advertising, and other business purposes. AsMA and its employees are released from any liability arising out of the use of your name, video, photographs, and/or organization name and location.

REGISTRATION FEE	EARLY BIRD† 1/1 – 1/31	ADVANCE 2/1 – 5/12	AT-THE-DOOR 5/21 – 5/25	REGISTRATION FEE REMITTED
☐MEMBER	$450†	$550	$650	
☐NON-MEMBER	$725†*	$850*	$950*	
☐NON-MEMBER PRESENTER	$625†*	$750*	$850*	
☐RESIDENTS	$325†	$400	$400	
☐STUDENTS	$75†	$125	$125	
☐FAA-AME SEMINAR§	$325†	$400	$400	
			REGISTRATION FEE SUBTOTAL ➔	

***Go to www.asma.org to become a member and take advantage of the reduced registration rates, receive the official Aerospace Medical Association journal, and other membership benefits.**

†***EARLY BIRD REGISTRATION MUST BE PAID IN FULL (INCLUDING ALL EVENTS AND MEAL FUNCTIONS) AT THE TIME OF REGISTRATION.***

§FEE COVERS AsMA OVERHEAD COSTS. CME CREDIT FOR THE FAA SEMINAR AND AsMA SESSIONS ATTENDED IS INCLUDED.

(See reverse for workshops & events)

NOTE: WORKSHOPS ARE LIMITED *** REGISTER EARLY

WORKSHOP DATE/NAME	FEE	Total Fee
☐ Sun., May 21, 8:00 am – 11:30 am Workshop: "Aerospace Medicine Faculty Development" (MAX 75)	$85	
☐ Sun., May 21, 8:00 am – 4:30 pm Workshop: "Altitude Decompression Sickness – Pathophysiology, Diagnosis, Treatment, and Mitigation" (MAX 75)	$175	
☐ Sun., May 21, 9:00 am – 4:30 pm Workshop: "Establishing Peer Support Programs Across All Aviation Sectors (MAX 75)	$150	

EVENTS *(NOTE: Advance Purchase Only requires tickets to be purchase during Early Bird & Advance registration – no tickets for these events will be sold onsite)*	# OF TICKETS	FEE PER TICKET	TOTAL FEE
☐ Sun., May 21, AsMA Welcome to New Orleans **(NOTE: All Attending Event Must Have Tickets)**		$15	
☐ Mon., May 22, 6:00 am, Richard B. "Dick" Trumbo 5K Fun Run/Walk ***(Advance Purchase Only)***		$15	
☐ Mon., May 22, Aerospace Human Factors Association Luncheon ***(Advance purchase only)***		$50	
☐ Mon., May 22, Civil Aviation Medical Association Luncheon ***(Advance Purchase Only)***		$50	
☐ Mon., May 22, Society of US Air Force Flight Surgeons Luncheon ***(Advance Purchase Only)***		$50	
☐ Mon., May 22, Society of US Army Flight Surgeons Luncheon ***(Advance Purchase Only)***		$50	
☐ Mon., May 22, US Navy Luncheon ***(Advance Purchase Only)***		$50	
☐ Mon. May 22, Fellows Dinner ***(Advance Purchase Only)*** **(MUST BE A FELLOW OR GUEST OF AsMA FELLOW)**		$90	
☐ Tues., May 23, Associate Fellows Breakfast ***(Advance Purchase Only)***		$50	
☐ Tues., May 23, AsMA Annual Business Meeting ***(Advance Purchase Only)*** **(Free Attendance; Ticket required for meal)**		$50	
☐ Tues., May 23, Reception to Honor International Members		$25	
☐ Wed., May 24, Canadian Society of Aerospace Medicine Breakfast		$50	
☐ Wed., May 24, Aerospace Nursing & Allied Health Professionals Society Luncheon		$50	
☐ Wed., May 24, Aerospace Physiology Society Luncheon		$50	
☐ Wed., May 24, Iberoamerican Association of Aerospace Medicine Luncheon		$50	
☐ Wed. May 24, Society of NASA Flight Surgeons Luncheon		$50	
☐ Thur., May 25, Space Medicine Association Luncheon		$50	
☐ Thur., May 25, AsMA Honors Night Banquet **(Black Tie Optional)**		$90	
	SUBTOTAL OF EVENTS		
TOTAL AMOUNT DUE (Registration Fee Subtotal + Workshop + Subtotal of Events)			

PAYMENT MUST ACCOMPANY FORM. ALL PAYMENTS ARE IN U.S. DOLLARS.

REGISTRANTS SUBMITTING VIA FAX MUST INCLUDE CREDIT CARD INFORMATION.

PAYMENT METHOD: **Check Number:** _____ ☐ **CHECK** ☐ **AMEX** ☐ **DISCOVER** ☐ **MASTERCARD** ☐ **VISA** ☐ **DINERS**

Name as it appears on card: (**PLEASE PRINT**)_____

Credit Card #_____ Exp. Date: _____ Security Code: _____

Street: _____ City: _____ State: _____ Zip/Mail Code: _____

Signature _____ Country: _____

Fax with credit card information to:
(703) 739-9652
OR
Mail with payment to:
Aerospace Medical Association
320 S Henry Street
Alexandria, VA 22314-3579

FAX TO (703) 739-9652. PLEASE REMEMBER TO INCLUDE BOTH SIDES WHEN FAXING.
*****USE ONLY ONE METHOD TO REGISTER*****

The Wing of AsMA meeting activities

New Orleans, LA, May 21–25, 2023

The Wing will have a hospitality room at the Sheraton New Orleans Hotel, a welcome reception, three group activities, and a luncheon. More info: the form in this issue, thewingofasma.com, or on Facebook (The Wing of the Aerospace Medical Association).

Future AsMA Annual Meetings

May 21 – 25, 2023
Sheraton New Orleans Hotel
New Orleans, LA

May 5 – 9, 2024
Hyatt Regency Chicago
Chicago, IL

June 1 – 6, 2025
Hyatt Regency Atlanta
Atlanta, GA

CLASSIFIED ADS

POSITIONS AVAILABLE

Read Current News Online!

Ever Upward! The AsMA Online Newsletter is posted monthly: http://www.asma.org/news-events/newsletters.

Visit Us on Social Media!

Twitter: https://twitter.com/aero_med
Facebook: www.facebook.com/AerospaceMedicalAssociation
LinkedIn: https://www.linkedin.com/company/2718542?trk=tyah&trkInfo=tarId:1404740611720,tas:Aerospace Medical,idx:1-1-1

May 21 - 25, 2023
Sheraton New Orleans
New Orleans, Louisiana

The WING of AsMA
AsMA 93rd Annual Scientific Meeting

REGISTRATION FORM

Please read the entire form before filling out or registering online. Fill out a separate form for each registrant.
Advance Registration closes *May 1, 2023*. No refunds *after May 1, 2023.*
Enter the TOTAL NUMBER of tickets and TOTAL DOLLAR AMOUNT on the line after each activity.
Send your advance registration directly to THE WING or register online.
DO NOT include with your spouse's/sponsor's AsMA registration.

***PLEASE NOTE: All prices are in U.S. dollars. Only U.S. funds will be accepted for Registration.**

NOTE: Registration is mandatory for participation in Wing activities. Register before May 1, 2023 to save $5 each on dues & registration. After that date, dues & registration will be $40 each.

Wing Dues (May 2023 – May 2024)	$35.00 /$40.00		$_____
_____New Member 2023 _____Renewal	_____2023 Dues Previously Paid		
Compulsory Registration Fee	$35.00/$40.00	No.____	$_____
Monday, May 22, 2:30 - 4:30 PM			
The WING Welcome Reception for Registrants only	**INCLUDED**	No.____	$ 0.00
Tuesday, May 23, 8:30 AM – 12:00 PM (Meet in Lobby @ 8:15 AM)			
Swamp Adventure – High Speed Airboat Tour*	$75.00	No.____	$_____
*SEE IMPORTANT DISCLOSURES			
OR			
Tuesday, May 23, 8:30 AM – 12:00 PM (Meet in Lobby @ 8:15 AM)	$55.00	No.____	$_____
Swamp Adventure - Swamp Boat Tour			
OR			
Tuesday, May 23, 9:30 AM – 2:00 PM (Meet in Lobby @ 9:30 AM)			
Self-Guided St. Charles Streetcar Tour			
Pay as you go …		No.____	
Wednesday, May 24, 10:00 AM – 1:00 PM (Meet in Lobby @ 9:30 AM)			
Annual Wing Buncheon & Business Meeting			
New Orleans School of Cooking	$50.00	No.____	$_____
Thursday, May 25, 8:45 AM – 12:30 PM (Meet in Lobby @ 8:45 AM)	$65.00	No.____	$_____
Mardi Gras Museum & Mask Making Class			
	TOTAL		**$**_____

Name_____
Last Name First Name Spouse's/Sponsor's Name
Address _____

City_____ State_____ZIP_____ Country _____

Phone_____ E-Mail_____

Affiliation (please circle one): Army Navy Air Force Corporate Civilian International Exhibitor

Register ONLINE at : www.thewingofasma.com
OR
Mail this form and your check (payable to Wing of AsMA in US DOLLARS) to:
Brenda Clinton, Treasurer 10603 Derby Mesa Ct – Colorado Springs, CO 80924

Annual Meeting and Tour Information

WELCOME RECEPTION Monday, May 22, 2:30-4:30 PM
Connect with old friends and make some new ones in a relaxed environment at our annual Welcome Reception. *Remember to bring a small gift reminiscent of your home city, state or country for the gift exchange and please include a short note letting the recipient know who/where the gift is from.* ***New members and first-time attendees don't bring a gift as we are very happy to welcome you to THE WING!***
This year's Welcome Reception will be held in **THE SHERATON NEW ORLEANS HOTEL *"Grand Couteau" Room.***

TOUR #1 – Swamp Adventure – Airboat Boat Tour* *(Gators!!)*
Tuesday, May 23, 8:30 AM – 12:00 PM **$75.00**
Meet at 8:15 AM in the Lobby at The Sheraton New Orleans Hotel.
We've chartered an airboat for an exhilarating adventure. You will experience an educational swamp tour and a high-speed airboat ride. Airboats are driven by a 454 Chevy Engine that will produce speeds up to 35 miles an hour. The boats are propelled by a huge fan that will blow air from the back of the boat more than 200 mph. Airboats ride in inches of water and go where traditional boats cannot go! These boats were designed to take you to inaccessible areas of the swamp, which you cannot reach otherwise.
Tips included. After return to the hotel, lunch is on your own.
*Airboat tours are performed in an open boat. If it rains, you will get wet AND you may get wet without rain, too. In case of inclement weather, the airboat tour may be shortened or replaced with the covered tour boat swamp tour. ***BECAUSE OF THE NATURE OF THE AIRBOAT RIDE, PREGNANT WOMEN OR PEOPLE WITH NECK OR BACK PROBLEMS CANNOT PARTICIPATE. HEARING PROTECTION IS PROVIDED BY THE COMPANY. YOU CAN PURCHASE INEXPENSIVE RAIN PONCHOS AT THE SWAMP TOUR SNACK SHOP.***

TOUR #1A – Swamp Adventure - Swamp Boat Tour *(Gators!!)*
Tuesday, May 23, 8:30 AM – 12:00 PM **$ 55.00**
Meet at 8:15 AM in the Lobby at The Sheraton New Orleans Hotel.
You will be very comfortable on this swamp tour boat. Complete with roof, restroom, cushioned seats and windows that can be raised or lowered during cold or rainy weather, along with plenty of standing and walking room. The slow drift of the swamp tour boat through moss draped trees and small waterways will provide ample opportunity for viewing and photography. The tour will be fully narrated. Most captains are natives of the Barataria Swamps with a background in gator hunting, fishing and trapping.
Tips included. After return to the hotel, lunch is on your own.

TOUR #2 – Self-Guided St. Charles Streetcar Tour
Tuesday, May 23, 9:30 AM – 1:00 PM **$ Pay as you go**
Meet at 9:30 AM in the Lobby at The Sheraton New Orleans Hotel. You and other adventurous Wing members will meet and navigate your way to the St. Charles Streetcar. Don't worry, we'll help get you started, but be sure and register so we know who all will be taking this self-guided independent tour. The St. Charles Streetcar can be boarded a couple of blocks from the hotel. Bring cash. Expect to pay $1.25 cash to get on the streetcar (but we recommend that you buy a daily pass for $3.00). The ride takes about 45 minutes each way to ride along St. Charles Street. The route gives you a grand view of some of New Orleans' most beautiful and interesting homes, the Central Business District, Audubon Park, plus Tulane and Loyola Universities. We suggest looking at the stops ahead of time and hopping off to browse in the shops or eat in one of the darling cafes along the way. If you like to explore on your own or with a small group and don't mind handling your own agenda, this tour is for you. Pay as you go for what you want. This tour is one ***you*** design as you go.

ANNUAL WING BRUNCHEON & BUSINESS MEETING
NEW ORLEANS SCHOOL OF COOKING **$ 50.00**
Wednesday, May 24, 9:30 AM – 1:00 PM
524 St. Louis Street – New Orleans, LA 70130
Meet in the lobby at 9:30 AM. We can either walk together (0.4 miles or about 12 minutes) or order a ride share to one of The Wing's favorite activities. We'll enjoy a demonstration class where we will "Watch – Learn – Eat". The lesson and meal includes: starter, entrée and dessert. We will learn about New Orleans folklore and how to make tasty dishes that are easy enough to make at home. Our Annual Wing Business meeting will be held in this delightful setting. Of course, there's a lovely shop where you'll find so many fun and unique New Orleans cooking items. This will be a great culinary learning experience with delicious food and a great business meeting. Dietary options are available – Vegan, Gluten Free & Vegetarian.
Please email to: **asmawing@gmail.com** if you request one of the dietary alternatives by **MAY 8, 2023.**
Tips are optional but can be given easily and discreetly at your table.

TOUR #3 – Mardi Gras World & Mask Making Class **$ 65.00**
Thursday, May 25, 8:45 AM – 12:30 PM
Meet in the lobby at 8:45 AM – Transportation is "on our own." We'll share taxis / ride shares and caravan together. It's about **1.5** miles over there. Too far to walk and too close to charter a bus! Get ready for a Behind the Scenes Tour of Mardi Gras World. The Wing gets to see a special side of Mardi Gras that no one else gets to see! We kick-off with a 15-minute introductory movie. Then, we have an hour walking tour through Mardi Gras World's working warehouse where their artists make over 80 percent of the Mardi Gras props, floats and fun. Be sure to bring your camera and take advantage of the many photo ops. Next, we'll enjoy a private Mask Making Class. One of Mardi Gras World's certified artists will lead us through designing our very own Mardi Gras mask. They provide all of the magic we need to create our masterpieces, including a premium felt backed mask, glitter, feathers and more. Once our creations are complete, we might agree to wear our works of art as a fun accessory to Honor's Night! We'll head back to the hotel and lunch is on your own.

WING HOSPITALITY ROOM AND REGISTRATION: "Grand Couteau" Room
Registration Hours: Sunday, May 21: 1-5 PM; Monday, May 22: 10 AM-1:30 PM
Hospitality Room Hours: Sunday: 1-5 PM; Monday: 10 AM-1:30 PM

Keeping AsMA Scholarships and Awards in Mind

Susan Northrup, M.D., M.P.H., FAsMA

Our Scientific Meeting is almost here! I hope you enjoy reviewing the abstracts as much as I did. Every year, the program gets more robust and the science more thought provoking. Huge kudos to the Scientific Program Committee and the home office staff for all the hard work and dedication it takes to get this far!

It is also that time of year for renewing memberships and awarding scholarships. AsMA had a bumper crop of applications for our four scholarships—including 13 for just one of them. Please remember as you speak with prospective members and contributors that there are scholarships to offset travel and education expenses for students, residents, and members new in the career field. The applications are on our website. In general, applicants must be members of AsMA, but there are student and resident membership levels as well as some reduced pricing packages for certain countries based on need. Let's see if we can get more deserving applicants next year!

If you haven't already done it, I'd book your travel and hotel soon! Our room block is filling up. There are also lots of fun things to do in the area if you come in early or stay a couple of extra days.

I can't wait to see everyone in May!

DOI: https://doi.org/10.3357/AMHP.944PP.2023

Late Breaking Room Changes for AsMA's 93rd Annual Meeting

Changes to the Napoleon Ballroom scientific session rooms were made in an effort to maximize seating space. The table below explains the changes.

Napoleon Session Rooms as Listed in April AMHP Journal	**Napoleon Session Rooms as Listed in the Meeting App & Meeting Addendum**
Napoleon Ballroom C1-D1	Napoleon Ballroom C1-C2
Napoleon Ballroom C2-D2	Napoleon Ballroom D1-D2
Napoleon Ballroom C3-D3	Napoleon Ballroom C3

Napoleon Ballroom A1-B3 remains the same.

In addition, the workshops were originally listed as being in the Napoleon Ballrooms as well, but are now in Rhythms Ballroom as below:

The Aerospace Medicine Faculty Development Workshop is now in Rhythms Ballroom III.

The Altitude Decompression Sickness —Pathophysiology, Diagnosis, Treatment, and Mitigation workshop is now in Rhythms Ballroom I.

The Establishing Peer Support Programs Across All Aviation Segments workshop is now in Rhythms Ballroom II.

CONTACT DETAILS:
Email: President@asma.org • **Web site:** www.asma.org • **Facebook:** Aerospace Medical Association • **Twitter:** @Aero_Med

AsMA 93rd ANNUAL SCIENTIFIC MEETING EDUCATIONAL INFORMATION

The theme for this year's Annual Scientific Meeting is "Aerospace and the Next Generation." With emerging technology and new entrants into the aviation and space environment, it is now more important than ever to encourage the next generation of young people to consider entering career fields like aerospace medicine, engineers, operators, pilots, mechanics, and air traffic controllers to name a few. In addition, AsMA members will need to maintain a full awareness and, in many cases, a working knowledge of the innovations so we can better respond to the needs of the aviation and space community. The future will require us to think differently as the airspace system changes.

As aerospace medicine is truly multi-disciplinary and international, our presentations come from diverse experts who will enhance the world's knowledge and understanding of the current challenges in Aerospace Medicine and demonstrate an impact on improving the health, safety, and human performance of those involved in aviation, space, and extreme environments. Our annual scientific meeting presents an opportunity to learn about the work of our colleagues from around the world, to share the knowledge and wisdom which we gain in our day-to-day work and practice, and is a great way to expand the overall community of aerospace medicine.

EDUCATIONAL OBJECTIVES & BENEFIT

Based upon responses to a survey provided at the end of the 92nd Annual Scientific Meeting in Reno, NV, the top 6 categories our members indicated a need for more information in were: Aerospace Medicine (65.65%); Space Medicine (48.03%); Medical Standards (43.01%); FAA Medicals (41.58%); Human Performance (37.63%); and Accident Investigation (37.63%). The 93rd Annual Scientific Meeting program will be focused on these 6 major categories. Sessions will cover the latest findings in the fields of aviation and space medicine, human performance, and related fields such as aerospace nursing, aerospace physiology, and human systems integration.

Abstracts are centered on the meeting objectives. The participant will: (1) apply principles of evidence-based medicine, operational risk management, and aeromedical decision-making in aircrew selection and clinical aerospace medicine practice; (2) learn about evolving trends and best practices in aerospace medicine; (3) analyze mechanical, human performance, and systems integration factors in aviation mishaps and safety programs; (4) identify mechanical, biological, social, cognitive, environmental stress, and systems factors that impact on optimal human performance and decision making in the full spectrum of aerospace operations; (5) apply ethical principles to aerospace medicine decision-making and foster competency in professionalism and systems-based practice in the application of aerospace medicine skills, teamwork, and interoperability in a multi-discipline professional environment.

KEY TOPICS

Key topics include: Space Medicine; three plenary lectures on aspects of aerospace medicine and aerospace operations; workplace stress and mental health; Aeromedical Grand Rounds and "RAM Bowl"; emerging technologies; hypoxia, acceleration, and high-altitude medical issues; spatial disorientation; patient safety and air transport medicine issues; in-flight medical events; human systems integration; human performance in aviation; aviation safety in civil and military settings; aviation medicine case studies.

CREDIT HOURS FOR ATTENDANCE

The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of 23.0 *AMA PRA Category 1 Credits™*. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

The Administrative Committee of the AOA Council on Continuing Medical Education approved the 93rd Annual Scientific Meeting of the Aerospace Medical Association for a maximum of (23.0) AOA Category 1-B credits. Each physician should claim only those credits that he/she actually spent in the activity.

Nursing CEUs: This activity has been submitted to Montana Nurses Association for approval to award contact hours. Montana Nurses Association is accredited as an approver of continuing nursing education by the American Nurses Credentialing Center's Commission on Accreditation.

ABPM CONTINUING CERTIFICATION PROGRAM (CCP)

The ABPM's CCP was developed in compliance with the new Standards for Continuing Certification mandated by the American Board of Medical Specialties and in response to feedback from ABPM Diplomates, who wanted a simpler but more meaningful program, and who overwhelmingly preferred an innovative alternative to the traditional high-stakes, point-in-time Maintenance of Certification (MOC) exam.

To ensure a smooth transition to the CCP, ABPM is introducing the new program in three separate and distinct phases.

Phase 1: 2023-2024

In Phase One of the transition, in effect for calendar years 2023 and 2024, Diplomates have only three annual requirements:

1. Maintain a current, valid, and unrestricted medical license in every U.S. state, U.S. territory, or Canadian province in which the Diplomate holds a license to practice medicine;
2. Pay the annual fee using the ABPM's Physician Portal;
3. Attest to earning 20 *AMA PRA Category 1 Credits™* (using the ABPM's Physician Portal)
   - Six of the credits must be relevant to Diplomates' ABPM Certification(s). Diplomates will choose for themselves which CME courses are relevant to the ABPM Specialties or Subspecialties in which they are Certified.

Phase 2: 2025-2029

Phase Two of the transition will begin in January 2025 and continue through December 2029, and will include an expansion of its LAP pilot for each ABPM Specialty and Subspecialty. The LAP will be an open-resource assessment that includes 30 questions annually, designed to be an innovative replacement for the traditional, high-stakes, point-in-time MOC exam.

Phase 3: 2030 and beyond

Finally, in January 2030, ABPM will launch Phase Three that will include both the annual CME and LAP requirements as well as an Improvement in Health and Healthcare component, the details of which are in development and will be shared once they have been finalized.

MEETING EVALUATIONS AND CME CREDIT

For CME credit, it is imperative that you reply to the post-meeting evaluation and answer all of the questions. Your evaluations are very important to us as they convey your educational needs and help us plan the academic program for the following year. In addition, this is an Accreditation Council for Continuing Medical Education (ACCME) requirement.

AsMA'S EDUCATIONAL MISSION

The Aerospace Medical Association's Annual Scientific Meeting is a forum in which the newest information on safe-guarding human life in flight environments is presented. During the rest of the year, the Association's monthly journal, *Aerospace Medicine and Human Performance*, fulfills this function.

Further information on the Aerospace Medical Association may be obtained by visiting our website at www.asma.org, by calling (703) 739-2240, or by writing to: Aerospace Medical Association, 320 S. Henry Street, Alexandria, VA 22314-3579.

Recording of sessions: The plenary lectures will be videotaped and offered online following the meeting. All slides and panel sessions will be live captured and made available to all paid registrants. Posters will be available as PDFs.

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Accreditation Statement: This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the Undersea and Hyperbaric Medical Society and the Aerospace Medical Association. The Undersea and Hyperbaric Medical Society is accredited by the ACCME to provide continuing medical education for physicians.

Full Disclosure Statement: All faculty members and planners participating in continuing medical education activities sponsored by the Aerospace Medical Association are expected to disclose to the participants any relevant financial relationships with ineligible companies. Full disclosure of all individuals in control of content and their relevant financial relationships will be made at the activity.

UHMS Disclaimer: The information provided at this CME activity is for Continuing Medical Education purposes only. The lecture content, statements or opinions expressed however, do not necessarily represent those of the Undersea and Hyperbaric Medical Society (UHMS), its affiliates or its employees.

AsMA Workshop Summaries

Altitude Decompression Sickness: Pathophysiology, Diagnosis, Treatment and Mitigation

Date: Sunday, May 21 (Max 75) **Time: 8:00 a.m. - 4:30 p.m.**

(Designation Statement: The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of 7.0 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.)

Altitude-induced decompression sickness (DCS) is an ever-present threat to aircrew. First seriously recognized as an entity around 1917, altitude DCS was not treated with recompression until 1959. Since then, it has been diagnosed and treated regularly within military aviation. This workshop is designed to provide attendees a relatively in-depth knowledge base upon which to diagnose, treat, and mitigate altitude DCS. Foundational presentations will address the history, etiology, pathophysiology, epidemiology, diagnosis, treatment, and efficacy of the USAF treatment algorithm. Additional special presentations will focus on low altitude DCS, epidemic DCS, and mitigation strategies to include the Altitude Decompression Sickness Risk Assessment Computer (ADRAC). Lastly, the workshop will host an expert clinical panel discussing the diagnosis and treatment of a number of challenging altitude DCS cases.

Establishing Peer Support Programs Across All Aviation Segments (Max 75)

Date: Sunday, May 21 (Max 75) **Time: 8:00 a.m. - 4:30 p.m.**

(Designation Statement: The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of 6.0 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.)

Peer support programs have demonstrated effectiveness in removing barriers for seeking mental health assistance and in improving wellbeing of individuals with less than optimum mental wellness. Aviation regulators have mandated of strongly recommended institution of peer support programs within the aviation industry as a strategy to improve safety and the mental wellness of those involved. This workshop will inform attendees of methods, programs and challenges in establishing peer support programs across the aviation industry. Experts from professional commercial airline pilot groups, cabin crew and maintainers, air traffic control services, business aviation, university and ab initio aviation training programs and all inclusive aviation peer support programs will present unique challenges with possible solutions for the establishment of peer support programs within their individual groups. The workshop will be interactive with opportunities for attendee participation and breakout sessions for individual groups. Attendees will be able to interact and request individual advice from speakers in small groups. The goal of this workshop is to provide attendees tools and templates to assist in establishing peer support programs withing their aviation groups. Ultimately, these Peer support programs will reduce barriers to help seeking, improve mental wellness and enhance aviation safety. Incorporation of mental wellness programs in all aviation groups should be incorporated in an organization's safety management system and its safety culture.

Aerospace Medicine Faculty Development Workshop

Date: Sunday, May 22 (Max 75) **Time: 8:00 a.m. - 11:30 a.m.**

(Designation Statement: The Undersea and Hyperbaric Medical Society designates this live activity for a maximum of 3.5 *AMA PRA Category 1 Credits*™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.)

The Accreditation Council for Graduate Medical Education (ACGME) requires faculty members regularly participate in organized clinical discussions, rounds, journal clubs, conferences, and on an annual basis pursue faculty development designed to enhance their skills. Faculty development is intended to describe structured programming developed for the purpose of enhancing transference of knowledge, skill, and behavior from the educator to the learner. This workshop will offer needs-based programming reflective of recent and upcoming changes to residency training as implemented by the ACGME and demonstrate solutions to current resident educational requirements. Focus areas will include Faculty Appointments and Promotion in Academic Medicine, Introduction to Curriculum Development, and How to Write a Case Report.

Register early! Attendance to workhops is limited.

Accreditation Statement: This activity has been planned and implemented in accordance with the accreditation requirements and policies of the Accreditation Council for Continuing Medical Education (ACCME) through the joint providership of the Undersea and Hyperbaric Medical Society and the Aerospace Medical Association. The Undersea and Hyperbaric Medical Society is accredited by the ACCME to provide continuing medical education for physicians.
Full Disclosure Statement: All faculty members and planners participating in continuing medical education activities sponsored by the Aerospace Medical Association are expected to disclose to the participants any relevant financial relationships with commercial interests. Full disclosure of faculty and planner relevant financial relationships will be made at the activity.
UHMS Disclaimer: The information provided at this CME activity is for Continuing Medical Education purposes only. The lecture content, statements or opinions expressed however, do not necessarily represent those of the Undersea and Hyperbaric Medical Society (UHMS), its affiliates or its employees.

2023 Annual AsMA Lectures

68th Louis H. Bauer Lecture
Chris Rocheleau, B.A., M.P.A.

"International Aviation & COVID-19: Response and Recovery"

Chris Rocheleau serves as the National Business Aviation Association's (NBAA) Chief Operating Officer, overseeing NBAA's activities relating to aircraft and flight department operations, as well as the administrative, financial, and human resources functions. Prior to joining NBAA, he served the Federal Aviation Administration (FAA) with distinction for over 20 years in multiple roles, including: Acting Associate Administrator for Aviation Safety; Chief of Staff; Assistant Administrator for Policy, International Affairs, and Environment; Executive Director for International Affairs; and Director of the Office of Emergency Operations and Investigations. While at the FAA, he supported response and recovery operations in several aviation crises related to natural disasters, government shutdowns, aircraft accidents, and public health events. During the COVID-19 pandemic, he became a U.S. Representative to the International Civil Aviation Organization.

Before joining the FAA, Mr. Rocheleau served as an officer and special agent with the United States Air Force, retiring from the USAF Reserve in 2010 as a lieutenant colonel. He was also among the first leaders of the Transportation Security Administration.

Mr. Rocheleau holds a bachelor's degree from Central Connecticut State University and a Master of Public Administration from City University of Seattle. He also completed the Executive National Security Program at Harvard's Kennedy School of Government, as well as USAF Air Command and Staff College. He is a member of the Aero Club of Washington, the International Aviation Club of Washington, Association of Former OSI Special Agents, and the Fraternal Order of Police.

57th Harry G. Armstrong Lecture

In support of the AsMA President's focus on Science, Technology, Engineering, and Mathematics (STEM), the Armstrong Lecture time will be used to allow two or three invited high school students who competed in the 2023 Greater New Orleans Science and Engineering Fair to make presentations about their science fair projects.

The Bauer Lecture will be given on Monday, May 22, at 8:00 a.m. during Opening Ceremonies in the Grand Ballroom A-E. Educational Support is provided by Wyle.

The Reinartz Lecture will be given on Tuesday, May 23 at 8:30 a.m. in Grand Ballroom A-B-C. Support is provided by the Eugen Reinartz Memorial Fund.

The Armstrong Lecture will be given on Thursday, May 25 at 8:15 a.m. in the Grand Ballroom. Eductional support is provided by Environmental Tectonics Corp.

9th Reinartz Lecture
Ansa Jordaan, M.B.Ch.B., B.Sc.(Hons) Aerospace Medicine, DOMH

"Civil Aviation in the Future: Key Issues to be Addressed"

Dr. Jordaan qualified as a doctor in 1989, obtained a degree in Aerospace Medicine in 1999, followed by a degree in Occupational Health in 2009. Since then, she has completed several courses, contributed to publications, and participated in international conferences in relation to clinical medicine, occupational medicine, aerospace medicine, aviation safety, and management pertaining to medical policies and health risk management.

Dr. Jordaan started her career in the South African Military Health Services in the emergency department of the Military Hospital. She then transferred to the South African Institute for Aviation Medicine conducting and certifying aviation medical examinations, as well as providing emergency air transport. She left the military service to obtain experience in private practice in both urban and rural areas. She then returned to aviation, establishing the Aviation Medicine Department in the South African Civil Aviation Authority, notably leading the amendment of the air ambulance regulations, developing a procedure to investigate the medical aspects of aircraft accident investigation, ensuring compliance with international standards and national regulations, and advising the Commissioner for Civil Aviation.

Following this, Dr. Jordaan founded an aeromedical consultancy providing advice to national and international organizations and then joined South African Airways (SAA) as Medical Director responsible for aviation medical management, occupational health, and passenger medical care. Upon leaving SAA, she joined Life Occupational Health in the position as Transnet Freight Rail Project Director and then International SOS as the Medical Director of Occupational Health, providing advice to clients in sub-Saharan Africa in relation to remote clinic services, occupational health, public health, and medical emergency response evacuation, including air evacuation.

Since 2015, Dr. Jordaan has been the Chief of the Aviation Medicine Section at the International Civil Aviation Organization (ICAO), responsible for aviation medical standards and the ICAO Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) program. She also serves as an advisor to the World Health Organisation in relation to specific topics affecting aviation. Her memberships include the South African Society for Aerospace and Environmental Medicine, the Aerospace MedicalAssociation, the International Academy of Aviation and Space Medicine, and the International Airline Medical Association.

2023 ABSTRACTS OF THE AsMA SCIENTIFIC SESSIONS

93rd Annual Scientific Meeting **Sheraton New Orleans**
May 21 – 25, 2023 **New Orleans, LA**

The following are the sessions and abstracts with rooms and presentation times for all presentations accepted after blind peer-review—in workshop, panel, slide, or poster sessions—for the 2023 Annual Scientific Meeting of the Aerospace Medical Association. The numbered abstracts are keyed to both the daily schedule and the author index. The Sessions numbers are listed as S-1 through S-89 (including workshops). Session chairs are included in the index to participants. The order of some sessions may have changed (check the Addendum provided at the meeting for the latest information). Abstracts withdrawn are listed as W/D. Presenters are underlined in the text.

SLIDES & PANELS: Each slide presentation is scheduled for 15 minutes (10-min talk and 5-min Q&A). We strive to keep slide presentation on time. Panel presentations have more flexibility and may not keep to a strict 15 minutes per presenter format. There will be a discussion period of 15 minutes at the end of each panel.

POSTERS: Posters will be presented digitally this year. Poster authors must be present for the full session in which their poster is scheduled.

EXHIBITS: Exhibits will be open Sunday evening during the Welcome Reception, and 9:30 a.m. to 4:30 p.m. Monday and Tuesday. Please wear your badge and visit every exhibit.

CONFLICT OF INTEREST: All meeting planners and presenters completed financial disclosure forms for this live educational activity. All potential conflicts of interest were resolved before planners and presenters were approved to participate in the educational activity. Any conflicts of interest that could not be resolved resulted in disqualification from any role involved in planning, management, presentation, or evaluation of the educational activity.

TEMPLATES: All Abstracts were submitted according to a certain category and type using provided templates. Not all abstracts submitted fit the mold for Original Research abstracts. We therefore have created an Education category with three additional types: Case Report, Program/Process, and Tutorial. The templates for these are provided for your information.

ORIGINAL RESEARCH TEMPLATE:

This type of abstract describes the results and significance of new research undertaken to address gaps in the current knowledge of aerospace medicine or human performance. It is typically an original analysis of a hypothesis involving data collection and analysis.

INTRODUCTION: *<This section includes the background, including a statement of the problem and why it is important, the status of the current research, and the hypothesis to be tested.>*
METHODS: *<This section includes a brief description of how the study was conducted, the number, type, and gender of the subjects, and how they were selected and grouped. It should also include the metrics collected, how they were measured, and how frequently they were recorded. The types of scales or questionnaires administered should be identified. Environmental conditions and administered medications should be described. In addition, a summary of the statistical methods should be provided. A statement concerning ethics approval for studies using human or animal subjects is also required.>*
RESULTS: *<This section includes a summary of the data and metrics of operational and/or statistical significance. "Results will be discussed" is not acceptable.>*
DISCUSSION: *<This section interprets the meaning of the results in terms of their application to the operational/clinical/scientific community and suggests areas for future research.>*

EDUCATION: CASE STUDY: CLINICAL OR HUMAN PERFORMANCE TEMPLATE:

This type of abstract describes the analysis of an individual clinical or operational case that is not a research study but provides pertinent information directly applicable to aeromedical practices, safety, or human performance.

INTRODUCTION: *<This section concisely summarizes the case.>*
BACKGROUND: *<This section describes the importance of the case and provides supporting evidence in the form of a literature review.>*
CASE PRESENTATION: *<This section describes the event.>*
DISCUSSION: *<This section explains the applicability and relevance to civilian and military operations.>*

EDUCATION: PROGRAM/PROCESS REVIEW TEMPLATE:

This type of abstract can describe a new Service thrust, e.g., identifying capability gaps, or reviews of critical areas, e.g., safety. It may be a description of a program or process that is used to solve a problem or accomplish a task.

BACKGROUND: *<This section describes why this is important to AsMA attendees and why this needs to be addressed now.>*
OVERVIEW: *<This section concisely describes the effort and how it applies to current or future gaps.>*
DISCUSSION: *<This section describes (1) the operational or clinical significance, (2) how it will this advance aeromedicine/human performance, and (3) address whether it supports cross Service/International/Military – Civilian spheres.>*

EDUCATION: TUTORIAL TEMPLATE:

This type of abstract describes new tools, models, techniques, methodologies pertinent to civilian and military aerospace medicine and human performance.

INTRODUCTION: *<This section summarizes what will be covered, e.g., list of topics or syllabus.>*
TOPIC: *<Description of new technology, procedure, methodology.>*
APPLICATION: *<This section details how the new material will be implemented and how broadly it applies to aerospace medicine and human performance.>*
RESOURCES: *<This is an optional section to provide citations where additional information can be found.>*

SUNDAY, MAY 21, 2023

Sunday, 05/21/2023, ***8:00 AM***
Rhythms Ballroom III

[S-01]: WORKSHOP: AEROSPACE MEDICINE FACULTY DEVELOPMENT WORKSHOP

Chair: Thomas Jarnot
Co-Chairs: Paul Newbold, David Miller

WORKSHOP OVERVIEW: *The Accreditation Council for Graduate Medical Education (ACGME) requires faculty members regularly participate in organized clinical discussions, rounds, journal clubs, conferences, and on an annual basis pursue faculty development designed to enhance their skills. Faculty development is intended to describe structured programming developed for the purpose of enhancing transference of knowledge, skill, and behavior from the educator to the learner. This workshop will offer needs-based programming reflective of recent and upcoming changes to residency training as implemented by the ACGME and demonstrate solutions to current resident educational requirements. Focus areas will include Faculty Appointments and Promotion in Academic Medicine, Introduction to Curriculum Development, and How to Write a Case Report.*

[1][2] AEROSPACE MEDICINE FACULTY DEVELOPMENT WORKSHOP

Jessica Servey, Gayle Haisher-Rollo
Uniformed Services University of the Health Sciences, Bethesda, MD, United States

(Education - Program/Process Review)

The Accreditation Council for Graduate Medical Education (ACGME) requires faculty members regularly participate in organized clinical discussions, rounds, journal clubs, conferences, and on an annual basis pursue faculty development designed to enhance their skills. Faculty development is intended to describe structured programming developed for the purpose of enhancing transference of knowledge, skill, and behavior from the educator to the learner. This workshop will offer needs-based programming reflective of recent and upcoming changes to residency training as implemented by the ACGME and demonstrate solutions to current resident educational requirements. Focus areas will include Faculty Appointments and Promotion in Academic Medicine, Introduction to Curriculum Development, and How to Write a Case Report.

Learning Objectives

1. Participants will be able to describe the appointment process, ranks, and benefits of pursuing an academic career in aerospace medicine.
2. Participants will be able to describe KERNS six steps for curriculum development and the importance of adhering to the guiding principles when undertaking this assignment
3. Attendees will be able to define the purpose, virtues, and limitations of a case report, the sections contained within, and sources of high quality examples.

Sunday, 05/21/2023 ***8:00 AM***
Rhythms Ballroom I

[S-02]: WORKSHOP: ALTITUDE DECOMPRESSION SICKNESS -- PATHOPHYSIOLOGY, DIAGNOSIS, TREATMENT, AND MITIGATION

Chair: Nathan Maertens
Co-Chair: William Butler

WORKSHOP OVERVIEW: *Altitude-induced decompression sickness (DCS) is an ever-present threat to aircrew. First seriously recognized as an entity around 1917, altitude DCS was not treated with recompression until 1959. Since then, it has been diagnosed and treated regularly within military aviation. This workshop is designed to provide attendees a relatively in-depth knowledge base upon which to diagnose, treat, and mitigate altitude DCS. Foundational presentations will address the history, etiology, pathophysiology, epidemiology, diagnosis, treatment, and efficacy of the USAF treatment algorithm. Additional special presentations will focus on low altitude DCS, epidemic DCS, and mitigation strategies to include the Altitude Decompression Sickness Risk Assessment Computer (ADRAC). Lastly, the workshop will host an expert clinical panel discussing the diagnosis and treatment of a number of challenging altitude DCS cases.*

[3] DCS - A HISTORICAL PERSPECTIVE

Nathan Maertens[1], Dave Johanson[2], Jamie Talley[3]
[1]*U.S. Air Force, Beale AFB, CA, United States;* [2]*Retired, Eglon, WA, United States;* [3]*Embry-Riddle Aeronautical University, Daytona Beach, FL, United States*

(Education - Tutorial/Review)

This session will bring historical perspective to Decompression Sickness (DCS). Presented will be the various findings and theories associated with DCS as our understanding of the ailment progressed through the years. We will journey from Robert Boyle's legendary viper eye bubble, to Paul Bert's *La Pression Barometrique*, to Caisson's Disease during construction of the Eads Bridge in St. Louis and the Brooklyn Bridge in New York City, to JSB Haldane's staged decompression. Discussion will continue with altitude DCS and how it was essentially disregarded until, finally in 1917, Yandell Henderson popularized it. Additionally, recompression treatment for altitude DCS will be introduced with Donnell & Norton's ground-breaking 1960 case report. Of note, particular attention will be paid to basic compartment modeling and the development of risk management through dive tables. Overall, this session will fabricate the foundation upon which the rest of the workshop is built.

Learning Objectives

1. The audience will learn about the evolution of our understanding of DCS.
2. The audience will learn about some of the founding research upon which our current understanding of DCS is based.
3. The audience will learn about basic compartment modeling and the development of dive tables to protect against DCS.

[4] ALTITUDE DECOMPRESSION SICKNESS PHYSIOLOGY

John Harrell
U.S. Air Force, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

This session focuses on the causes, physiological development, and pathophysiology of altitude-induced decompression sickness. The information will include the manifestations and symptomology that aid in the diagnosis of decompression sickness. Lastly, we will explore the epidemiological trends and gender differences of aviation-related decompression sickness.

Learning Objectives

1. The audience will hear a review of the causes, physiological development, and pathophysiology of altitude-induced decompression sickness.
2. The audience will also learn information about the manifestations and symptomology that aid in the diagnosis of decompression sickness.
3. Lastly, the audience see the epidemiological trends and gender differences of aviation-related decompression sickness.

[5] SPECIALTY DECOMPRESSION SICKNESS

William Butler
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

This session will focus upon two uncommon, yet high profile special instances of decompression sickness (DCS) --- epidemic DCS and low

altitude DCS. Although most cases of DCS are solitary, occasionally a cluster (i.e., outbreak) of cases is encountered, the so-called epidemic DCS. Epidemic DCS takes two forms: after a single exposure and after multiple exposures over an extended time period. This session will describe the two types of epidemic DCS, how to investigate them, and a methodology (i.e., Haddon Matrix) for implementing control measures. In addition, low altitude DCS will be discussed. Generally, signs and symptoms of DCS following an altitude exposure below 18,000 feet are viewed in askance. However, such cases happen with surprising frequency. A large case series of low altitude DCS will be reviewed, characterizing the altitude exposures, presentations, and treatments. An approach for predicting low altitude risk will be offered as the Altitude DCS Risk Assessment Computer (ADRAC) is not applicable to exposures below 18,000 feet.

Learning Objectives

1. Participants will learn about epidemic decompression sickness to include what it is, how to investigate it, and a methodology (i.e., Haddon Matrix) for implementing control measures.
2. Participants will learn about low altitude decompression sickness to include what it is, how it is characterized, and how to risk-assess for it.

[6] ALTITUDE DECOMPRESSION SICKNESS RISK MITIGATION

Todd Dart
KBR, San Antonio, TX, United States

(Education - Tutorial/Review)

INTRODUCTION: Hypobaric decompression sickness (DCS) is a potential health risk when exposed to barometric pressures less than one-half the pressure at sea level. Aerospace performance and healthcare professionals need to understand how to quantify and mitigate this risk. **TOPIC:** Altitude (or hypobaric) DCS is an illness that follows ambient pressure reduction sufficient to cause formation of bubbles from gases dissolved in body tissues. This can occur in conditions of low pressure such as full or partial aircraft decompression, unpressurized flight or parachuting sorties, and during extravehicular (space suit) activity. This section of the workshop will discuss hypobaric DCS risk mitigation practices. **APPLICATION:** Mission success for hypobaric operations requires DCS risk mitigation planning. The planning process starts with a DCS assessment of the planned hypobaric exposure using the Altitude Decompression Sickness Risk Assessment Computer. Managing the predicted risk requires learning and understanding the implications and limitations of the risk model as it applies to populations versus individuals and judicious application of DCS risk mitigation techniques such as selection of oxygen prebreathe duration, decision on the use of exercise during prebreathe, determining the prebreathe altitude, setting the exposure duration limit, and establishing an acceptable DCS risk level. Application of a DCS risk mitigation may include ensuring compliance with directives and established best practices, setting policy guidance for breaks in prebreathe, first responder DCS treatment procedures, and consideration of mission and environment-specific risk mitigation procedures. When properly applied, risk mitigation plans and techniques prior to hypobaric exposure reduce the occurrence and severity hypobaric DCS. **RESOURCES:** Applicable government instructions and policies will be reviewed. The presentation may use video of hypobaric testing to illustrate presented material.

Learning Objectives

1. Understand the environmental and physiological factors affecting hypobaric decompression sickness risk.
2. Learn procedures that can be undertaken to mitigate hypobaric DCS risk.
3. Learn how to access, use, interpret results, and understand the capabilities and limitations of the Altitude Decompression Sickness Risk Assessment Computer (ADRAC).

[7] ALTITUDE DECOMPRESSION SICKNESS TREATMENT

Gary Toups
Mayo Clinic, Rochester, MN, United States

(Education - Tutorial/Review)

This session will focus on the treatment of altitude decompression sickness (DCS). The US Air Force (USAF) Altitude DCS Treatment Algorithm as well as US Navy protocols will be presented. Primary treatment modalities will be spotlighted --- ground level 100% oxygen, hyperbaric oxygen via Treatment Table 5, and hyperbaric oxygen via Treatment Table 6 --- and contrasted with the primary treatment modality for diving DCS (i.e., US Navy Treatment Table 6). The contrast between treatment regimens will be highlighted by comparing the clinical and operational features of diving and altitude DCS. US Navy treatment tables will be emphasized, but seldom-today-employed USAF treatment tables (essentially modifications to the Navy treatment tables) will also be presented. Other less frequent hyperbaric oxygen treatment modalities, (e.g. USAF Treatment Table 8, Comex 100, Catalina Treatment Table, Hart-Kindwall monoplace no-break treatment table) and adjuvant therapies (e.g., IV fluids, aspirin, lidocaine, anticoagulation, steroids) will be discussed. At the same time, the efficacy of altitude DCS treatment outcomes (95-98% complete recovery) with the USAF DCS treatment algorithm will be discussed and contrasted with the treatment outcomes for diving DCS.

Learning Objectives

1. The participant will be familiar with the most common protocols for treatment of altitude decompression sickness.
2. The participant will be able select an appropriate treatment modality for altitude decompression sickness consistent with patient presentation.
3. The participant will be familiar with adjunctive therapies and patient transport considerations for patients with altitude decompression sickness

[8] CLINICAL CASES — A PANEL DISCUSSION

William Butler
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

This session will pose a number of clinical cases of decompression sickness (DCS) for discussion by a panel of experts. Special attention will be paid to the presentation of the case. Panelists will be asked to discuss their diagnosis of the problem and the treatment modalities they might employ to remedy the situation. Specific treatments for discussion will include ground level 100% oxygen, hyperbaric Treatment Table 5, and hyperbaric Treatment Table 6. Application of these treatments within the framework of the USAF treatment algorithm for altitude DCS will be emphasized. And, lastly, other treatment modalities will be brought to light as needed within the discussions.

Learning Objectives

1. A number of decompression sickness cases will be presented to the participants. Panel experts will review the diagnoses, all within the framework of the USAF treatment algorithm. These reviews will serve as simulations upon which the participants can glean best diagnostic practices.
2. A number of decompression sickness cases will be presented to the participants. Panel experts will review the treatments, all within the framework of the USAF treatment algorithm. These reviews will serve as simulations upon which the participants can glean best treatment practices.

Sunday, 05/21/2023 ***8:00 AM***
Rhythms Ballroom II

[S-03]: WORKSHOP: ESTABLISHING PEER SUPPORT PROGRAMS ACROSS ALL AVIATION SEGMENTS

Chair: Quay Snyder
Co-Chair: Ries Simons

WORKSHOP OVERVIEW: Rationale: *Peer support programs have demonstrated effectiveness in removing barriers for seeking mental*

health assistance and in improving wellbeing of individuals with less than optimum mental wellness. Aviation regulators have mandated of strongly recommended institution of peer support programs within the aviation industry as a strategy to improve safety and the mental wellness of those involved. Methods: This workshop will inform attendees of methods, programs, and challenges in establishing peer support programs across the aviation industry. Experts from professional commercial airline pilot groups, cabin crew and maintainers, air traffic control services, business aviation, university and ab initio aviation training programs and all inclusive aviation peer support programs will present unique challenges with possible solutions for the establishment of peer support programs within their individual groups. ***Opportunities:*** *The workshop will be interactive with opportunities for attendee participation and breakout sessions for individual groups. Attendees will be able to interact and request individual advice from speakers in small groups.* ***Objectives:*** *The goal of this workshop is to provide attendees tools and templates to assist in establishing peer support programs withing their aviation groups. Ultimately, these Peer support programs will reduce barriers to help seeking, improve mental wellness and enhance aviation safety. Incorporation of mental wellness programs in all aviation groups should be incorporated in an organization's safety management system and its safety culture.*

[9] ESTABLISHING PEER SUPPORT PROGRAMS ACROSS ALL AVIATION SEGMENTS

Quay Snyder[1], Ries Simons[2]
[1]*Aviation Medicine Advisory Service & ALPA Int'l, Centennial, CO, United States;* [2]*Netherlands Organization for Applied Scientific Research (TNO), Soesterberg, Netherlands*

(Education - Tutorial/Review)

RATIONALE: Peer support programs have demonstrated effectiveness in removing barriers for seeking mental health assistance and in improving wellbeing of individuals with less than optimum mental wellness. Aviation regulators have mandated of strongly recommended institution of peer support programs within the aviation industry as a strategy to improve safety and the mental wellness of those involved. **METHODS:** This workshop will inform attendees of methods, programs and challenges in establishing peer support programs across the aviation industry. Experts from professional commercial airline pilot groups, cabin crew and maintainers, air traffic control services, business aviation, university and ab initio aviation training programs and all-inclusive aviation peer support programs will present unique challenges with possible solutions for the establishment of peer support programs within their individual groups. **OPPORTUNITIES:** The workshop will be interactive with opportunities for attendee participation and breakout sessions for individual groups. Attendees will be able to interact and request individual advice from speakers in small groups. **OBJECTIVES:** The goal of this workshop is to provide attendees tools and templates to assist in establishing peer support programs withing their aviation groups. Ultimately, these Peer support programs will reduce barriers to help seeking, improve mental wellness and enhance aviation safety. Incorporation of mental wellness programs in all aviation groups should be incorporated in an organization's safety management system and its safety culture.

Learning Objectives

1. Attendees will understand key elements and challenges in establishing peer support programs in various aviation groups.
2. Attendees will interact individually with experts within their aviation industry group for assistance and advice in establishing peer support programs consistent with their needs and resources.

[10] ELEMENTS OF AN AIRLINE PEER PROGRAM

Ellen Brinks[1], Dave Fielding[2], Quay Snyder[3]
[1]*ALPA Int'l, McLean, VA, United States;* [2]*BALPA, London, United Kingdom;* [3]*Aviation Medicine Advisory Service, Centennial, CO, United States*

(Education - Program/Process Review)

The attendee will learn some of the key objectives in developing a peer program that fits the size, culture and generational age of the airline and pilot group. Communication between different generations and methodology of contacting a peer program will be addressed. As a large group of pilots are retiring or retired due to the Covid pandemic, having resources available to the retiree as well as keeping their knowledge base to help with the education of incoming generations is essential. How to design a peer program structure that effectively supports and trains all pilots through initial, recurrent and continuing education.

Learning Objectives

1. The audience will learn how to collaboratively work to ensure the peer program is supported by all stakeholders.
2. The participant will be able to understand and encourage research for communication and technology between all generations.
3. The participant will be able to understand the support needed to support pilots as they transition to retirement.

[11] THE CRITICAL ROLE OF PEER SELECTION, TRAINING, DEVELOPING AND RETAINING IN ADVANCING WORKFORCE MENTAL HEALTH WELLBEING

Heather Healy
Association of Flight Attendants, Washington, DC, United States

(Education - Program/Process Review)

Today, peer assistance programs are being recognized as a valuable tool in supporting the mental well-being of the workforce they serve and enhancing the safety of that industry. Trained peers are the engine of a cabin crew peer assistance program. They identify, reach out to and assist struggling flying partners in addition to attending to their own professional and personal commitments. Not everyone is a good fit to be a peer. In addition to peer selection, other critical elements of program effectiveness include training, developing and retaining these volunteers This presentation will provide an overview of the many challenges inherent in managing any network of peer assistance volunteers and the strategies that the Association of Flight Attendants has developed to address many of them over its four decades of operation.

Learning Objectives

1. The audience will learn about and reflect on the many challenges inherent in managing a network of peer volunteers that support mental health well being in the workplace.
2. The audience will learn about program policies and practices to overcome these identified challenges in managing a peer support network.
3. The audience will come to appreciate the value and role of peer support in enhancing workforce mental health and industry safety.

[12] PEER SUPPORT PROGRAMS AND THE AIR TRAFFIC CONTROL WORKFORCE

Andrew LeBovidge
National Air Traffic Controllers Association, Washington, DC, United States

(Education - Tutorial/Review)

INTRODUCTION: As the establishment of Peer Support Programs are gaining traction in the aviation community as an effective method to address the mental wellbeing individuals performing critical safety work, there are segments of the industry which have not yet been incorporated into these initiatives. **CHALLENGE:** Air Traffic Control Specialists (ATCOs) represent a significant body of that universe and do not have a viable PSP. **CONCLUSION:** Further discussions need to occur on whether PSP are suitable for this community, and, if so, what actions would need to been undertaken to establish such programs. Conversations require open dialogue, trust, and commitment from employers, regulators, and trade

unions and any outcomes must be developed and implemented in a fully collaborative manner.

Learning Objectives

1. The current status of Peer Support Programs for the air traffic control workforce in the United States.
2. Current efforts to evaluate the viability of PSP for ATC in the United States.

[13] PEER SUPPORT PROGRAM CHALLENGES FOR BUSINESS AVIATION

Mark Larsen[1], Quay Snyder[2]
[1]*National Business Aviation Association, Washington, DC, United States;* [2]*Aviation Medicine Advisory Service, Centennial, CO, United States*

(Education - Tutorial/Review)

INTRODUCTION: Business aviation organizations often face unique challenges from those of larger airlines when setting up peer support programs. **TOPIC:** Business aviation organizations come in all types and sizes. Most business aviation organizations have one aircraft, and only 1-3 pilots, often depending on the number of pilots legally required for flight and the total annual hours expected to be flown. Larger Part 91 flight departments may have roughly 50 employees, though these organizations often feel resource-constrained for the multiple aircraft they fly. Only a few large business aviation charter management and fractional ownership programs employ numbers of people akin to the airlines with internal peer support programs that are viable. One constant among business aviation organizations is that their pilots, maintainers, flight attendants, schedulers/dispatchers, and managers can all benefit from access to peer support, just as these employee groups within airlines benefit from their own peer support programs. Aggregating the resources of business aviation organizations to provide peer support could be one way to provide this critical mental wellness tool to more business aviation organizations than possible with internal programs. **APPLICATION:** Business aviation organizations can benefit from peer support programs and it is up to the industry to innovate existing peer support models to normalize mental wellness in aviation, remove barriers to seeking help, and provide for enhanced mental health within the business aviation sector.

Learning Objectives

1. Attendees will learn about the organizational differences between common business aviation operations and scheduled airline operators, relative to peer support programs.
2. Attendees will learn about possible ways that business aviation organizations could viably implement peer support programs to support mental wellness among their employees.

[14] IMPLEMENTING A PEER SUPPORT PROGAM IN A COLLEGIATE AVIATION FLIGHT TRAINING PROGRAM

Elizabeth Bjerke, Kaylee Trottier, Ryan Peene, Mark Volk Porter
University of North Dakota, Grand Forks, ND, United States

(Education - Tutorial/Review)

INTRODUCTION: While peer support programs have become engrained in many air carriers around the world, the concept is relatively new in the flight training environment. Due to an increase in anxiety and depression brought on by the impact of the COVID-19 pandemic, universities began to explore new ways to better serve the students' rising mental health concerns. After connecting with a number of airlines about the positive impact of peer support programs the concept to adapt this program into the collegiate aviation environment began. **IDENTIFIED CHALLENGES:** The process of implementing a new peer support program needs to be championed by the peers themselves, so the first challenge was selecting the group of student peer volunteers and ensuring that they received proper training. One challenge will be the constant turnover of peer supporters as they progress in their studies and graduate from the university. Another challenge is ensuring that the peers are well supported by a mental health expert. The last challenge identified was finding a proper modality in which to connect student pilots to a peer supporter, as the next generation of pilots do not communicate in the same ways as older generations. **CURRENT EFFORTS:** The University of North Dakota launched UpLift in the Fall of 2022 with 15 student peer supporters and an embedded psychologist offering support for the program. While the program is still very new, a lot has been learned and adapted throughout the past year. **CONCLUSION:** Peer Support Programs have proven to be an effective intermediary for pilots seeking help in the air carrier arena that will also be impactful earlier in a pilots training. We hope to share what has been learned in our program in order to help other flight training organizations implement similar programs.

Learning Objectives

1. The audience will learn about the current efforts to establish a peer support program for student pilots in a flight training environment.
2. The audience will understand the challenges faced while implementing a peer support program, as well as the current efforts underway.

[15] AVIATION MENTAL HEALTH; IT'S NOT JUST ABOUT AIRLINE PILOTS DUMMY!

Herwin Bongers
Massey University, Palmerston North, New Zealand

(Education - Program/Process Review)

BACKGROUND: The aviation system is one of complexity with many influencing components but invariably there is a human at the end of every process preventing accidents as the last line of defence. The mental health of airline pilots has become a focus after high profile tragedies, but when taking a whole safety-of-flight approach, the mental health of all personnel who operate in the aviation system is of paramount importance. The true threat that occurrences of impaired mental wellness have upon aviation safety is the associated correlation to workplace errors. **OVERVIEW:** Through the experience of establishing an aviation peer support program unique in its provision of nationwide cover to all aviation medical license holders as an industry wide wrap-around support network, an opportunity exists to share learnings. By offering a tiered system where different levels of provided assistance is available and looking to protect any gaps from the time a pilot or air traffic controller starts training until the time they retire, ensures all aviation personnel can be responded to and thus normalizing the act of assistance seeking when wellness is impaired. **DISCUSSION:** The Maori of New Zealand weave cloaks (Korowai) for protection during inclement times. Seeking to weave the strengths of collegial, well trained, evidence based methods for assistance in times of impaired wellness provides the benefits of a trustworthy, reliable and robust peer support network. If only provided to airline pilots, the weave of the Korowai protecting the collective mental health of the aviation system is fundamentally threadbare and distinctly compromised in its effectiveness. Offering nationwide assistance to all pilots and air traffic controllers throughout a career "cradle to grave", realizes a more comprehensive aviation system safety cloak (Korowai). Utilizing the skills of trained volunteers for all cases and providing free escalation to a mental health expert for those personnel who work for organizations that fund the program allows scope for anyone to feel unencumbered when seeking assistance.

Learning Objectives

1. To convey the key learnings of success and pitfalls to avoid in the provision of a comprehensive aviation peer support program across the whole aviation system.
2. Accentuate the need to discuss aviation mental health in an operational error management context.

[16] REGULATOR PERSPECTIVES ON MENTAL HEALTH AND WELLBEING SUPPORT FOR MEDICAL CERTIFICATION

Kate Manderson[1], Susan Northrup[2], Cristian Panait[3]
[1]*CASA Australia, Phillip, Australia;* [2]*FAA, Washington, DC, United States;* [3]*EASA, Cologne, Germany*

(Education - Program/Process Review)

BACKGROUND: "There is no health without mental health". As our industry emerges from one of the most disruptive periods in our history it has never been more important for us to acknowledge this truth. Regulators play a key role in supporting industry to respond to this issue effectively. **OVERVIEW:** Acknowledgement of mental illness and asking for support with mental wellbeing continues to be associated with deeply embedded cultural stigma. Despite the aviation industry's awareness about human factors in performance and safety, we still need to navigate these barriers both for the people in our industry and for the systems with which it is regulated. "It is better to prevent than to treat". Several regulators are taking a best-practice preventive approach with the use of support groups and peer programs to facilitate the management of risk factors, and to prevent their evolution into established mental illness. Support groups and industry peer supporters can be a valuable layer in mental wellbeing and illness prevention and therapy. Their involvement could motivate licence holders to complete their treatments and return to flying duties. **DISCUSSION:** The future of aviation medical certification for mental health and wellbeing will ultimately be aligned with certification for other human conditions that impact function and performance such as fatigue. Compared with diseases like heart disease or diabetes, where there are well established and reliable diagnostic tests, mental wellbeing is difficult to quantify. However, we must strive to apply scientific method to the prevention, assessment and management of mental health issues. This panel will discuss: strategies to overcome barriers to diagnosis and declaration; approaches to working with workplace and industry for risk assessment; models for mental wellbeing, illness prevention and management in the aviation industry; and opportunities for research and scientific endeavours in aviation mental health. There remains a considerable body of work for regulators and industry to achieve the goal of accepting mental wellbeing as part of the normal human continuum. We can approach this task with optimism now that awareness of the issues has been firmly established in the aeromedical and aviation industry.

Learning Objectives

1. The audience will learn about the salutogenic approach to mental wellbeing, health and illness.
2. Participants will have greater awareness of how peer support workers and programs can support mental wellbeing in the aviation industry.
3. The audience will learn about approaches that regulators and airlines can use in prevention of mental illness as a part of better medical certification process.

[17] EXPAND RISK ASSESSMENTS TO INCLUDE PSYCHOSOCIAL RISKS AND INCLUDE AN INTEGRATED HEALTH AND SAFETY PROGRAM AS PART OF SMS

David Schroeder
Retired, Oklahoma City, OK, United States

(Education - Program/Process Review)

RATIONALE: Data from the U.S., the UK, and other countries has consistently demonstrated that the most widespread hazard in the workplace is stress. Cooper (2000) provides a dynamic illustration of how psychosocial stressors in the workplace impact individual health, the organization and overall well-being. If unresolved, they can lead to poor health and lowered work performance. **DISCUSSION:** Cooper (2008) in commenting on the Black report indicates that this "requires a changed perception of health and well-being and a willingness from both employers and employees to invest resources and change behaviours." This presentation will demonstrate how psychosocial stressors in the workplace impact the safety culture in an organization by creating job strain and burnout which leads to lowered employee engagement, workplace compliance, and lowered perfromance. The literature clear illustrates how the interaction of job demands and resources can produce burnout in pilots, flight attendants, and maintenance personnel and impact their performance and safety. Recent integrated health and safety programs (Harvard's Safety Well, NASA's Integrated Employee Health Program and NIOSH's Total Worker Health program) provide sufficient evidence that health or well-being needs to be integrated with efforts to improve safety in the workplace. Those efforts include individual initiatives as well as organizational support for stress management, peer support groups and other interventions designed to support individuals and reduce the presence of psychosocial stressors in the workplace. **RECOMMENDATION:** The AsMA Aerospace Mental Health Work group has recommended that organizational Safety Management Systems (SMSs) have an integrated program that addresses both psychosocial risks as well as safety risks. In addition to existing efforts to reduce safety risks, efforts are needed to reduce the psychosocial risks and include the introduction of interventions (lifestyle, stress management, peer support) for individuals and the organization to improve employee health, safety, and wellbeing.

Learning Objectives

1. Be able to identify three of the more prominent psychosocial stressors within aviation workplaces.
2. Understand basic principles involved in an organization with an integrated health and safety program.

MONDAY, MAY 22, 2023

Monday, 05/22/2023 ***8:00 AM***
Grand Ballroom A-E

OPENING CEREMONIES AND 68TH LOUIS H. BAUER LECTURE

Chris Rocheleau, B.A., M.P.A.

"International Aviation & COVID-19: Response and Recovery"

Monday, 05/22/2023 ***10:30 AM***
Grand Ballroom A-B-C

[S-04]: PANEL: GOVERNMENTAL INTERAGENCY AND COMMERCIAL COLLABORATIVE APPROACH TO HUMAN SPACE FLIGHT MEDICAL SUPPORT

Chair: Melissa Runge

PANEL OVERVIEW: *This panel presents a multi-agency effort to launch and recover the Space X Crew Dragon 4. The collaboration starts with training aerospace medicine experts who care for astronauts or lead rescue and recovery operations and results in synergistic capabilities between NASA, the Department of Defense (DoD) and SpaceX to accelerate our nation's human spaceflight program. US Space Command will review the DOD's role in Human Space Flight support, how we are organized, the planning process, and finally cover the role of the USSPACECOM Command Surgeon in medical operations. NASA looks at how crew surgeons prepared for the Commercial Crew mission with SpaceX and through emergency simulation, prepared their flight surgeons for a coordinated response supported by the DoD. A presentation by SpaceX describes the coordination required to work with and train DoD assets for rescue and internal resources used for nominal recovery. From 1st Air Force, Detachment 3, the DoD's Human Space Flight Support office, they describe the preparation and hands-on training required to ensure ready forces for Joint Service rescue operations and the DoD Surgeon's role to lead a collaboration for*

definitive care. Finally, the last presentation informs the audience on the complexity of a crew surgeon's responsibility in any one of the Operations Centers supporting human space flight. The panel will showcase the medical capabilities and challenges present when multiple agencies collaborate to support human space flight operations.

[18] US SPACE COMMAND'S ROLE IN HUMAN SPACE FLIGHT SUPPORT

Melissa Runge, Maiya Anderson
U.S. Space Command, Colorado Springs, CO, United States

(Education - Program/Process Review)

BACKGROUND: The DoD provides a range of capabilities to NASA as part of their crewed spaceflight programs, including rescue and recovery of astronauts, landing site support and medical operations. **OVERVIEW:** Understanding the planning process, as well as the responsibilities and complexities for DoD, NASA, and Commercial companies to successfully launch, land and recover crewed missions provides a context for what is required for safe and effective spaceflight operations. **DISCUSSION:** An understanding of each organization's structure, ensuring clearly defined processes and procedures, as well as established communication and collaboration norms is critical to operations. Through the lens of the Crew 4 mission, US Space Command will review the DoD's role in Human Space Flight support, how we are organized, the joint and interagency planning process, and the role of the USSPACECOM Command Surgeon in defining medical requirements and ensuring effective medical operations. As the human space flight mission and the number of mission partners grow, it is important to have clear and repeatable processes and collaboration methods to ensure safe and effective operations across multiple agencies in support of US Human Space Flight Programs.

Learning Objectives

1. Understand the DOD Human Space Flight support mission and how the DOD is organized to execute this mission.
2. Explain the requirement and planning process for DOD Human Space Flight Support from a Combatant Command Perspective.
3. Identify the role and key tasks of the US Space Command medical office in supporting human space flight across multiple organizations.

[19] NASA COMMERCIAL CREW PROGRAM AND MEDICAL OPERATIONAL CHALLENGES

Joseph Dervay
NASA, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: NASA embarked on the Commercial Crew Program to launch astronauts into low-earth orbit from US soil and dock with the International Space Station (ISS). The eventual industry providers selected were SpaceX (SpX) and Boeing. These commercial transportation systems are vital to ensure crew availability on ISS for research and discovery. **OVERVIEW:** NASA/SpaceX Demo-2 (DM2) mission launched from the Kennedy Space Center in 2020 as the historic first crewed test-flight of the Crew Dragon spacecraft with two NASA Astronauts onboard. DM2 represented the first flight in 9-years from US soil since STS-135 in 2011. The 63-day mission ended with splashdown in the Gulf of Mexico, the first US water recovery in 45-years since Apollo-Soyuz. Validation of system hardware and operations allowed four-person crews to launch on subsequently missions (Crew-1, Crew-2, Crew-3, Crew-4, Crew-5 to date), which included International Partner crewmembers. **DISCUSSION:** A multitude of operational, training, medical, and technical issues needed to be addressed between NASA Medical Operations, the commercial provider SpaceX, and the Department of Defense. These included Flight rule development, occupant protection, pressurized suit testing, communication plans during mission phases, and emergency simulations for supporting Flight Surgeons and Biomedical Engineers. In providing crew experience with expected launch and entry G-force profile, Centrifuge training was established. Preventive health measures via the Health Stabilization Program were especially vital during the global COVID-19 pandemic. Unique aspects arise for SpX Dragon parachute splashdown and shipboard recovery operations in the Atlantic Ocean and Gulf of Mexico. The new Commercial Crew Program is indeed a wonderfully challenging and exciting era for human spaceflight.

Learning Objectives

1. Using the Crew 4 launch and landing as a model of success, describe the interagency collaborative approach required to address operational, training, medical and technical issues in preparation for the Commercial Crew Program.
2. Identify how flight surgeons used emergency simulations to prepare for contingency operations.

[20] SPACEX MEDICAL RECOVERY OPERATIONS

Brandon Trapp, Jaime Mateus
SpaceX, Hawthorne, CA, United States

(Education - Program/Process Review)

BACKGROUND: This abstract is submitted as part of the USSPACECOM Command Surgeon's panel demonstrating the medical capabilities and challenges involved in human space flight support operations. SpaceX launched its first human spaceflight mission (Demo-2) as part of the NASA Commercial Crew Program in 2020. Since then, SpaceX has continued to launch both NASA and commercial astronaut missions. **OVERVIEW:** As part of bringing astronauts home safely from low Earth orbit, SpaceX provides medical capabilities for both nominal and contingency situations. These recovery missions include: Two ocean splashdown capabilities; Dragon recovery vessels specially designed for retrieval of the Dragon spacecraft and care of its crew; Coordination with NASA and its international partners, and/or commercial astronaut mission teams; Team design and training; Equipment preparation; Helicopter MEDEVAC from the vessel to either a nominal receiving center or nearby hospitals; and Pre-mission coordination with local trauma and hyperbaric centers. **DISCUSSION:** This presentation will give the audience the opportunity to see a SpaceX recovery mission from the viewpoint of the various entities involved including the returning crew, SpaceX medical and non-medical personnel, customer medical representatives, supporting medical facilities, medevac aircraft personnel, ship crew, and mission control operators. The audience will learn how these various governmental and non-governmental groups train independently and together to coordinate a successful mission. The audience will also learn the composition of the medical team including physicians, paramedics, and nurses and how they work together to form a cohesive team. Attention will also be paid to the pre-mission and mission-day logistics involved in putting this team in the right place at the right time to provide care to returning astronauts.

Learning Objectives

1. Describe the key groups involved in a SpaceX medical recovery mission.
2. List the primary members comprising the joint medical recovery team and describe their roles and responsibilities.

[21] THE ROLE OF DET 3 IN HUMAN SPACE FLIGHT SUPPORT

Sky (Jen) Wolf, Kristin Sylvia, Brent Maney
Air Force Space Command Det 3, Patrick SFB, FL, United States

(Education - Program/Process Review)

BACKGROUND: Det 3 is the office of primary responsibility for the Department of Defense's (DoD) Human Space Flight Support (HSFS) and the only unit within the DoD tasked to support contingency operations. Det 3 has been involved with HSFS since 1958 and currently consists of 50 personnel who specialize in global rescue, nominal recovery, retrieval/salvage, and medical response. **OVERVIEW:** HSFS, medical operations, includes support to 3 programs: Soyuz, Artemis,

and the Commercial Crew Program (CCP), encompassing 4 capsules: Russia's Soyuz, NASA's Orion, SpaceX's Dragon, and Boeing's Starliner. **DISCUSSION:** Our case study will focus on Det 3's involvement with rescue forces in preparation for support of Crew 4's launch and landing where Det 3 coordinated the following processes: Integration of NASA's request for assistance (RFA) into a Program Requirements Document (PRD), which was subsequently translated into a request for forces (RFF) through the Joint Forces Global Force Management Program; Support of multilateral multidomain training/exercises with NASA, SpaceX, and DoD rescue forces; Procurement and allocation of medication and blood products; Medical oversight and instruction of the Pre-Hospital Space Medical Care Course (PHSMCC) during the Rescue Forces Qualification Course (RFQC) where rescue teams train on the intricacies of space medicine (including deconditioned astronauts, detection of hazardous chemicals to safe the capsule and procedures for extracting the crew); and Participation in the Joint Mission brief. Prior to launch and landing, Det 3 validated mission ready rescue forces in terms of blood products, medical equipment, medications, and crew health records. Finally, Det 3 conducted global command and control (C2) in the Support Operations Center (SOC) on the day of launch and day of landing which led to mission success.

Learning Objectives

1. Identify the key roles required to provide Global Rescue Response in support of the Crew-4 launch and landing.
2. Describe mission requirements for the Department of Defense to meet NASA's Request for Assistance in support of the Crew-4 launch and landing.

[22] COMMAND AND CONTROL FOR HUMAN SPACE FLIGHT SUPPORT MEDICAL OPERATIONS

Benjamin Johansen[1], Melissa Runge[2]
[1]*NASA and USAF Reserves, Alexandria, VA, United States;* [2]*U.S. Air Force, Colorado Springs, CO, United States*

(Education - Program/Process Review)

The coordination required to communicate across two governmental agencies, the Department of Defense (DoD) and National Aeronautics and Space Administration (NASA), and the civilian corporation SpaceX requires clear lines of communication and command and control. Systems in place to ensure success in contingency operations requires flight surgeons with the training to ensure operational safety, arrange transport to definitive medical care, lead patient care enroute, communicate across multiple agencies and the skillset to multitask and think critically. Command and Control is centered around a Joint SpaceX and NASA leadership team representing various disciplines including medical. The team operates from multiple control centers across the United States with the responsibility of maintaining situational awareness, facilitating flow of information, and managing risk in response to anomalies. Medical operations are further supported by flight surgeons and additional personnel representing NASA, DoD, and SpaceX with each position tasked to a specific element of the mission. Effective communication and well-defined roles and responsibilities are essential to team success. Each flight surgeon utilizes a variety of communication tools including voice loops, phone, messaging, and email with interfaces unique to each control center. Communication etiquette and jointly integrated tactics, techniques, and procedures allow the teams to function seamlessly through each mission phase. Using the NASA/SpaceX Crew 4 launch and landing as a model of success, this presentation will inform the audience on the complexity of a flight surgeon's responsibility in any one of the Operations Centers supporting human space flight.

Learning Objectives

1. Identify key tasks of flight surgeons who support human space flight across multiple organization's operations centers.
2. Explain the lines of communication which allow for full transparency in the event of patient rescue and transfer during human space flight operations.

Monday, 05/22/2023 ***10:30 AM***
Grand Ballroom D-E

[S-05]: PANEL: CURRENT TRENDS IN VISION SCREENING AND SURGERY FOR PILOT SELECTION

Chair: Jonathan Ellis

PANEL OVERVIEW: *All branches of service are experiencing challenges to fill pilot training slots with qualified applicants. Advances in surgical and vision screening techniques have allowed a way to safely open the aperture and recommend waiver for pilot training for applicants with conditions previously considered disqualifying. Despite the advances, the fundamental vision requirements of visual acuity, visual field, and stereopsis remain as key requirements for safey of flight in the aviation environment. Additionally, the Aeromedical Risk Analysis and Assessment Matrix (AMRAAM) has been developed, validated, and is currently being used to highlight the level of aeromedical risk. This panel will consist of four presentations from the Ophthalmology Branch of the Aeromedical Consult Service in the USAF School of Aerospace Medicine. The panelists will discuss advances in ocular coherence tomography (OCT) as a method to screen for pathologic conditions that can impact vision and safety in flight, discuss conditions that can be identified with this technology, and provide the calculated risk for those conditions with the AMRAAM. Next, innovative methods of using simple principles of optics will be showcased as a method to distinguish between possible visual field defects secondary to posterior staphyloma versus early glaucoma. Finally, a new classification of surgical techniques, minimally invasive strabismus surgery, will be presented. The indications, expected outcomes, and potential aeromedical impact for this strabismus surgery and how this surgical advancement can be leveraged to increase pilot applicants will be presented. Additionally, preliminary findings from both the Abnormal OCT and the Strabismus Surgery Management Groups will be discussed.*

[23] CURRENT TRENDS IN VISION SCREENING AND SURGERY FOR PILOT SELECTION PANEL

Jonathan Ellis
Aeromedical Consult Service, USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

TOPIC: Minimally invasive strabismus surgery (MISS) is a newer surgical technique designed to correct smaller amounts of strabismus. Previously, this level of strabismus was only correctable with prism glasses, which are not approved for use in USAF aircrew. Initially, the surgery was only performed by few and was not readily adopted. Now, it is performed much more commonly with more predictable results. The surgical techniques, indications, aeromedical risks, outcomes, and potential uses for the surgery in pilot applicants will be discussed. Preliminary results of the USAF Strabismus Surgery Management Group will be discussed to include outcomes of both traditional strabismus surgery and minimally invasive strabismus surgery. Finally, the Aeromedical Risk Analysis and Assessment Matrix (AMRAAM) will be used to highlight the overall aeromedical risk for pilot applicants who undergo MISS. **APPLICATION:** Correction of small angle strabismus to improve ocular alignment and stereopsis in pilot applicants. **RESOURCES:** 1. Wright KW. Mini-tenotomy Procedure to Correct Diplopia Associated with Small-Angle Strabismus. Trans Am Ophthalmol Soc. 2009;107:97-102. 2. Leenheer RS, Wright KW. Mini-plication to Treat Small-Angle Strabismus: A Minimally Invasive Procedure. J AAPOS. 2012;16:327-330. 3. Mojon DS. Minimally Invasive Strabismus Surgery for Horizontal Rectus Muscle Reoperations. Br J Ophthalmol. 2008 Dec;92(12):1648-1652. 4. Sanz PM, Sanchez, PG, Dominguez IB. Minimally Invasive Strabismus Surgery (MISS) Compared with the Fornix Approach in Pediatric Horizontal Strabismus Surgery. Strabismus. 2015;23(4):159-163. 5. Gupta P, Ddadeya S, Kamlesh, Bhambhawani V. Comparison of Minimally Invasive

Strabismus Surgery (MISS) and Conventional Strabismus Surgery Using the Limbal Approach. J Pediatr Ophthalmol Strabismus. 2017 Jul 1:54(4) 208-215. 6. Pellanda N, Mojon DS. Combined Horizontal Rectus Muscle Minimally Invasive Strabismus Surgery for Exotropia. Can J Ophthalmol. 2010 Aug: 45(4):363-367.

Learning Objectives

1. The participant will be able to identify two types of Minimally Invasive Strabismus Surgeries.
2. The audience will learn about the indications, aeromedical risks, and outcomes for Minimally Invasive Strabismus Surgeries.
3. The audience will learn how to apply the new USAF Aeromedical Risk Analysis and Assessment Matrix to pilot applicants who have Minimally Invasive Strabismus Surgery.

[24] OCT TECHNIQUES FOR INITIAL FLYING CLASS EXAMINATIONS

Austen Tanner
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The OCT and applicable operating techniques are essential for Initial Flying Class Examinations. **SPEAKER:** Austen Tanner, **OD TOPIC:** Ocular Coherence Tomography (OCT). OCT provides a quantifiable way to measure the health of the retina and optic nerve. Proper technique, scan selection and interpretation is essential to usage of the device. While the USAF does not have a medical standard for OCT test result values, the device's diagnostic capabilities are helpful in identifying several potentially disqualifying conditions. Overview of required USAF OCT testing for initial pilot applicants will be discussed alongside a case example that enumerates the abilities of the device. In addition the OCT Study Group will be introduced along with it's application to USAF medical standards. **APPLICATION:** Ocular examination of pilot applicants and applicable standards. **RESOURCES:** 1. Carl Zeiss Meditec. (2015). Cirrus HD-OCT User Manual - Models 500, 5000. Jena, Germany. 2660021159751 Rev. A 2015-08. 2. Kabashi A, Dedushi K, Ymeri L, Ametxhekaj I, Shatri M. Colloid Cyst of the Third Ventricle: Case report and Literature Review. Acta Inform Med. 2020 Dec;28(4):283-286. 3. Palmer E, Gale J, Crowston JG, Wells AP. Optic Nerve Head Drusen: An Update. Neuroophthalmology. 2018 Apr 25;42(6):367-384. 4. Venkatesh R, Sinha S, Gangadharaiah D, Gadde SGK, Mohan A, Shetty R, Yadav NK. Retinal structural-vascular-functional relationship using optical coherence tomography and optical coherence tomography - angiography in myopia. Eye Vis (Lond). 2019 Mar 7;6:8. 5. Zha Y, Zhuang J, Lin D, Feng W, Zheng H, Cai J. Evaluation of myopia on retinal nerve fiber layer thickness measured by Spectralis optical coherence tomography. Exp Ther Med. 2017 Sep;14(3):2716-2720.

Learning Objectives

1. Participants will be able to understand the basics of OCT operation in a clinical / occupational setting.
2. Participants will understand how specific OCT functions can be used to identify pathology.

[25] IDENTIFICATION AND EVALUATION OF POSTERIOR STAPHYLOMAS BY OCT

Darrell Rousse
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

TOPIC: The ACS Ophthalmology Branch has completed Optical Coherence Tomography (OCT) testing on all USAF initial pilot applicants for the past few years. Two case examples will be used to demonstrate how the OCT may be used to quickly identify individuals who require further evaluation. More specifically, classic characteristics of OCT imaging of posterior staphyloma will be illustrated and discussed. Finally, a novel visual field test technique will be showcased as an innovative approach to distinguish functional loss as a result of posterior staphylomas from other causes of visual field loss. **APPLICATION:** USAF initial pilot applicants.

Learning Objectives

1. The participant will be able to understand the use of a screening OCT for identification of a posterior staphyloma.
2. The participant will be able to understand the use of an OCT and VF for detailed evaluation of structural loss and functional vision loss related to a posterior staphyloma.

[26] POSTERIOR STAPHYLOMA AS A CAUSE FOR VISUAL FIELD DEFECT IN PILOT APPLICANT

Michael Parsons
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial / Review)

TOPIC: A staphyloma is a circumscribed outpouching of the wall of the globe. Posterior staphyloma is considered a hallmark of pathologic myopia and are among one of the major causes of developing maculopathy. However, it can be present in non-myopic eyes. The most common form affects the macula, resulting in a very myopic prescription. This applicant had a rare form which occurs nasally and temporally, and in her case, spared the fovea. This subtype is called a Septal Staphyloma. Upon presentation to ACS, member continued to have a repeatable visual field defect OD within the central 20 degrees of fixation. She was also noted to have a nasal and peripheral staphyloma on OCT, but spared macula and fovea, making it difficult to detect. Using a novel approach and manipulating optics, we demonstrated that staphyloma was the cause of her visual field defect, and not of neurological etiology. Ultimately, the result of this was a persistent and repeatable visual field defect in the right eye within 20 degrees of central fixation, not qualified for aircrew duties. Applying the USAFSAM Aeromedical Consultation Service Medical Risk Assessment & Airworthiness Matrix (AMRAAM) tool, the member's visual field defect is always present, and therefore the likelihood is considered Continuous and the severity level is considered Critical. This results in an overall aeromedical risk score of (3), representing a High Risk level. There were no effective risk mitigation strategies that resolved this fixed visual field defect. **APPLICATION:** Recognize ocular anatomical structure abnormality and it's resulting effect on optics, as cause for monocular visual field defect in a prospective UPT applicant. **RESOURCES:** 1. Curtin BJ: The Posterior Staphyloma of Pathologic Myopia. Trans Am Ophthalmal. Soc., vol. LXXV, 1977. 2. Von Graefe A: Zwei Sektionsbefunde bei Sclerotico-choroiditis posterior und Bemerkunger uber diese Kramkheit. Albrecht von Graefes Arch Ophthalmol 1:390-401,1854. 3. Curtin BJ, Karlin DB: Axial length measurements and fundus changes of the myopic eye. Part 1. The posterior fundus. Trans Am Opthalmal Soc 68:312-334, 1970.

Learning Objectives

1. The audience will learn about an anatomical abnormality of the globe called a staphyloma that can negatively impact visual performance.
2. Additionally, the audience will see how a basic application of optical principals can be used to explain how form can impact function.

Monday, 05/22/2023 ***10:30 AM***
Grand Chenier

[S-06]: SLIDES: CLINICAL AEROSPACE NEUROLOGY

Chair: Jim DeVoll
Co-Chair: Jeffrey Kinard

[27] CLINIC CASE: OPTIC NEUROMYELITIS IN A CIVIL AVIATOR

Patricia Barrientos[1], Giancarlos Conde[2], Alexandra Mejia[1], Johana Giraldo[1], Maria Angelita Salamanca[1]
[1]*Aerocivil - Civil Aviation Authority of Colombia, Bogota, Colombia;* [2]*Universidad de Cartagena, Corporacion Universitaria Rafael Nunez Grupo de Investigacion GINUMED, Cartagena, Colombia*

(Education - Case Study)

INTRODUCTION: The optic neuromyelitis is an inflammatory and autoimmune illness of the central nervous system. It is characterized by attacks of optic neuritis and myelitis, being able to produce blindness, great neurological disability and even the short term death. Some years ago it was considered as a form of multiple sclerosis. It is currently considered a different disease, according to the clinical manifestations, imaging, serology and immunopathology profile. So far there is no effective treatment, the therapy is centered in the treatment of the acute attacks, the medical prevention of the complications and the rehabilitation. It is important to analyze the crew member possibilities under this condition to return to flight, managing the safety risk. **METHODS:** The case of a 27-year-old male aviator is presented here. He is reported based on his clinical findings which began with cervical pain associated with paresthesia in hands and lower limbs. Finally diagnosed and treated as a seronegative optic neuromyelitis spectrum disorders: antimog, medically controlled, autoimmune etiology. **RESULTS:** The case was reviewed and discussed at a medical board in order to decide a waiver possibilities. **DISCUSSION:** This is a review of an uncommon illness, considering aeromedical implications and the requirements for making decisions regarding about psychophysical fitness and the possibilities for giving a waiver to safety sensitive aeronautical personnel.

Learning Objectives

1. The audience will be able to understand the aeromedical considerations to decide about risk and aviation safety when a crew member has this kind of neurological conditions.
2. The audience will be able to understand how the medical and scientific advances play the role to change the aeromedical considerations about fitting to fly.

[28] CURRENT NEUROIMAGING TECHNIQUES TO MEASURE NEUROCOGNITIVE BRAIN ADAPTABILITY UNDER EXTREME ENVIRONMENTAL CONDITIONS

Sven-Erik Sönksen[1], Christian Moritz[1], Hans-Jürgen Noblé[2], Sven Kühn[3]
[1]*German Armed Forces Hospital Hamburg, Hamburg, Germany;* [2]*German Air Force Center of Aerospace Medicine, Cologne, Germany;* [3]*Federal Armed Forces Central Hospital Koblenz, Koblenz, Germany*

(Education - Program/Process Review)

BACKGROUND: Extreme environmental conditions such as high altitudes and outer space, pose constant challenges to humans and coming aeronautical missions. The (patho-) physiological adaptation of the brain and neurocognitive strategies are both subject of current research. In addition to already established morphological imaging modalities such as magnetic resonance imaging (MRI), functional investigations continue to be in the foreground. Current and future functional neuroimaging techniques for neurocognitive assessment, learning, and expertise development will be presented and discussed. **OVERVIEW:** In particular, measurements under and after environmental exposure led to significant physiological findings. Currently, multiparametric MRI measurements are mainly concerned with gray and white matter morphology. These are complemented by measurements of cerebral blood flow (arterial spin labeling technique) and white matter microstructural integrity (diffusion tensor imaging, DTI). However, these techniques generally ignore the processing of cognitive activities. In the last decade, neuroimaging research has moved beyond this with the three main neuroimaging modalities: functional magnetic resonance imaging (fMRI), functional near-infrared spectroscopy (NIRS), and electroencephalography (EC) enable connectivity analysis to reveal the dynamic properties of large brain networks. **DISCUSSION:** Understanding the adaptive mechanisms as well as functional pathways of the brain are essential in pathophysiological studies under extreme environmental conditions. An attractive tool is offered by NIRS due to its hemodynamic measurement basis in the study of brain function. This can additionally be combined with structural, high-resolution 3D MRI data to produce complete functional maps. In addition, studies suggest that dynamic functional connectivity analysis may be a useful imaging biomarker to monitor changes in brain function. Ultimately, the combination of current modalities seems promising. Neuroimaging continues to have the potential to add to commonly used cognitive measurement tools to validate/challenge established theoretical assumptions and provide insight into pathophysiology.

Learning Objectives

1. Understanding of modern functional neurological imaging techniques in pathophysiological investigations.
2. Possible combination of neuroimaging techniques in analysis under extreme environmental conditions.

[29] INCIDENTAL FINDINGS ON MRI BRAIN IMAGING IN THE FIGHTER PILOT COHORT OF THE CANADIAN WHITE MATTER HYPERINTENSITY STUDY

Joan Saary[1,4], Sharef Danho[2], Joel Ramirez[3], Bradley MacIntosh[4], Fuqiang Gao[3], Christopher Scott[3], Shawn Rhind[5], Oshin Vartanian[5], Gary Gray[1], Sandra Black[3]
[1]*Canadian Forces Environmental Medicine Establishment, Toronto, ONT, Canada;* [2]*McMaster University, Hamilton, ONT, Canada;* [3]*Sunnybrook Research Institute, Toronto, ONT, Canada;* [4]*University of Toronto, Toronto, ONT, Canada;* [5]*DRDC, Toronto Research Centre, Toronto, ONT, Canada*

(Original Research)

INTRODUCTION: Adding data to an international research effort to understand the clinical and occupational relevance of white matter hyperintensities (WMH) in aircrew, MRI brain imaging was undertaken on Royal Canadian Armed Forces (RCAF) fighter pilots to quantify the presence and amount of WMH in this population with unique occupational flight-related exposures (e.g. non-hypoxic hypobaria, G-forces). Invariably, in a given sample of MRI images, incidental findings are anticipated. This presentation will describe the incidental neuroanatomical findings found in a cohort of fighter pilots, compare them to incidental findings in other populations, and discuss aeromedical relevance. **METHODS:** After protocol ethical approval, 48 volunteer participants underwent brain imaging using a 3 Tesla (T) scanner as part of 2 days of research testing (additional results will be presented in future). Participants were assigned a unique study number to ensure confidentiality, also used as the identifier on the images. Nine imaging sequences were completed over the course of 2 hours for every participant. Incidental findings identified on structural MRI were reviewed by both a local Research Neuroradiologist and Neurologist, then flight surgeons to determine whether additional imaging would be required prior to a decision on aeromedical fitness, if needed. **RESULTS:** In total, brain imaging was completed on 48 participants (42 pilots, 6 high-altitude para-jumpers). Incidental neuroanatomical findings were detected in 4 individuals, all male fighter pilots (mean age 29.5, range 25-34) and included normal anatomical variants, developmental venous anomalies (DVAs), arachnoid cyst, and a non-specific nodule later deemed to be an imaging artifact. After review, one required additional imaging to further elaborate the findings, and none were ultimately deemed disqualifying. **DISCUSSION:** The rate and nature of incidental findings in this study are consistent with those expected using a 3T MRI. Given increasing availability of high-resolution MRI in clinical practice and research, identification of incidental findings is expected to grow. Many such findings have unclear medical significance particularly among aircrew, but some can be benign and managed expectantly. We present an approach to 4 incidental findings in fighter pilots; documenting such cases is important

to enable risk-based selection and surveillance decisions among unique trades in which sample sizes are small.

Learning Objectives

1. The audience will develop an understanding of common incidental findings found during brain MRI.
2. The audience will develop a framework for approaching incidental findings in healthy individuals that includes consideration of implications for use of screening MRIs in healthy Air Force applicants.

[30] MULTIPLE SCLEROSIS IN CIVIL AVIATORS: CASE SERIES

Alexandra Mejia[1], Giancarlos Conde[2], Johana Giraldo[1], Patricia Barrientos[1], Maria Angelita Salamanca[1]

[1]*Aerocivil - Civil Aviation Authority of Colombia, Bogota, Colombia;* [2]*Universidad de Cartagena, Corporacion Universitaria Rafael Nunez Grupo de Investigacion GINUMED, Cartagena, Colombia*

(Education - Case Study)

INTRODUCTION: Multiple sclerosis (MS) is a CNS disease, with different phenotypic and variable course, demyelinating, chronic and autoimmune that progressively affects the individual, compromising their occupational and social role. The aim is to make known the atypical presentation in flight pilots and the considerations by aeronautical regulation in Colombia for patients with MS. **METHODS:** A case series is reported, three patients with MS, aged 33, 38 and 44 years respectively. 33-years-old male, manifestation of August 2019, with sensory and cervical symptoms, high lesion load, treated with alemtuzumab. 38-year-old female, begins in March 2020, with sensory symptoms in legs and genitals, high lesion load, with lesions in different CNS topographies, ocrelizumab is indicated with a favorable response and remission of symptoms. 44-years-old male, beginning 2001, with episodes of optic neuritis and outbreaks of central sensory and motor symptoms, required initial management with interferon B1 a, changed to fingolimod, due to persistence of new demyelinating plaques and new events, management of high lesion load is indicated with ocrelizumab. **RESULTS:** All the three cases were reviewed and discussed individually in medical boards, the aviation safety risk was taken into account to consider granting a waiver. **DISCUSSION:** MS is of unknown cause. In Colombia it is an orphan an disabling disease. The consideration could be to fly with operational limitations that allow aviation safety risk mitigation and periodic controls by neurologyst which must be report complications.

Learning Objectives

1. The audience will be able to understand how the medical and scientific advances play the role to change the aeromedical considerations about fitting to fly.
2. The audience will be able to understand the aeromedical considerations to decide about risk and aviation safety when a crew member has this kind of neurological conditions.

[31] RELEVANCE OF CLINICAL INCIDENTAL FINDINGS IN THE INITIAL ASSESSMENT SCREENING FOR PROSPECTIVE PILOTS

Hans-Juergen Noblé, Lennard Ostrop

Centre of Aerospace Medicine of the German Air Force, Köln, Germany

(Education - Case Study)

In our presentation, we talk about the significance of clinically incidental findings in the imaging screening process of young pilot candidates. In our department, we use a 3-T MRI as a high-end device, which covers the entire spectrum of MRI imaging with maximum performance. Thus, we combine expertise from the fields of military and civil aerospace medicine. Aeronautical fitness and flight safety are key to a successful pilot career. We present and discuss the two cases of a 19- and 20-year-old pilot candidate with a "syringomyelia" and a "dorsal thoracic arachnoid web." These two cases will be presented as examples because they represent a potential hazard to flight safety. Syringomyelia describes a cavitary enlargement in the spinal cord, an accumulation of fluid due to the Dilation of the persistent central canal. In fact, it is very difficult to distinguish hydromyelia from syringomyelia, which is why the collective names hydrosyringomyelia or simply "syrinx" are often used to describe fluid accumulation in the spinal cord. The etiology and clinical presentation are variable, and little is known about the prevalence and clinical significance. Most of them are congenital idiopathic. Arachnoidial web syndromes are very rare entities, with fewer than 10 cases reported in the neurosurgical literature. The main feature suggesting the diagnosis is a focal dorsal indentation and anterior displacement of the thoracic medulla by a thickened intradural extramedullary band of arachnoid tissue with compression of the spinal cord. The clinical presentation and prognosis are variable and depend on the extent of the mass effect on the spinal cord. Because of the limited number of reported cases, the incidence of this condition may be underestimated. Surgical lysis is potentially curative. The above cases demonstrate the importance of finding such lesions in the spinal cord, as they are clinically silent and usually congenital idiopathic time bombs with uncertain prognosis to recognize before starting a career pilot.

Learning Objectives

1. Spinal cord lesions can threaten flight safety. As a fact there are regularly incidental findings in clinically silent pilot candidates that definitely exclude their fitness to fly. Therefore it is essential to search for spinal cord lesions systematically.
2. High performed MRI-Imaging is the key to discover these lesions.
3. Spinal cord lesions are very variable in their clinical appearance.

[32] PERIPHERAL BLOOD IMMUNO-INFLAMMATORY RESPONSE PROFILING IN MILITARY PILOTS AND AIRCREW – RESULTS FROM THE CANADIAN WHITE MATTER HYPERINTENSITY STUDY

Shawn Rhind[1], Alex Di Battista[1], Maria Shiu[1], Oshin Vartanian[1], Sandra Black[2,3], Joel Ramirez[2], Christopher Scott[2], Miriam Palmer[4], Gary Gray[4], Joan Saary[3,4]

[1]*DRDC, Toronto Research Centre, Toronto, ONT, Canada;* [2]*Sunnybrook Research Institute, Toronto, ONT, Canada;* [3]*University of Toronto, Toronto, ONT, Canada;* [4]*Canadian Forces Environmental Medicine Establishment, Toronto, ONT, Canada*

(Original Research)

INTRODUCTION: Subcortical white matter hyperintensities (WMH) on T2-weighted magnetic resonance imaging scans are reported in military aviation populations with exposures to non-hypoxic hypobaria. Pilots with high WMH burdens showed poorer cognitive functioning compared to those with low burden. Pathobiological mechanisms underlying WMH lesions and related cognitive impairments could be linked to dysfunctional central and peripheral immuno-inflammatory activation with resultant microstructural white matter damage and neuronal injury. **METHODS:** This study compared immuno-inflammatory mediator profiles in a sample of male Royal Canadian Armed Forces (RCAF) pilots/aircrew (*n*=48;age:39y) with possible occupational exposure to hypobaria, with healthy unexposed CAF controls (*n*=27;age:33y). Unfractionated whole-blood samples underwent a 3-h culture with lipopolysaccharide (LPS) using TruCulture® (TC) assay system to assess *de novo* synthesis of soluble immune mediators. A 'Null' tube without immunogen served as unstimulated control. Circulating concentrations (pg/ml) of 50 inflammatory mediators [tumor necrosis factor alpha (TNF)-a, interleukins (IL)-1b, -1ra, -2, -4, -5, -6, -7, -8, -10, -11, -12p70, -13, -15, -17A, -18, -19, -22, -33; chemokines (CCLs)-2,-3,-4,-8,-16,-17,-18,-19,-20, (CXCLs)-5,-9,-10,-13; cytokine-receptors TNFR-1,-2, IL6R, C-reactive protein (CRP), myeloperoxidase (MPO), endothelial selectin (E-Sel), vascular cell adhesion molecule (VCAM)-1, intercellular adhesion molecule (ICAM)-1, matrix metalloproteinase (MMP)-9] were quantified using Simple-Plex™ multianalyte cartridges on Ella® immunoassay platform. Usable values were defined as those within quantitation limits and displaying a CV< 15% between duplicates. Group differences estimated by intercept-only linear

modelling. **RESULTS:** Pilots/aircrew had higher plasma levels of inflammatory mediators compared to controls, notably CCL2 (134.5 vs 124, 99% posterior probability [pp]) MPO ($19.6x10^3$ vs$16.3x10^3$, 92% pp) and TNF-a (6.4 vs 5.8, 87.2% pp). Conversely, CRP ($11.5x10^5$ vs $9.7x10^5$, 92% pp), and IL6R ($5.1x10^4$ vs $4.8x10^4$, 87% pp) were lower in pilots. TC stimulation elicited greater inflammatory reactivity in pilots vs controls, as TNF-a, IL-6, IL-1b, CCL-2 CCL-20, CCL8, IL-8 were all higher in response to LPS-stimulation. **CONCLUSIONS:** The distinct profile of peripheral immuno-inflammatory biomarker expression and reactivity suggests a link between WMH and inflammatory activation.

Learning Objectives

1. The audience will learn about the methods used to evaluate for dysfunctional central and peripheral immuno-inflammatory activation.
2. The audience will learn about a distinct profile of peripheral immuno-inflammatory biomarker expression and reactivity suggesting a link between WMH and inflammatory activation in a sample of RCAF fighter pilots and jumpers.

Monday, 05/22/2023 ***10:30 AM***
Napoleon Ballroom C1-C2

[S-07]: SLIDES: DO YOU REALLY WANT TO GO THAT HIGH? BAROTRAUMA & DCS

Chair: William Buck Dodson
Co-Chair: Bria Morse

[33] DECOMPRESSION SICKNESS RISK ASSOCIATED WITH REPEAT ALTITUDE EXPOSURE

Vivienne Lee[1], Desmond Connolly[2], Timothy D'Oyly[1], Thomas Smith[2]
[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*King's College London, London, United Kingdom*

(Original Research)

INTRODUCTION: In 2017, two Royal Air Force parachute jump instructors experienced symptoms of severe decompression sickness (DCS) whilst undertaking despatcher duties at 25,000 ft. This prompted more conservative altitude exposure limitations and denitrogenation requirements for high altitude parachuting. Despatchers' risk of DCS is greater than aircrew and parachutists due to greater physical activity during cabin decompression, but absolute risk is uncertain due to lack of representative research. This study investigated the risk to despatchers following the new procedures and explored the potential for safely conducting repeat exposures in a single duty period. **METHOD:** Fifteen men aged 20 to 50 yr, without 'right-to-left' vascular shunts, underwent repeat altitude chamber decompression breathing 100% oxygen. Phase 1 comprised two ascents to 25,000 ft, 1 hr followed by 1.5 hr, each with 1 hr denitrogenation at 15,000 ft. In Phase 2, an identical initial ascent was followed by two 1.5 hr ascents to 22,000 ft with 30 min denitrogenation at 15,000 ft. All ascents were separated by 1 hr breathing air at ground level. Participants undertook activities representative of parachutist despatchers throughout. Cardiac echocardiography was undertaken every 15 mins to monitor venous gas emboli (VGE) loads. Participants diagnosed with DCS were recompressed and did not proceed to further ascents of that phase. **RESULTS:** Four cases of DCS were diagnosed from 29 initial ascents to 25,000 ft. One participant was diagnosed with DCS during subsequent ascent to 25,000 ft. No DCS occurred at 22,000 ft. During initial exposures of both phases, the majority of participants produced heavy VGE loads, from multiple limbs, within 30 mins. Participants tended to exhibit lighter, and later, VGE loads during subsequent exposures. Older participants (>40 yr) were more likely to experience symptoms and early heavy VGE loads. **CONCLUSIONS:** Exposure to 25,000 ft for 1 hr, with exercise, presents a risk of DCS. DCS is more likely during an initial ascent to 25,000 ft compared to a second ascent occurring after about an hour. VGE loads tend to be reduced in subsequent ascents indicating carryover benefit of denitrogenation from prior ascents. Individuals over 40 yr are at greater risk of DCS.

Learning Objectives

1. The presentation will discuss the factors influencing risk of decompression sickness with repeated (same day) exposure to a provocative altitude. The audience should keep in mind the following: altitude; duration; exertion; denitrogenation; time spent breathing 100% oxygen; age; exposure interval.
2. The audience will be familiarised with the nature of venous gas emboli (VGE) loads with exertional decompression stress, emphasizing early onset, heavy and persistent bubble loads despite effective denitrogenation procedures.

[34] EARLY PATHOPHYSIOLOGICAL RESPONSES TO EXERTIONAL, NON-HYPOXIC, HYPOBARIC DECOMPRESSION STRESS

Desmond Connolly[1], Leigh Madden[2], Stephen Harridge[3], Victoria Edwards[1], Timothy D'Oyly[1], Vivienne Lee[1]
[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*University of Hull, Hull, United Kingdom;* [3]*King's College London, London, United Kingdom*

(Original Research)

INTRODUCTION: Consistent blood biomarkers of hypobaric decompression stress remain elusive. Laboratory investigation of decompression sickness (DCS) risk with repeat (same-day) exposure to 25,000 ft pressure altitude enabled investigation of pathophysiological responses to exertional decompression stress. **METHODS:** Fifteen healthy men, aged 20 to 50 yr, undertook two ascents to 25,000 ft, for 60 and 90 min, breathing 100% oxygen, each following an hour of denitrogenation. An hour separated the ascents, breathing air at 400 ft amsl. Venous blood was sampled pre-exposure (T0), after ascent two (T8) and next morning (T24). Besides whole blood hematology, endothelial microparticles (EMPs) were analyzed by flow cytometry, and selected proteins by enzyme-linked immunosorbent assay (ELISA). Targets included cytokines, markers of endothelial function, inflammation, coagulopathy, oxidative stress, brain insult, cortisol and creatine kinase. Blood/plasma volume shifts and diurnal variation were accounted for. **RESULTS:** Participants experienced heavy venous gas emboli (VGE) loads with three exposures curtailed due to limb bend DCS. Acute (T8) hematological effects on neutrophils (mean 72% increase), eosinophils (40% decrease), and monocytes (37% increase) normalized by T24. Mean five-fold elevation of interleukin-6 (IL-6) at T8 ($P<0.00001$) was pro-inflammatory (suppression of IL-10 and absent cortisol stress response). Complement system activation increased peptide C5a ($P<0.05$), and mean C-reactive protein (CRP) rose by 100% over baseline ($P<0.005$), supporting an acute phase response. Increased circulating total EMPs and tissue factor (TF) support endothelial dysfunction and oxidative stress influenced enzymatic and non-enzymatic markers. Glial fibrillary acidic protein (GFAP), a sensitive brain injury marker, increased 10% at T24 ($P=0.015$), and T8 serum levels of the neurotransmitter glutamate tended to rise ($P=0.078$). **DISCUSSION:** Pulmonary VGE loading appears to drive IL-6 release from neutrophils and/or endothelial cells, determining the magnitude of the acute phase response (CRP). Hematological responses and IL-6 normalized quickly but increased CRP, C5a, TF, total EMPs, GFAP and neutrophil gelatinase-associated lipocalin (indicating neutrophil activation) persisted, suggesting ongoing susceptibility to further decompression stress. The GFAP and glutamate data warrant concern; potential brain markers of decompression stress require further evaluation.

Learning Objectives

1. The presentation will outline the early blood biomarker responses to exertional decompression stress, emphasizing hematological, cytokine and acute phase (inflammatory) responses and suggesting a likely pulmonary basis for these in relation to oxidative stress and impact of venous gas emboli.

2. The time course of recovery from the innate immune response to altitude decompression stress will be discussed in relation to potential increased risk of decompression sickness with provocative altitude exposures on successive days.

[35] PHYSIOLOGICAL CEREBRAL ALTERATIONS UNDER HYPOBARIC/HYPOXIC EXPOSURE - A NEUROIMAGING EXCURSION

Sven Kühn[1], Hans Jürgen Noblé[2], Sven-Erik Kühn[3]
[1]*Bundeswehr Central Hospital Koblenz, Koblenz, Germany;* [2]*German Air Force Centre of Aerospace Medicine, Cologne, Germany;* [3]*Bundeswehr Hospital Hamburg, Hamburg, Germany*

(Education - Program/Process Review)

BACKGROUND: The physiological and pathophysiological adaptation of the brain at high altitude continue to be a matter of discussion. Understanding the mechanisms forms the crucial basis for preventive as well as therapeutic measures for affected groups suchs as high-altitude athletes and aeronautical professionals. This presentation will provide an overview of the current state of research and highlights the particular role of neuroimaging procedures. **OVERVIEW:** Hypoxia, and presumably to an unknown extent hypobaria, trigger a cascade of cerebrovascular mechanisms. Brain edema seems to play a key role. They are the result of significant vasodilation and are involved in the frequently accompanying headaches in high-altitude. Three different types of brain edema may develop, both overlapping and sequential: cytotoxic, ionic, and vasogenic. In addition, possible compression of smaller vessels of the white matter may be involved. Probably to varying degrees, there is a breakdown of the blood-brain barrier in later stages in some cases. At the latest with increasing intracranial pressures, the so-called glymphatic system is affected/will be impaired. Its exact role within this cascade remains unclear. There are already initial indicators of an involvement in the development of high-altitude cerebral edema. Accordingly, factors affecting the glymphatic system, such as sleep, are the focus of current research. Recent neuroimaging methods also contribute to the understanding of the background of this problem. **DISCUSSION:** Pathophysiological understanding of cerebral mechanisms under hypobaric and/or hypoxic exposure is essential. Physiological mechanisms that are not yet well understood, such as the glymphatic system and factors that influence it, could provide further insights. However, to fill the missing gaps in the cascade known so far, it is essential to fully exploit the possibilities of neuroimaging. This presentation is therefore of broad interest to clinicians and researchers who are interested in discussing the value and possibilities of neuroimaging in this particular field.

Learning Objectives

1. The audience will learn about the physiological mechanisms of the brain at high altitude.
2. The audience will be informed about the possibilities of neuroimaging to investigate these mechanisms.

[36] PREVALENCE OF BAROTRAUMA DURING HYPOBARIC CHAMBER TRAINING AT THE COLOMBIAN AIR FORCE, 2010-2020

Diego Leonel Malpica Hincapie[1], Laura Maria Pineda Jimenez[2], Maria Alejandra Correa Guarin[1], Sonia Jaimes[1], Gustavo Adolfo Celis Ceballos[1]
[1]*Colombian Air Force, Bogota, Colombia;* [2]*Universidad Nacional de Colombia, Bogota, Colombia*

(Original Research)

INTRODUCTION: The hypobaric chamber is a simulator of the physical and physiological phenomena that occur due to the decrease in barometric pressure. The present study aimed to investigate the frequency and recurrence rates of barotrauma during hypobaric chamber training in the Colombian Air Force from 2010 to 2020. **METHODS:** Retrospective observational study on aircrews undergoing hypobaric chamber training at the Directorate of Aerospace Medicine, who were diagnosed with middle ear barotrauma, oxygen aerotitis, paranasal sinus barotrauma, alternobaric vertigo and aerocolia by the Otorhinolaryngology and Aerospace Medicine service. **RESULTS:** 6,745 crewmembers underwent hypobaric chamber training, 257 cases were included in the study due to symptoms of barotrauma, mostly men 195 (75.87%), ages from 19 to 47 yr (median 29 yr) and from the military 247 (96.10%). Middle ear barotrauma occurred most frequently 232 (90.27%), followed by oxygen aerotitis 22 (8.56%). Regarding the grade of middle ear barotrauma, according to Teed's classification, the most frequent was grade 1 (77.15%), followed by grade 0 (19.39%), grade 3 (1.72%), grade 2 (0.86%), grade 4 (0.43%) and grade 5 (0.43%). The recurrence occurred in 42 events (16.34%), of which the majority were instructors. Total prevalence of barotrauma was 3.81% and, specifically, middle ear barotrauma prevalence was 3.43%. **DISCUSSION:** The prevalence of middle ear barotrauma during and after hypobaric chamber training is similar to what is reported in the literature, suggesting that a pre-chamber medical check including noninvasive methods such as questionnaires and physical examination, can help to identify subjects at risk.

Learning Objectives

1. The participants will be able to understand the frequency of barotrauma in the hypobaric chamber training located at 8300 ft asl in both students and instructors and compare it to what is found on published scientific research.
2. The audience will learn about the strategies for prevention of barotrauma among the aircrews when subjected to hypobaric chamber training in the Colombian Air Force.

[37] HYPOBARIA-INDUCED CHRONIC BEHAVIORAL CHANGES IN A FERRET MODEL OF COMBINED UNDER-VEHICLE BLAST AND CORTICAL IMPACT-INDUCED TRAUMATIC BRAIN INJURY

Molly Goodfellow[1], Boris Piskoun[1], Amanda Hrdlick[1], Julie Proctor[1], Ulrich Leiste[2], William Fourney[2], Catriona Miller[1], Gary Fiskum[1]
[1]*University of Maryland School of Medicine, Baltimore, MD, United States;* [2]*University of Maryland College Park, College Park, MD, United States*

(Original Research)

INTRODUCTION: Warfighters targeted by improvised explosive devices may incur a unique traumatic brain injury (TBI) caused by under-vehicle blast (UVB) with or without an accompanying impact injury. Rodent studies have shown that aeromedical evacuation (AE)-relevant hypobaria exposure within 72 hr of TBI exacerbates injury. While rodent studies are useful, translating findings to improved patient outcomes is challenging, perhaps due to the rodent lissencephalic brain. Thus, a UVB + impact TBI model was developed in ferrets, who possess human-like gyrencephalic brains. **METHODS:** The protocol was approved by the University of Maryland, Baltimore and the U.S. Air Force Surgeon General's Office of Research Oversight and Compliance; research was performed in compliance with DODI 3216.1. Male ferrets were secured to a metal plate "vehicle," exposed to UVB via detonation of pentaerythritol tetranitrate, and given a controlled cortical impact (BCCI). Twenty-four hours post-injury, animals underwent a 6-hr simulated AE equivalent to ambient pressures at 8000 ft (hypobaria; HB) or sea level (normobaria; NB). Mood (play behavior) and motor function (ladder walk) were assessed monthly in BCCI and naïve animals. Additional mood/motor function (open field) and memory (novel object recognition and object location) tests were employed once at six months post-injury. **RESULTS:** Increased open field thigmotaxis by BCCI animals suggests anxiety-like behavior, particularly in those exposed to HB. Perirhinal cortex-dependent and, perhaps, hippocampus-dependent memory may be impaired following BCCI+HB but not BCCI+NB. No significant play behavior differences were noted though repeated exposures to mood assays may decrease sensitivity.

Gross motor impairments may persist; however, injured animals do show improvement over time. Changes in histopathological and neuroimaging measurements persist to at least six months following BCCI and may be further exacerbated by HB exposure. **DISCUSSION:** Preliminary results indicate that ferrets have potential as a gyrencephalic TBI model. This project is ongoing and will, eventually, compare outcomes from animals exposed to 0-5 simulated flights. Results will inform the creation of guidelines for the safe transport of TBI patients. The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the DOD or of the USAF. Supported by USAF FA8650-20-2-6H20.

Learning Objectives

1. The audience will learn about the short and long-term effects of aeromedical evacuation-relevant hypobaria following traumatic brain injury.
2. The audience will learn about differences in brain anatomy between rats, ferrets, and humans and how these differences can affect outcomes following traumatic brain injury.

[38] A RE-EVALUATION OF THE ACUTE EFFECTS OF WEIGHTLESSNESS

Jay Buckey[1], Mimi Lan[2]
[1]*Geisel School of Medicine at Dartmouth, Lebanon, NH, United States;*
[2]*Thayer School of Engineering at Dartmouth, Hanover, NH, United States*

(Education - Tutorial/Review)

INTRODUCTION: A common analog for weightlessness is head-down tilt. The fluid shift produced when moving from supine to head-down tilt is believed to be similar to weightlessness where fluid moves headward from the loss of hydrostatic gradients. The move from supine to head-down tilt suppresses muscle sympathetic nerve activity (MSNA), reflecting a baroreflex-mediated response to the fluid shift. Peripheral resistance falls as a result of suppressed MSNA. We used numerical modeling and a literature review to determine if the same events occur with weightlessness. **METHODS:** The MSNA results of Iwase et al. were examined to assess the MSNA response to acute weightlessness during parabolic flight. A numerical model of the cardiovascular system that incorporates hydrostatic gradients and tissue weight effects was used to simulate possible primary effects of acute microgravity exposure on peripheral resistance. Multiple preflight body weights were simulated to study their impact. **RESULTS:** MSNA in the Iwase et al. study rose towards the end of the parabolas, rather than staying suppressed as happens with head down tilt. At the same time, blood pressure fell. Numerical modeling showed arterial and venous blood pressures falling in weightlessness because of reduced compressive forces on the vessels. Greater preflight body weight resulted in more dramatic decreases in inflight blood pressure. **DISCUSSION:** The acute effects of weightlessness and head-down tilt differ significantly. A possible explanation is that tissue weight likely effects the veins and arteries throughout the body by creating extravascular compression, and that the removal of this compression in weightlessness increases vascular compliance. This could produce a primary, weightlessness-induced reduction in peripheral resistance which remains reduced throughout a spaceflight and is associated with increased sympathetic nerve activity. Reductions in blood pressure seen with numerical modeling simulations support this explanation. This decreased peripheral resistance in weightlessness is not due to a baroreflex-mediated reduction in MSNA (similar to the cascade of events in head-down tilt). Instead, the reduced peripheral resistance may be a primary effect of weightlessness prompting by a baroreflex mediated increase in MSNA.

Learning Objectives

1. The audience will learn a different perspective on the acute effects of weightlessness.
2. The audience will learn about how the removal of tissue compressive forces is important in weightlessness.

Monday, 05/22/2023 ***10:30 AM***
Napoleon Ballroom D1-D2

[S-08]: PANEL: CHANGES IN MEDICAL STANDARDS & SYSTEM CAPABILITIES DRIVEN BY NEW AEROSPACE TRANSPORTATION TECHNOLOGIES

Chair: Melchor Antunano
Co-Chair: Ryan Mayes

PANEL OVERVIEW: *This is a panel session sponsored by the Aerospace Medicine Research Alignment and Collaboration (AMRAC) working group. The AMRAC was established to pursue R&D coordination and collaboration in aerospace medicine between the FAA, NASA, US Army, US Navy and USAF. In this panel, NASA will discuss advancing medical system design and risk-informed decision making for space exploration beyond low Earth orbit to promote human health and performance. The FAA will discuss the application of General Systems Performance Theory to quantitatively assess the adequacy of human performance given current health state when determining fitness for duty in current and emerging aerospace systems. The US Army will focus on the impact of the Army's future family of aircraft, "Future Vertical Lift," on Army aircrew performance, occupant protection, aeromedical standards, and system capabilities, based on the requirements driving the FVL acquisition program and anticipated available technologies in the 2030-2040 timeframe. The US Navy will focus on aeromedical and human performance challenges of new platforms in distributed maritime and expeditionary operations, including discussion of air crew safety and performance issues in F-35 B/C and patient movement in the new CMV-22 tiltrotor platform. The USAF will discuss future operations through two lenses: 1) The challenges of patient movement with decreased access and increased time and distance, and 2) Optimization and maintenance of human performance as operations evolve.*

[39] EFFECTS OF FUTURE ROTORCRAFT DESIGNS ON AVIATOR PERFORMANCE, AEROMEDICAL FITNESS STANDARDS, AND AVIATION MEDICINE

John Crowley
U.S. Army Aeromedical Research Lab, Fort Rucker, AL, United States

(Education - Program/Process Review)

BACKGROUND: The U.S. Army's Future Vertical Lift (FVL) program is developing a family of new aircraft with expanded mission and flight characteristics, featuring new technologies that will test the limits of human performance, and present new physical challenges to aircrew health and survival. The U.S. Army Aeromedical Research Laboratory (USAARL) is leading a comprehensive research program into the aeromedical challenges presented by the FVL family of aircraft. This presentation will highlight the platform and technology characteristics that are enhancing capability while urgently driving research leading to changes in selection criteria, training, and aviation operations. **OVERVIEW:** The expanded flight envelope of FVL aircraft will expose aircrew to hazards related to vibration and sustained acceleration that could affect future aircrew training and require aeromedical input to aircraft design specifications. Changes to the aircraft flight profile will demand redesign of aircraft crashworthiness systems critical to aircrew survival in the post-impact environment. Anticipated changes to mission duration and consequences of large-scale combat operations heighten concerns regarding acute and chronic aircrew fatigue. Ever-increasing complexity of evolving aircraft systems and tactics have raised concerns about aircrew workload that may exceed capabilities. The necessity of operating in a range of degraded visual environments (DVE) introduces new pilot-cueing technologies that will place new demands on aircrew senses and cognition. **DISCUSSION:** New fitness standards are already under development for FVL aircrew: 1) Visual displays with augmented/virtual

reality: Future displays featuring stereo imagery and/or symbology with overlaid environments require a relook at stereopsis requirements as well as research into susceptibility to, and countermeasures for, motion sickness variants (e.g., VR/AR/simulator sickness); 2) Spatial auditory displays: 3D (spatial) audio cues, while reducing workload, will require development of safe binaural hearing standards; and 3) Physiological monitoring: Real-time operator state monitoring systems, feeding into adaptive aircraft automation systems, will require a new look at waivered medical conditions and pharmacology, as these may interfere with necessary state detection algorithms. Ongoing research is aimed at ensuring an optimal match between future aircraft platforms and the Army aviator of tomorrow.

Learning Objectives

1. The audience will learn about the aeromedical challenges of future military rotorcraft.
2. The participant will be able to discern the potential effects of future aviation platforms on human performance, protection, and medical fitness standards.

[40] AEROSPACE MEDICINE IMPLICATIONS OF POTENTIAL FUTURE U.S. AIR FORCE OPERATIONS

Ryan Mayes[1], Tamara Averett-Brauer[2], Peter Baldwin[3], David Burch[2], Lidia Stana Ilcus[4], Maximilian Lee[1], Paul Nelson[1], Clifford Otte[2], Anthony Waldroup[1], Amy Hicks[1]

[1]*USAFSAM, Wright-Patterson AFB, OH, United States;* [2]*711th Human Performance Wing, Wright-Patterson AFB, OH, United States;* [3]*Air Force Futures and Concepts, Falls Church, VA, United States;* [4]*Office of the Air Force Surgeon General, Falls Church, VA, United States*

(Education - Program/Process Review)

BACKGROUND: As the United States Air Force (USAF) prepares for potential future conflicts, it has published several documents outlining what operations could look like in the near- and mid-future. In general, the USAF is preparing for potential peer or near-peer conflicts. Specifically, these plans address evolving concepts of operations in situations of denied access, loss of sanctuary, disrupted Command and Control and logistics, and adversary disregard for ethical constraints. **OVERVIEW:** The USAF provides aeromedical support to both Air Force and Space Force and will need to account for future operations of both services. As operations evolve, aerospace medicine considerations will change accordingly; this presentation will discuss those implications through two primary lenses. The first perspective will describe the challenges of patient movement with decreased access to wounded troops and with dramatic increases in the time and distance needed to move those patients. The second perspective will explore the need to maximize readiness, ensure effective human systems integration, and the optimization and sustainment of human performance in future operations. **DISCUSSION:** Future operations will drive significant changes to aerospace medicine in the USAF. Decreased access to combat zones would likely impact the ability to stabilize or restore patients in the field, and would create challenges in preparation for aeromedical evacuation. Once in flight, the time and distance to higher levels of care are likely to increase; when this factor is combined with patients who may be less ready for flight, USAF care in the air may need to evolve. From a human performance perspective, future operations may bring a complex mixture of multiple domains and varying levels of automation. This may change the physical requirements for combat, and is likely to increase cognitive demand on operators. Fatigue may be a significant factor as demand on operators may increase. Finally, medical readiness needs may change based on these operations.

Learning Objectives

1. Understand the aeromedical implications of potential future U.S. Air Force operations.
2. Understand differences in future requirements for patient movement vs. human performance.

[41] AEROMEDICAL CERTIFICATION USING GENERAL SYSTEMS PERFORMANCE THEORY

Thomas Van Dillen

FAA CAMI, Oklahoma City, OK, United States

(Education - Program/Process Review)

INTRODUCTION: The determination of medical fitness to fly requires ascertainment of the pilot's current level of morbidity and estimation of the adequacy of piloting performance given that morbidity level. In the vast majority of dispositions, this determination is primarily based on the application of standards and medical examiner expert opinion as a functional capacity assessment would require access to a flight simulator. **TOPIC:** Theory provides an overarching explanation of how and why one would expect potential factors to predict an outcome. General Systems Performance Theory (GSPT) is offered as a promising theoretical perspective for explaining how and why morbidity level will predict human performance. The critical step in using GSPT as the theoretical perspective for medical certification is to focus on the effect of morbidity on the availability of human performance resources. GSPT posits that any system, to include the human system, can be logically decomposed into a set of performance resources. A performance resource is defined as a functional unit with a corresponding dimension of performance. Each performance resource contributes to a multi-dimensional performance space. The human-system task interface is then defined by resource economics. A task imparts performance resource demands on the human. Human performance resource availability must exceed task resource demand for all involved resources for successful task performance. As a result, a threshold (non-linear) relationship exists between task performance and resource availability. A performance resource will be limiting up to a task-determined threshold value, and thereafter more of the resource will not necessarily result in improved task performance. This relationship is empirically defined in GSPT through nonlinear causal resource analysis. **APPLICATION:** A set of pilot performance resources with an associated resource availability measurement battery can be identified that is suitable for use in the medical examiner office setting. By empirically establishing peak piloting task resource demand from human in the loop simulation studies, pilot performance resource availability minimum thresholds can be empirically established for use in aeromedical decision making. This approach is extensible to both existing and anticipated aerospace systems and thus accommodates changes in the human role in systems.

Learning Objectives

1. The audience will appreciate that globally, aerospace medicine is faced with the following challenges that must be addressed in this decade including understanding how medical certification is implemented through a hyper-safe operating environment and evolving from rule based to performance based medical standards.
2. The audience will appreciate the basic General Systems Performance Theory Key Concepts as any system (to include the human system) can be logically decomposed into a set of performance resources and a dimension of performance is always defined so that more of a resource is better.

[42] ADVANCING EXPLORATION MEDICAL CAPABILITY THROUGH COORDINATED INTEGRATION OF RESEARCH, DEMONSTRATIONS AND SYSTEMS ENGINEERING

Jay Lemery, Kris Lehnhadrt, Ben Easter

NASA Exploration Medical Capabilities, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: NASA's Exploration Medical Capability focuses on clinical and scientific research, systems engineering and trade space analysis, and technology development and demonstrations—with goal of integrating progressively Earth-independent medical operations (EIMO) into future medical & vehicle systems for both Artemis & Mars.

OVERVIEW: Many facets are needed to optimize exploration medical systems, and the ExMC is endeavoring an unprecedented degree of research integration amongst ground development & testing; adoption of new approaches to medical protocols & procedures; deployment into analog environments; technology demonstrations on ISS, in lunar orbit, & on the lunar surface; and transition to operations for deep space exploration missions. **DISCUSSION:** The ExMC has a undertaken a three-pronged approach to promulgate a progressively Earth-independent medical research agenda through: answering key clinical and science research questions: applying systems engineering processes to medical system design to yield robust requirements for integration into future space exploration vehicle designs; developing and demonstrating novel medical technologies to improve future medical capabilities in space. ExMC has supported a diverse foundation to inform future EIMO work for long-duration missions. Successful examples include in situ analysis of blood and medical procedure support via AMOS (autonomous medical officer support) as well as enhancing onboard resource efficiencies via intravenous fluid generation and medical consumables tracking. The Element has yielded invaluable insights on pharmaceutical stability as well as assessments of pharmacodynamics and pharmacokinetics. Integrated data architecture and clinical decision support tools supported by ExMC have advanced the research agenda around numerous facets of autonomous medical systems. Its medical system model design work, linking concept of operations, NASA standards and medical conditions will inform medical system requirements to serve as a foundation for long duration mission requirements. Finally the IMPACT trade space analysis tool suite will allow for sophisticated, informed decision making by analyzing numerous medical and non-medical variables of long duration spaceflight. By highlighting the above work, this presentation will focus on scientific and technical conceptual drivers for the Element, the current and future research risks and gaps, future strategic direction of the Element.

Learning Objectives

1. Understand the strategy and rationale for advancing earth independent medical operations.
2. Understand the foundational work of the NASA Human Research Program ExMC Element.
3. Understand the future research challenges of Earth Independent Medical Operations [EIMO].

[43] AEROMEDICAL AND HUMAN PERFORMANCE CHALLENGES OF FUTURE US NAVY AND MARINE CORPS AIRCRAFT

Richard Arnold
Naval Medical Research Unit Dayton, Wright-Patterson AFB, OH, United States

(Original Research)

The U.S. Navy and Marine Corps are undergoing significant changes in several of their principal airframes that support key operational missions. The F-35 Lightning II will replace the Navy's F/A-18 family of carrier based tactical aircraft with the F-35 C, and the USMC is acquiring the F-35 B short takeoff and vertical landing (STOVL) variant. On the rotary wing front, although the US Army leads the DoD's future vertical lift (FVL) program, the Navy and Marine Corps have significant stakes in the program with likely replacements to existing rotary wing and tilt-rotor platforms to be selected via the FVL program. Lastly, the Navy has recently transitioned from the C-2 to the CMV-22 tilt-rotor for carrier onboard delivery (COD). The CMV will also be utilized for patient transport in the maritime domain. Aspects of these new platforms present new aeromedical and human performance challenges. This panel presentation will discuss recent, ongoing, and planned aeromedical, physiological, and human performance-related research that will inform aeromedical and human performance solutions to anticipated challenges posed by these new aircraft. For example, recent and ongoing research on the role of cognitive workload in contributing to pilot spatial disorientation can inform a better understanding of pilot performance in the information-rich cockpit of 5th generation fighters such as the F-35. The CMV-22 platform will extend the Navy's capabilities for patient transport in the maritime environment. However, long transport times in unpressurized aircraft presents novel challenges for patient transport in maritime operations. This panel presentation will discuss research findings and identified research gaps responsive to aeromedical and human performance challenges presented by these new airframes.

Learning Objectives

1. The audience will learn about research addressing pilot workload and situational awareness.
2. The audience will learn about emerging concepts and research on patient movement in maritime operations.

Monday, 05/22/2023 ***10:30 AM***
Napoleon C3

[S-09]: SLIDES: HUMAN PERFORMANCE UNDER AEROSPACE STRESS

Chair: Douglas Boyd
Co-Chair: Chuck DeJohn

[44] USING THE WHIPPET FACILITY TO MONITOR LINGERING EFFECTS OF MODERATE ALTITUDE EXPOSURE ON SIMULATED PRECISION FLIGHT CONTROL

Jeremy Beer[1], Bria Morse[1], Todd Dart[1], Paul Sherman[2]
[1]*KBR Science & Space, San Antonio, TX, United States;* [2]*U.S. Air Force 59th Medical Wing and USAFSAM, San Antonio, TX, United States*

(Original Research)

INTRODUCTION: The WHIPPET (Wayfinding, Hypoxia, and Interceptive Performance in Pilots Executing Transitions) simulation concept was evaluated to measure effects of moderate altitude exposure on visual vehicle control in a limited subject group. The facility combines visual flight simulation with an accurate cockpit model in a reconfigurable hypobaric chamber environment. Objectives were to detect subtle piloting deterioration and monitor physiological processes throughout exposure and recovery. **METHODS:** Seven subjects trained to perform precision instrument control (PICT) flight and unusual attitude recovery (UAR), and then completed chamber flights dedicated to the PICT and UAR respectively. Each flight comprised five epochs including ground level pressure (GLP), ascent through altitude plateaus at 3050m, 4270m, and 5338m, then post-exposure recovery. PICT performance was assessed using RMS-based flight simulator error (FSE) and time-out-of-bounds (TOOB). UARs were assessed using time to achieve level (RTT), initial response time (RTI) and time to first correct input (RTC). Physiological indices included SpO_2, heart rate (HR), end tidal O_2 and CO_2 pressures ($P_{et}O_2$, $P_{et}CO_2$), and respiration. Analysis comprised repeated-measures ANOVA using Epoch as the independent factor. The study was conducted in compliance with human subject protection regulations. **RESULTS:** Altitude influenced PICT performance; higher FSE was recorded at 5338m and Recovery than GLP, and TOOB was longer during Recovery. UAR effects were less clear; RTT and RTI responses accelerated during and after exposure respectively. Physiological altitude effects included elevated HR and ventilation, decreased S_pO_2, $P_{et}O_2$, $P_{et}CO_2$, and slowed respiration during Recovery. **DISCUSSION:** The concept evaluation was successful; subtle piloting impairment and physiological responses were detected during exposure. Lingering effects on certain metrics were monitored during recovery. Whereas S_pO_2 has been employed as an indicator of altitude effects, the precision piloting effects measured here are interpreted in a context of corollary physiological processes including respiration and hypocapnia. It is proposed that certain underlying compensatory mechanisms operate across a longer timeframe than post-exposure S_pO_2 recovery, which is typically rapid. Potential areas for future research

include implications and monitoring of effects on precision piloting during recovery.

Learning Objectives

1. The audience will understand the demonstration of a physical apparatus and empirical approach to assess effects of challenging conditions including hypobaric hypoxia on performance in a synthetic piloting task.
2. The audience will understand the monitoring of slight increases in piloting error and changes in physiology and respiration metrics during and after hypobaric exposure.

[45] MODERATE HYPOXIA IMPAIRS AND MODERATE EXERCISE PARADOXICALLY IMPROVES PERFORMANCE ON A VISUAL TRACKING TASK

LCDR Joseph Geeseman[1], Olivia Fox Cotton[2], Kim Prisk[3], Janelle Fine[3], Justin Morgan[2], Kevin Durkee[2], John Feeney[2]
[1]*U.S. Navy, Patuxent River, MD, United States;* [2]*Aptima, Inc, Dayton, OH, United States;* [3]*University of California-San Diego, San Diego, CA, United States*

(Original Research)

INTRODUCTION: Cognitive performance suffers under hypoxic conditions and visual tracking tasks can assess this. Personnel exposed to hypoxia are often required to perform some degree of exertion, potentially increasing the degree of impairment that results from hypoxia alone. In this study, participants performed a ball tracking task while exercising on a stationary bicycle breathing a normobaric or moderate hypoxic gas. **METHODS:** The tracking task, ran on a 13-inch tablet, manipulated ball speed, occlusion, and starting side to vary trial difficulty and measure performance degradation in response to imposed physiological stress. Subjects (n=7, 4 female, aged 18-38 yr) were exposed to normobaric normoxia and hypoxia (FIO2 0.21 and 0.125) and to a low to moderate level of exercise (5W, 50W). The mean pixel distance to target measure of performance (lower = better) was used in each trial. **RESULTS:** Hypoxia at low exercise reduced arterial O2 saturation (99.4±0.7 [mean±SD], 89.4±4.3, P<0.001, ANOVA), while moderate exercise did not lower normoxic SaO2 (99.5±0.6, P=0.97). Hypoxia + moderate exercise resulted in a SaO2 (88.0±5.7, P < 0.001). In all trials the best performance was with slow speed and no occlusion, (38.1±13.9) for low exercise normoxia compared to (85.0±26.0, P<0.001) for fast speeds and occlusion under the same condition. For the easiest trials (slow, no occlusion) there was no main effect of hypoxia (37.7±13.2 normoxia; 40.8±10.8 hypoxia, P=0.5) or of exercise (39.3±12.5 low exercise; 39.1±11.8 moderate exercise, P=0.9). For the hardest trials (fast, occluded) there was a main effect of hypoxia increasing mean distance (79.9±22.9 normoxia; 91.3±41.6; hypoxia P=0.0005) but a main effect of exercise level reducing mean distance (89.9±39.5 low exercise; 81.4±26.9 moderate exercise; P=0.009). **DISCUSSION:** Modest hypoxia impaired performance in more challenging trials, but not in easier trials. Modest exercise had minimal effect on the easier trial, but a paradoxical improvement in performance in challenging trials. The results suggest that the tablet-based task provides subjects a sensitive and graded degree of challenge. Why a modest level of exercise was associated with improved performance requires further investigation.

Learning Objectives

1. The audience will learn about the effects of hypoxic conditions and physical exertion on cognitive performance.
2. The audience will learn about physiological changes experienced during hypoxic conditions.

[46] SEX COMPARISONS OF PHYSIOLOGICAL AND COGNITIVE PERFORMANCE DURING HYPOXIC CHALLENGE

Kaila Vento[1], Cammi Borden[2], Caitlin O'Guin[3], Kara Blacker[1]
[1]*Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States;* [2]*Oak Ridge Institute of Science and Education, Wright-Patterson AFB, OH, United States;* [3]*Leidos, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: A poor understanding of potential sex differences on aeromedically relevant environmental stressors could lead to suboptimal performance, safety, and health guidelines. To illustrate, the threat of hypoxia and its possible contribution to recent unexplained physiological events are at the forefront of human performance research and operations. Yet, progress toward sensor development and improving hypoxia training are stunted due to limited knowledge of how individual characteristics, including sex, potentially underlie hypoxia symptoms and performance impairment. Therefore, we retrospectively investigated whether sex was a predictor of physiological and cognitive performance during hypoxic challenge. **METHOD:** N=116 (male, n=78; female, n=38) participant datasets were combined from 6 previous experimental hypoxia studies. Separate stepwise linear regression models analyzed the independent variables (i.e., Model 1= sex, age, and BMI; Model 2= altitude and exposure minutes) on the dependent variables (i.e., SpO_2, heart rate, neural modulation, cognitive performance, hypoxia-related symptom frequency). Additional binary (yes/no response) logistical regression models analyzed the above independent variables on each hypoxia-related symptom. The NAMRU-D's Institutional Review Board approved all 6 previous hypoxia studies. **RESULTS:** Female sex predicted lower SpO_2 (p<.001), though in combination with age and BMI alone, explained only 6% of the variance. Female participants were 3.33 times more likely to report a headache (P=0.02), during hypoxia. Age significantly predicted decreased heart rate and was associated with increased reports of hot flashes, headaches, and fatigue, all P<0.05. Expectedly, increased altitude significantly predicted lower SpO_2, higher hypoxia-related symptom frequency scores, and increased reports of several individual symptoms, all P<0.05. The neural modulation and cognitive performance models did not converge, suggesting high intra-individual variability. **DISCUSSION:** The current study found that sex, age, and BMI were not the most robust predictors in responses to hypoxic challenge. The knowledge gained will help to refine hypoxia familiarization training, enhance the precision of monitoring sensor development, and update emergency response and recovery protocols in the event of a hypoxia occurrence suitable for all aircrew.

Learning Objectives

1. Address any potential sex-specific disparities in aeromedically relevant environmental stressors.
2. Understand the physiological and cognitive repercussions during hypoxic challenge between sexes.

[47] HEART RATE VARIABILITY AS AN OBJECTIVE MEASURE FOR LOW BACK DISCOMFORT: A POTENTIAL METHOD FOR EVALUATING AIRCREW SEATING ENDURANCE

Peter Le
Air Force Research Laboratory, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Non-neutral seating postures commonly seen in military aviation are associated with low back pain (LBP) and subsequent reports of fatigue and distraction. However, given the variability and hesitance of subjective discomfort reporting among aviators, an objective measurement is needed to understand discomfort and its impact on aircrew seating endurance. Recent work in the physical ergonomics literature employed heart rate variability (HRV) as an approach to investigate whole-body discomfort. Variation between the R-R peaks represent the fluctuation between sympathetic and parasympathetic responses. Within the frequency domain, an increased low-frequency to high-frequency ratio (LFHF) has been associated with increased physical discomfort. The aim of this study was to evaluate physiologic discomfort through HRV during prolonged seating in a non-neutral posture with an axial load. This is a subset of a larger study investigating low back fatigue and trunk stability. **METHODS:** Twenty participants (10M, 10F) sat for three continuous hours in a simulated helicopter seat while wearing a 20lb weighted vest to simulate aviator equipment. Heart rate data were

collected and variability between R-R peaks were assessed in 30-minute epochs in the frequency domain. Stepwise logistic regression was used to evaluate anthropometry, time, and LFHF associations with subjective reports of low back discomfort. **RESULTS:** Statistically significant (α=0.05) differences were seen over time in the LFHF ratio (p=.0341) with the lowest value occurring in the first 30-minute time block. Logistic regression showed an association between time, the LFHF ratio, and anthropometry in predicting low back discomfort (p<.0001). **DISCUSSION:** The LFHF ratio increased over time and followed the same trend as reported low back discomfort. Through logistic regression, anthropometric variables (sex, age, shoulder width, sternum depth, head width) alongside the LFHF ratio and time were able to predict low back discomfort. These findings are in agreement with published work investigating anthropometric associations with physiologic measures in predicting discomfort for automotive seat design. Collectively, these results suggest a need for quantifying discomfort through the interaction of physiologic measures and individual differences. Quantifying and understanding these changes may provide insights into aircrew seating endurance and methods to qualify future aircraft seat designs.

Learning Objectives

1. The audience will learn how heart rate variability may be used to investigate discomfort during low-level physical loading.
2. The audience will learn how discomfort/seating endurance is multifactorial through the interaction of anthropometry and physiological measures.

[48] INITIAL TRIAL TO INVESTIGATE THE FEASIBILITY AND FIDELITY OF THE ROYAL CANADIAN AIR FORCE AIRCREW CONDITIONING PROGRAM

Erin Smith[1], Reilly Tara[2], James Anderson[3], Andrea Bowman[4], Kelly Debouter[5], Thomas Karakolis[6], Tyler Kung[2], Kathleen Schmit[7], Alyssa Sims[8]

[1]*Canadian Forces Environmental Medicine Establishment, Toronto, ONT, Canada;* [2]*Canadian Forces Morale & Welfare Services, Ottawa, ONT, Canada;* [3]*Canadian Forces Morale & Welfare Services, Moose Jaw, Saskatchewan, Canada;* [4]*Canadian Armed Forces, Comox, British Colombia, Canada;* [5]*Canadian Armed Forces, Ottawa, ONT, Canada;* [6]*DRDC, Toronto, ONT, Canada;* [7]*Canadian Armed Forces, Shilo, Manitoba, Canada;* [8]*Canadian Forces Morale & Welfare Services, Edmonton, Alberta, Canada*

(Original Research)

INTRODUCTION: More than 90% of RCAF aircrew report significant flight-related neck pain (Smith, 2021). One solution is strength and conditioning programs (Ang, 2009; Salmon, 2011). As recommended by the NATO HFM RTG 252 (Farrell, 2020) and demonstrated by the RAF and RAAF, the Aircrew Conditioning Program (ACP) effectively reduces/prevents neck injury, reduces time away from flying and improves performance (Slungaard, 2018; Slungaard, 2019; Wallace, 2019). With direction from CFEME, the RCAF adopted a modified ACP at 408 Squadron and 2 Canadian Forces Flying Training School (CFFTS). Implementation required a dedicated Physical Exercise Specialist (PES) and commitment from RCAF leadership to mandate that all aircrew complete a minimum of two RCAF ACP training sessions per week. **METHODS:** Evaluation included objective (physiotherapy, fitness assessments) and subjective (surveys) metrics to determine (1) effectiveness, and (2) feasibility to implement a similar program across the RCAF. Metrics were collected at baseline and 3,6,12 month intervals. Effectiveness was determined by physical testing and survey responses. Program feasibility was assessed via:(1) resource utilization and CAF personnel availability, (2) compliance, and (3) evolutions to the program. **RESULTS:** From baseline to 3-months, 408 Sqn aircrew improved deep neck flexor endurance by 26.4s, but decreased by 17.1s from 3 to 6-months. At 2 CFFTS, DNF improved from baseline to 3-months by 28.4s and 44.6s (Group 1&2), and improved from 3-6 months by 22.1s and 11.71s (Group 1 & 2). At 408 Sqn, compliance was 56% in week 1, 5% in week 12 and <5% in week 24. At 2 CFFTS, compliance in Groups 1&2 was 94% and 92% in week 1, 47% and 79% in week 12 and 33% and 71% in week 24, respectively. **DISCUSSION:** Objective testing suggests that the RCAF ACP is effective after 12 weeks of training. However, effectiveness is reliant on compliance. Low compliance prevented program progression at 408 Squadron. The structured environment at 2 CFFTS facilitated better attendance/compliance. Challenges included scheduling, limited ability to progress and the perceived risk of injury/grounding. Future work must include additional efforts to identify/remove barriers, maximizing participation. While awaiting implementation of the RCAF ACP at other bases, all aircrew are encouraged to follow a conditioning program which focuses on total body/core fitness, and supervised isometric neck-specific exercises.

Learning Objectives

1. The audience will learn about the development of the RCAF ACP and initial trial implementation of this program at two RCAF flying units.
2. The audience will learn about the results of the initial trial of the RCAF ACP, the effectiveness and feasibility of the program and future proposed work.

[49] HYDRATION, BLADDER RELIEF, & HUMAN PERFORMANCE IN MILITARY AVIATION

Kelly VandenBossche, Mark Harvie, Billie Flynn

Omni Defense Technologies, Colchester, VT, United States

(Education - Program/Process Review)

BACKGROUND. Maintaining peak performance requires the ingestion of fluids before, during, and after activity. With adequate fluid intake, the human body produces approximately 50 to 100mL of urine/hour. Because of the limitations of most available bladder relief systems (BRS) for voiding urine produced, military aviators often avoid taking in enough fluids, leading to dehydration, suboptimal cognitive and physical performance, and potentially grounding health issues. The majority of available BRS are cumbersome and decrease safety during use. In the US Air Force (USAF) alone, there have been at least 10 class 'A' mishaps that were attributed, at least in part, to fumbling with piddle packs. In 2001, USAF recognized this capability gap and wrote the first Small Business Innovative Research grant for development of a state-of-the-art BRS. Since then, BRS's have been continuously improved through extensive research, development, test and evaluation efforts. **OVERVIEW.** Thirty USAF pilots and aircrew who flew in ejection seat aircraft participated in 3rd generation developmental test (DT). After each test phase, findings and recommendations from the debrief were integrated into the design for the subsequent phases, following a 'fly-fix-fly' process. Upon completion of DT, the BRS was tested in the flight environment resulting in 'Safe To Fly' approval. **DISCUSSION.** The outcome is a BRS that's hands-free, eyes-free, and automatic, meeting the stringent requirements of military aviators and the harsh aviation environment. It increases safety in military flight operations, and allows aviators to hydrate rather than avoiding fluid intake, or "tactically dehydrating." By maintaining normal body water levels, the aviator doesn't experience the physical and cognitive performance degradations that are brought on by dehydration. Although operating tactical jet aircraft is a well-known example of an occupation that makes bladder relief difficult and hazardous, multi-piloted aircraft – especially those with mixed gender crew; firefighters; and CBRN Response enterprise are occupations that will also benefit from trouble-free BRS. More importantly, individuals will be able to maintain high physical and cognitive readiness through proper hydration. This presentation will discuss the latest research efforts and will also delve into the effects of dehydration on performance, hydration recommendations, and available BRS for military aviators.

Learning Objectives

1. The audience will understand the physiological effects of dehydration on physical and cognitive performance, especially as it relates to military aviation.
2. The audience will understand the relationship of fluid intake to human performance and will learn what are the current fluid intake recommendations to prevent dehydration.

3. The audience will learn about the research, development, test, and evaluation efforts for bladder relief systems as well as the current options available for in-aircraft bladder relief.

Monday, 05/22/2023 ***10:30 AM***
Nottoway & Oak Alley

[S-10]: SLIDES: MENTAL HEALTH & CERTIFICATION

Chair: Anthony Wagstaff

[50] A PROPOSED RESEARCH FRAMEWORK TO STUDY AEROMEDICAL CERTIFICATION OF PILOTS WITH A MENTAL HEALTH CONDITION.

William Hoffman[1], Anthony Tvaryanas[2]
[1]*Brooke Army Medical Center, Fort Sam Houston, TX, United States;*
[2]*FAA CAMI, Oklahoma City, OK, United States*

(Education - Program/Process Review)

BACKGROUND: U.S. pilots are required to disclose symptoms of, a diagnosis or treatment for a mental health condition during screening conducted as part of periodic aeromedical examinations due to safety concerns for incapacitation or degraded performance in flight. But while mental health symptoms are common in pilots, evolving data suggest many pilots avoid healthcare and/or withhold information during aeromedical screening due to fear for aeromedical certificate loss. This phenomenon is proposed to result in negative consequences to the pilot, prompting stakeholders to call for an alternative approach to aeromedical certification related to mental health. Data to guide a change in policy are lacking and an organized research framework is necessary. **OVERVIEW:** We propose a theoretical framework to guide research efforts related to aeromedical certification of pilots with a mental health condition. It is hypothesized that a certain burden of mental health symptoms results in a negative impact to pilot performance, but this clinical point is undefined. Using principles of population health, the framework includes the proposed distribution of mental health symptoms in the population of pilots. It also identifies the following points: (1) the burden of mental health symptoms that results in a negative impact to performance (aeromedically significant disease), (2) the proportion of pilots identified with a mental health condition using current aeromedical screening practices, and (3) the ideal proportion of pilots identified with a mental health condition using future, yet undefined, aeromedical screening practices. **DISCUSSION:** Stakeholders are calling for an alternative approach to aeromedical certification related to mental health and we present a theoretical research framework to study this complex clinical, regulatory and safety question. The model is complimentary to and augments existing Safety Management System (SMS) programs (Federal Aviation Administration (FAA) Order 8000.369) by adding a population health consideration to current safety models. Benefits of such a model include (1) guiding a multi-institutional research agenda, (2) promoting a shared use of terms, and (3) facilitating communication of clinical and safety research questions with stakeholders.

Learning Objectives

1. Identify current aeromedical screening objectives related to mental health and the subsequent impact to pilot healthcare seeking behavior.
2. Identify the following points in the proposed research framework: (1) distribution of mental health symptoms in the population, (2) the burden of mental health symptoms that results in a negative impact to performance, (3) the proportion of pilots identified with a mental health condition using current and future screening practices.
3. Identify how the proposed research framework might support (1) guiding a multi-institutional research agenda, (2) promoting a shared use of terms, and (3) facilitating communication of clinical and safety research questions with stakeholders.

[51] CASE REPORT – CAN A DIAGNOSED WITH AUTISM WITH AUTISM SPECTRUM DISORDER BECOME AN AIRLINE PILOT?

Eran Schenker
Civil Aviation Authority Israel, Tel Aviv, Israel

(Original Research)

METHODS: A 21-year-old male has applied for a medical certificate as part of his desire to become an airline pilot. The AME explained to the candidate that it would be difficult to diagnose if his social and communication limitations were barriers to getting the wings he had been dreaming of for many years. However, the AME decided to request a medical waiver from the flight surgeon at the Civil Aviation Authority in Israel (CAAI). **RESULTS:** After a comprehensive set of psychologist assessments, the candidate has been approved for a medical certificate with a medical waiver as the first step to embark on an aviation career. **DISCUSSION:** The CAAI, like the FAA, identifies several disqualifying medical conditions, including several psychological ones. Autism spectrum disorders aren't listed as such. The knowledge, skills, and experience requirements for completing training and licensure are all performance-based. Log the hours, pass the tests, and you're a pilot. Since Some believe that flying an airplane is substantially about rote procedures and cut-and-dry technical knowledge, many individuals on the spectrum probably may pull it off. But is it safe? Asperger syndrome is an autistic spectrum disorder characterized by impaired social interaction and restricted, repetitive, and stereotyped behavior patterns. The DSM-5 diagnostic criteria also include significant impairment in social or occupational functioning. Nevertheless, if language skills and cognitive development are not impaired and someone diagnosed with Asperger's syndrome may be able to acquire the skills necessary to function safely as a pilot or air traffic controller. Interpersonal difficulties may arise or emerge in the Crew Resource Management environment of the modern professional airline cockpit.

Learning Objectives

1. The audience will learn about the FAA guide on disqualifying medical conditions, including several psychological ones which Autism spectrum disorders aren't listed as such.
2. The audience will learn about Autism and flying. Autism has been significantly redefined in recent years to where there is no real definition anymore.
3. The audience will learn how to establish the correct assessments to declare if an Autism Spectrum Disorder aviator candidate passes the medical ANE exam.

[52] FAA SSRI PROGRAM: A WIN-WIN FOR PILOT MENTAL HEALTH AND FLYING CAREERS

Christopher Flynn
FAA, Washington, DC, United States

(Original Research)

INTRODUCTION: Since May 2010, the FAA has approved the use of four Selective Serotonin Reuptake Inhibitors (SSRI) medications for aviator psychiatric treatment and medical certification. Data are presented on aviators who are successfully in treatment and flying in the FAA SSRI Special Issuance (SSRI-SI) program. **METHODS:** Basic mental health information for every SSRI-SI aviator is reviewed annually by an FAA psychiatrist. Between October 2019 and August 2022, diagnostic information and renewal status was captured on 501 SI airmen. In a convenience sample of 150 aviators: psychiatric history, medical classification, age, antidepressant years of use, and flying hours were reviewed. **RESULTS:** Overall, 474 (95%) of 501 aviators continued their SI without interruption, while 27 (5%) had their SI stopped due to worsening symptoms, lack of regulatory compliance or change in medication use. Of the 27 with an interrupted SI, 9 returned to flying: a total of 483 aviators (96%). SI aviators with complex psychiatric histories were able

to participate: 299 (60%) had 1, 167 (33%) had 2 and 45 (9%) had 3 or more psychiatric conditions. In SI aviators: 322 (64%) had Anxiety, 287 (60%) had Mood, 71 (14%) had CFR Substance conditions and 85 (17%) had Other Disorders. In a sub-group of 150 SI aviators, 32 (21%) had combined use of 2+ psychiatric medications, 11 (7%) had past suicidal ideation, 8 (5%) had past psychiatric hospitalization, 5 (3%) had an unsubstantiated history of bipolar illness, 4 (3%) had combined use of 2+ antidepressants. Continuous antidepressant use was 8.8 years (SD, +/− 5.8 years), and 48 (32%) were taking an antidepressant before the FAA SSRI-SI program began in May 2010. **DISCUSSION:** Aviators may develop mental disorders that require psychiatric treatment, including medications. Since May 2010, the FAA has returned aviators with a wide range of diagnoses and psychiatric histories (including intensive treatment) to flying, when they met policy and health requirements – and it was safe to do so. Of 501 current SSRI-SI aviators, 96% were successfully flying during this 34 months period. The FAA SSRI-SI program succeeds at encouraging aviators to receive psychiatric treatment while continuing their flying career.

Learning Objectives

1. The participant will be able to reflect the substantial benefit for pilots who seek mental health treatment on their ability to maintain their careers.
2. The participant will be able to express that pilots with a wide range of mental health diagnoses were successfully flying in the FAA SSRI program.
3. The participant will be able to identify that there was a 96% success rate for pilots to continue flying during this 34-month period.

[53] A PERFORMANCE-CENTERD MENTAL HEALTH AND WELLBEING CURRICULUM FOR COLLEGIATE STUDENT PILOTS.

Reyné O'Shaughnessy

Duquesne University, Pittsburgh, PA, United States; Brown University, Providence, RI, United States; University of California-Berkeley, Berkeley, CA, United States; Functional Medicine Academy, Pittsburgh, PA, United States

(Education - Program/Process Review)

BACKGROUND: Aircraft pilots function in highly complex, safety-critical environments that demand high cognitive and physical performance This requires pilots to maintain adequate physical and mental wellbeing. The importance of wellbeing in aviation is growing due to (1) evolving data demonstrating its role in performance, (2) increasing relevance following the effects of the SARS-CoV-2 pandemic on wellbeing and mental health, and (3) factors such as pilot burnout and lower retention rates. However, while the importance of aviator wellbeing is becoming increasingly clear, many collegiate aviation training programs lack formal wellbeing and mental health curriculum, i.e. non-technical skills (NTS). **OVERVIEW:** To fill this gap, we have proposed a performance-centered mental health and wellbeing curriculum catering to collegiate student pilots. The curriculum includes four virtual modules designed to complement an established technical flight training program: (1) fundamentals of sleep, (2) nutrition for wellness and performance (3) exercise science for aviators, and (4) mindfulness tailored for aviators. The relevance of such a program was demonstrated through survey results from collegiate students where ninety-four percent of students indicating that mental health and wellbeing training can positively address their general health and wellbeing. **DISCUSSION:** The importance of wellbeing in aviators is becoming increasingly clear. The aim is to provide student pilots with critical tools to build and maintain their wellbeing throughout their aviation career. It is hypothesized that building wellbeing skills can build safety and positively improve operational safety and efficiency by expanding the skill sets of pilots. NTS training supports the operational safety and efficiency of civilian, international, and military aviation spheres. Within military spheres, it has been suggested that NTS training can improve individual and team combat skills. Within the civilian and international sphere, NTS training may boost safety and performance in unexpected situations through improved teamwork and communication. Future research questions could include the impact of curriculum on (1) performance outcomes, (2) airline costs savings due to burnout, and (3) improved physical and mental health.

Learning Objectives

1. The audience will learn about a curriculum that complements the technical side of a traditional aviation training program.
2. The audience will learn the four critical tools (NTS) of health in order to build and maintain wellbeing.
3. The audience will learn about why we sleep and why it is the bedrock to health.

[54] HOW DOES A SUCCESSFUL AIRLINE-BASED ALCOHOL AND OTHER DRUG REHABILITATION PROGRAM EFFECTIVELY PROMOTE RECOVERY IN WORKERS WITH SUBSTANCE ABUSE ISSUES

Julia Myers[1], Ben Johnston[2], Giles Newton-Howes[1], Elliot Bell[1], Jessica Nairn[3]

[1]*University of Otago, Wellington, New Zealand;* [2]*Air New Zealand, Auckland, New Zealand;* [3]*Capital Coast and Hutt Valley District, Te Whatu Ora Health New Zealand, Wellington, New Zealand*

(Original Research)

INTRODUCTION: Limited published evidence suggests alcohol and other drug (AOD) rehabilitation programs specific to professional groups such as pilots and doctors achieve high success rates compared to standard programs. The reasons for this are unclear. This research focused on gaining an in-depth understanding of how a workplace AOD program effectively facilitates individuals with substance abuse issues to achieve and maintain recovery, based on the perspectives and experiences of those who have engaged with a successful airline-based AOD program. **METHOD:** During 2022, eight current airline employees in recovery, and six doctors currently or formerly associated with the airline medical unit, were interviewed in-depth. A qualitative grounded theory approach was used to conceptualize and develop an explanatory model of how an airline-based program effectively promotes recovery for workers with diagnosed substance abuse disorders. **RESULTS:** Themes developed from the interview data illustrate how the characteristics of individuals, programs, and workplace culture, play crucial and interconnected roles in supporting recovery. The individuals in recovery possess high internal motivation to return to work; they have invested in a career they love and see it as a key part of their identity. Already familiar with an employment structure contingent on the need to undergo regular evaluations to demonstrate their fitness to work, they are kept "on track" by a balance of motivators (carrots) and consequences (sticks) through both soft and hard mandates. Key aspects of the program include early and accessible specialist input and a strong emphasis on facilitating involvement with peer networks. Culturally, the workplace is seen as providing an optimal environment within which recovery succeeds, combining the aviation-specific emphasis on safety with a "just culture" focused on doing the right thing. Crucially, buy-in from the company is tangible, making those in recovery feel valued, and facilitating the development of mutual respect and trust between workers, management, medical staff, and the regulator. **DISCUSSION:** These study findings assist in understanding how airlines can effectively support workers requiring AOD rehabilitation and point to the overarching importance of company culture. Programs based on these principles can increase aviation safety and also make good business sense.

Learning Objectives

1. The audience will understand how company culture can effectively support airline-based workers diagnosed with substance abuse disorders to successfully achieve and maintain recovery.
2. The audience will understand how interconnected features of the individual workers, program makeup and company culture impact on the success of an airline-based AOD rehabilitation program.

[55] WHEN EATING BREAD BEFORE FLIGHT CAN BE A PROBLEM

Sarita Dara, Tim Sprott, Claude Preitner
Civil Aviation Authority of New Zealand, Wellington, New Zealand

(Education - Case Study)

INTRODUCTION: Consumption of poppy seed (PS) containing products can result in opiate-positive urine drug screen (UDS) results and pose challenges in distinguishing PS consumption from opiate administration. A preflight nonnegative UDS has serious implications from an aviation medical certification perspective. **BACKGROUND:** This case discusses approach to assessment of an aircrew with opiate positive UDS. The aircrew claimed that PS containing bread that was consumed preflight, explained the non-negative UDS. Studies analyzing opium alkaloids in PS suggest that there is huge variation in morphine and codeine levels between the same batch and between sources of PS. Variation in alkaloid levels is attributed to many factors: season, harvesting and thermal processing. Grinding and baking of PS can reduce morphine content by 50 - 80%. General guidance for interpretation of UDS is that codeine concentration >300 ug/L coupled with a morphine to codeine ratios of <2 are generally indicative of codeine consumption. In recent times, there are reports of individuals who produced codeine-positive and morphine negative UDS, and who denied codeine use, attributing their test results to the consumption of PS containing food. Specific marker for PS ingestion is Thebaine, which can be tested and reported by the laboratory. **CASE PRESENTATION:** A 25-year-old aircrew returned a non-negative UDS test for codeine, as part of a random preflight check. The results were the same on a repeat UDS. He was stood down from flying. UDS results were confirmed by mass spectroscopy with codeine positive above cut off levels of 300ug/L and morphine was not detected. Aircrew denied taking codeine containing medications or substances but attributed the non-negative test result to consumption of PS bread prior to reporting for flight. Aircrew stopped taking the bread and repeated the UDS a few days later and this was negative for opiates. Further detailed analysis was done of the initial urine samples and these showed high levels of codeine (1000ug/L -2500ug/L) with non-detectable morphine (<300ug/L). The reanalysis also detected thebaine in both the urine samples, which is an opium alkaloid specifically found in poppy seeds. Further UDS test done a few weeks later was negative. **DISCUSSION:** This presentation will highlight the approach to interpretation of UDS result and draws on the best available evidence to determine aeromedical disposal of an atypical non-negative UDS in an aircrew.

Learning Objectives

1. The audience will learn about the approach to interpretation and analysis to opiate positive urine drug screen (UDS) in an aircrew.
2. The participant will be able to understand the various factors that need to be considered when presented with an atypical UDS screen.
3. The audience will learn about the current evidence about interpretation of opiate positive UDS and claims related to poppy seed consumption.

Monday, 05/22/2023 ***2:00 PM***
Grand Ballroom A-B-C

[S-11]: SLIDES: THERE'S AN APP FOR THAT... MEDICAL DEVICES IN SPACE

Chair: Ben Easter
Co-Chair: Samantha King

[56] OPTIMAL FORMULATION FOR AN INFLIGHT ULTRA-COMPACT URINARY CALCIUM MEASUREMENT DEVICE

Mimi Lan[1], Darin Knaus[2], Clive Devoy[2], Kate Fergusson[2], Scott Phillips[2], Jay Buckey[3]
[1]*Thayer School of Engineering at Dartmouth, Hanover, NH, United States;* [2]*Creare LLC, Hanover, NH, United States;* [3]*Geisel School of Medicine at Dartmouth, Lebanon, NH, United States*

(Original Research)

INTRODUCTION: Spaceflight bone loss and kidney stone prevention programs are currently assessed postflight for effectiveness. Inflightassessment would enable a preventative approach, where countermeasures could be adjusted and individualized for each astronaut. Urinary calcium levels increase dramatically in space making them good potential markers for bone loss and kidney stone risk. Calcium concentrations from the Skylab mission increased 2-to-4-fold relative to preflight baselines. Clinically, 24-hour urine collections are typically used to assess urinary calcium excretion, but calcium concentration measurements taken from only the first void of the day can provide similar information. Using spot measurements, rather than 24-hour collections, could provide actionable operational information with minimal crew time, power, and stowage. **METHODS:** We developed a small, handheld device that measures urinary calcium concentration fluorometrically using the marker calcein. Calcium binds with calcein to form a fluorescing complex. The magnitude of the fluorescence signal is proportional to the calcium concentration. The first generation assay we developed uses an compact disposable: a small capillary tube (optrode) with a fixed amount of calcein reagent coated onto the interior wall. Urine is drawn into the capillary tube which is then inserted into a compact handheld fluorimeter to measure urinary calcium concentration. Testing of our initial optrode design showed a narrow linear range (a dynamic range of 2). A wider dynamic range would reduce or eliminate the need to dilute samples to a concentration that fits within the readable linear range, and this improvement would simplify inflight sample preparation procedures. We have tested variations on the recipe to see what formulations improve the dynamic range. Testing explored the inclusion or exclusion of potassium-citrate and the use of KOH or NaOH as the buffering ingredient. **RESULTS:** The results favor the recipe using KOH with potassium citrate. This formulation has a dynamic range of 4, which is higher than the other formulations. NaOH without potassium citrate had a dynamic range of 2, KaOH without potassium citrate had a dynamic range of 2, and KaOH with potassium citrate had a dynamic range of 1.5. **DISCUSSION:** The inclusion of potassium citrate may have prevented precipitation of calcium from out of solution, leading to better results.

Learning Objectives

1. The audience will learn about serial first morning void sampling rather than 24-hour urine collection as a more operationally compatible method to analyze urine samples in spaceflight.
2. The audience will learn about a compact device that can enable inflight monitoring of bone loss and kidney stone risk for astronauts by spot checking urine calcium concentrations.

[57] FLYING DUXS: DIAGNOSTIC ULTRAPORTABLE X-RAY FOR SPACE

Sheyna Gifford[1], David Lerner[2]
[1]*Washington University-St. Louis, St. Louis, MO, United States;* [2]*University of Washington, Seattle, WA, United States*

(Original Research)

INTRODUCTION**:** The only diagnostic imaging modality routinely available in microgravity is ultrasound. Prior attempts to expand imaging modalities, including the Diagnostic Radiographic Imaging System (DRIS), were unable to provide a risk-to-benefit profile supportive of deploying medical X-Ray systems in space. In this presentation, we describe how the barriers of launch mass and operational complexity were overcome using newer, ultraportable digital technology to perform the first high-quality human X-Rays in microgravity. **METHODS:** A commercial, off the shelf (COTS), ultraportable (total mass 10.3 kg), digital X-Ray system was flown on a parabolic flight through a series of microgravity intervals. Two flyers, an X-Ray technician and a physician, achieved image stability during 20-30 second microgravity intervals by utilizing a combination of positioning (seated, belted, foot- and handholds), a harness-based mounting system, and short exposure times at 90 kVp. In the first parabolic arch, images of a line phantom were taken to establish baseline image quality. Images taken during subsequent parabolas including real anatomical locations of interest to diagnoses listed in the Integrated Medical Model and the

IMPACT condition list. **RESULTS:** Review of the line phantom for spatial and contrast resolution revealed imaging capabilities in microgravity that were equal to stationary imaging systems on Earth at 1 gravity. These were considered diagnostic images qualitatively by a panel of fellowship trained radiologists. The human radiographic images were also considered diagnostic images qualitatively by a panel of fellowship trained radiologists. **DISCUSSION:** Diagnostic Ultra-portable X-Ray for Space (DUXS) experiment described here demonstrated for the first time that extant COTS technology is capable of producing medical-grade images of human beings in a microgravity environment. On Earth, this same technology is also routinely used to create high-quality images of animals and hardware during non-destructive evaluation. It has been used to image space suit components, has dental diagnostic capability, is rugged, and user-independent. Given the results of the DUXS experiment and the demands of the IMPACT condition list to rapidly and accurately diagnose an increasing number of conditions amenable to X-Ray analysis, now is the time to discuss the best paths to implementation of ultraportable X-RAY systems into near and far-term medical care beyond Earth.

Learning Objectives

1. Ultraportable X-ray technology addresses multiple Human Research Roadmap gaps and allows for clear diagnosis of many of the Integrated Medical Model and IMPACT list medical conditions including at least seventeen conditions that can only be diagnosed by X-Ray, such as dental caries/abscess, stress fractures, and acute sinusitis.
2. Newer advances in X-ray imaging capability allow the realistic possibility of diagnostic x-rays for human, animal, and non-destructive component evaluation in microgravity.

[58] FLEXIBLE MACHINE LEARNING PIPELINE FOR THE PREDICTION OF TACHYCARDIA FOR DEEP-SPACE MEDICAL MONITORING.

Cyril Mani[1], Tanya Sarah Paul[2], Alexandre Marois[2]
[1]*McGill University, Montreal, PQ, Canada;* [2]*Thales Research and Technology Canada, Quebec City, PQ, Canada*

(Original Research)

INTRODUCTION: Deep-space missions restrict the ability of ground resources to assist crews in need of medical attention. One solution is to empower the crew directly with on-board health monitoring capacities. This enables preventative care relying on predictive models and health data for anticipating or detecting in-space pathologies. Deploying such models requires flexible edge computing, which Open Neural Network Exchange (ONNX) formats could optimize by enabling inference directly on flight-proven wearable computing devices. This work demonstrates the performance of an ONNX machine-learning model pipeline which recognises periods of normal sinus rhythm (NSR), atrial fibrillation (AFIB) and atrial flutter (AFL) and from a 2-lead ECG wearable. **METHODS:** Over 563 hours of ECG recordings from diverse patients were used to train and test a supervised multinomial regression model. The data was pre-processed into 30-s normalized and denoised strips where self-adjustable variable mode decomposition removed muscle artifacts and electrosurgical noise. Then, 17 heart rate variability and morphological ECG features were extracted by convoluting peak detection with Gaussian distributions - for probabilistic peak locations - and by delineating QRS complexes using discrete wavelet transforms. Models based on rotated ECG features and hyperparameters were 10-fold cross-validated against cardiologist labelling of the ECG recordings and compared with F-1 scoring. **RESULTS:** The selected model had a mean F-1 score of 0.88 with specific scores of 0.95 for NSR, 0.92 for AFIB and 0.76 for AFL. It attributed most weight (β) to the following features: median P amplitude (0.71), PNN20 (0.12), mean heart rate (0.08), maximum heart rate (0.03), SDNN (0.02), PNN50 (0.01), median S amplitude (0.01) and SDSD (0.01). The ONNX-adapted ECG pipeline from raw sliding window to prediction took 9.2 s per strip. **DISCUSSION:** The model based on morphological and high-impact computed signal features demonstrated accurate detection of tachycardia with lower identification of AFL compared to AFIB and NSR. The multivariable deterministic predictions can support on-board medical officers with constant monitoring of the crew's health to prioritise resource allocation when tachycardia patterns are detected. Using the ONNX format, future pipeline iterations can be easily adjusted to other types of tachycardia to help further understand microgravity-induced cardiovascular degradation.

Learning Objectives

1. The audience will be able to visualize the working steps of a whole machine learning model pipeline and understand its quantitative capacity to recognize atrial fibrillation, atrial flutter and normal sinus rhythm from biomonitoring ECG wearable data streams.
2. The audience will learn about methodologies to denoise for muscle artifacts, power supply interference and electrosurgical noise common in wearable ECG data taken in analog spacecraft environments.
3. The audience will understand the use cases of a real time multivariable cardiovascular predictive model in assisting the on-board medical officer of a deep space mission. In addition, they will learn about the advantages of ONNX-adapted models in such use cases.

[59] NON INVASIVE VENTILATION EVALUATION FOR EXPLORATION MISSIONS

Aaliya Burza[1], Christopher Haas[2], David Alexander[2]
[1]*SUNY Downstate Health Sciences University, Brooklyn, NY, United States;* [2]*NASA JSC, Houston, TX, United States*

(Education - Tutorial/Review)

INTRODUCTION: This session will review the evidence supporting the use of non-invasive ventilation (NIV) for acute respiratory failure and will evaluate the validity and viability of using various modalities of NIV within the mass and volume constraints of exploration missions. **TOPIC:** NIV is the delivery of ventilatory support or positive pressure into the lungs without an invasive endotracheal airway, usually through a mask. The use of NIV for acute respiratory failure has rapidly increased over time and observational and meta-analysis studies have demonstrated a trend towards lower intubation rates when used early during respiratory failure. **APPLICATION:** Potential NIV devices that can provide noninvasive ventilation include continuous positive airway pressure (CPAP) devices used for obstructive sleep apnea and some transport ventilators. These devices can deliver the oxygen, positive end expiratory pressure (PEEP), and minute ventilation needed by the patient while matching the increased demand flow rates that can occur during acute respiratory failure. Using a travel CPAP and transport vent can further make them adaptable to spaceflight given the small mass and volume footprint of these devices. Emerging developments in high flow nasal cannula (HFNC) have opened the possibility to use HFNC as an NIV device and may also be considered. While some devices will be more easily integrated into exploration vehicles, all devices currently available will need some modifications to be spaceflight ready. Regardless, it is important to understand how the latest evidence supports the use of NIV early for acute respiratory failure in exploration missions and can also lead to more rapid improvement of physiological variables and a reduction in the need for invasive mechanical ventilation.

Learning Objectives

1. The audience will learn about the evidence supporting the use of Non invasive ventilation (NIV) in acute respiratory failure.
2. The audience will also learn about the various types of NIV devices available that can be potentially considered to be used during the flight.

[60] DERIVING AN OPTIMIZED ANTIMICROBIAL KIT FOR NASA'S ACCEPTED MEDICAL CONDITION LIST

Jose Castillo-Mancilla, Arian Anderson
University of Colorado, Aurora, CO, United States

(Education - Program/Process Review)

BACKGROUND: Medical care aboard the International Space Station (ISS) benefits from habitable volume and proximity to earth and allows for a relatively large medical kit. With upcoming deep

space missions however, the paradigm for medical system design will change to substantially minimize mass and volume. Infectious diseases are among the largest contributors to medical risk in spaceflight and represent nearly ¼ of NASA's updated Medical Condition list. Therefore, optimizing a robust but minimalistic kit for exploration spaceflight presents an important challenge. We aim to use antibiogram data in conjunction with NASA's condition list and known constraints of the spaceflight environment to derive an optimized antimicrobial kit. **OVERVIEW:** NASA's 120 Accepted Medical Conditions were filtered to select conditions resulting from infectious disease ranked by risk of death. The University of Colorado Hospital (UCH) antibiogram was then overlayed with these conditions to create a rank of antibiotics for treatment of each condition. Antibiotic spectrum, including Methicillin-resistance Staphylococcus aureus (MRSA) and Pseudomonas aeruginosa was included based on prior spaceflight data. Each antibiotic was assigned a score based on effect size, utility in spaceflight, and resource requirement for both outpatient (mild) and inpatient (severe) treatments and collated to a total value score. 29 of 120 conditions were identified as involving infectious etiologies and 30 antibiotics were considered based on the UCH antibiogram. After considering spectrum, oral bioavailability, possibility of parenteral dosing and tolerability, the most valuable outpatient antibiotics included oral levofloxacin and linezolid and inpatient included intramuscular (IM) ceftriaxone and cefepime. **DISCUSSION:** Our methodology identified a limited number of outpatient and inpatient antibiotics that combine to a small formulary that can cover all infectious disease conditions included on NASA's medical condition list. An antimicrobial kit including oral levofloxacin oral linezolid, ceftriaxone (IM), and cefepime (IM) can treat all infectious conditions of concern. If excluding antibiotic stewardship and the kit can be further reduced in size but increases risk of resistance. Inclusion of fluconazole and valacyclovir creates the most complete and optimized medical kit needed to treat all infectious disease related conditions impacting medical risk in spaceflight.

Learning Objectives

1. Understand the constraints of a medical system for exploration class missions to deep space.
2. Demonstrate how antibiogram data can be used with a medical condition list to identify organisms that most contribute to medical risk.
3. Use the list of infectious organisms to derive an optimized antimicrobial kit.

[61] PROCEDURAL MEDICINE PRACTICALITIES FOR SPACEFLIGHT

Dana Levin[1], Tovy Kamine[2]
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(Education - Program/Process Review)

BACKGROUND: Medical planning for exploration class missions may require a higher level of procedural skill than has been available on spacecraft to date. NASA's updated conditions list for exploration missions from the Human Research Program's Exploration Medical Capability Element includes several conditions that reflect this. While it is unlikely that spacecraft will support or require fully invasive surgical capability in the foreseeable future, there are many procedures that may be required to treat these conditions that are potentially practical in the spaceflight environment. **DESCRIPTION:** Subject matter experts (SMEs) in procedural medicine and space medicine were assembled to discuss procedures that may be required to treat the conditions on NASA's IMPACT Conditions List. The SMEs evaluated each procedure according to necessity, alternatives, chance of a successful outcome, requirements of post procedural management, recovery time, and practicality in the spaceflight environment. **DISCUSSION:** The resultant list of procedures represents a potential component of future space medical officer training to ensure safety of flight.

Learning Objectives

1. Understand that procedural training will likely be needed by CMOs on exploration missions.
2. Understand that many procedures are not practical in spaceflight and will need to be modified or will not be possible.
3. Describe a method by which practical procedures can be identified to develop effective training.

Monday, 05/22/2023 ***2:00 PM***
Grand Ballroom D-E

[S-12]: SLIDES: COVID-19 & HISTORY... POTPOURRI

Chair: Kristian Mears
Co-Chair: Denise Baisden

[62] CHALLENGE OF COVID-19 VACCINE MEDICAL EXEMPTION IN A MILITARY PILOT AFTER BELL'S PALSY

Jianzhong Zhang[1], Sarah Madden[2]
[1]*55th Medical Group, Offutt AFB, NE, United States;* [2]*55th Operation Group, Offutt AFB, NE, United States*

(Education - Case Study)

INTRODUCTION: An active-duty RC-135 pilot developed Bell's palsy after COVID-19 infection. After full recovery he was returned to flying status. Due to the strong association of COVID-19 infection with the development of the Bell's palsy. The member is hesitant to be vaccinated and applies for medical exemption, which if granted, will help him to stay in military service. If vaccinated he is at high risk to develop further Bell's palsy symptoms which will result in him losing his military and civilian aviation career. **BACKGROUND:** Bell's palsy is not life threatening but can be a career eliminating disease in military aviation service. Literature review indicates that people infected with COVID-19 have a higher risk to develop Bell's palsy. It is possible that the virus or antibody to COVID-19 is responsible for causing Bell's palsy. If so, should medical exemption be granted? The answers are complicated and are discussed below. **CASE PRESENTATION:** A 34 y.o. male pilot comes in the clinic to discuss potential issues of receiving COVID-19 vaccine exemption due to the fact that he contracted Bell's palsy 3 weeks after being diagnosed with COVID-19 infection. He notes weakness in the right lower face especially with laughing and smiling. He reports some aberrant regeneration with crocodile tears when eating and also closure of right eye when smiling, and he cannot raise his right forehead fully. He was diagnosed on 30 Dec 2020 with moderate to severe Bell's Palsy (a House-Brackmann facial paralysis score of 5) and was started on Prednisone 60mg/day and Valtrex 1gm bid x 7 days. At his follow up appointment on 9 March 2021 it was documented that he improved (recovered about 70%) with residual symptoms (some facial weakness). His symptoms were near completely resolved and he was returned to flight status with a waiver on 18 May 21. It took more than a year for him to get medical exemption on 22 Sept 22. **DISCUSSION:** Member seems to have a clear viral infection related to nervous system disorder. In a given year and virus, the medical recommendation to not vaccinate should be straight forward. However, given the unprecedented world-wide health concern caused by COVID-19, the medical exemption process took time and insight. After returned to duty, his unwillingness to be vaccinated put him in danger of losing his career. With the improvement of population immunity, treatment options and understanding of the virus, he received medical exemption.

Learning Objectives

1. The participant will be able to make appropriate vaccine medical exemption recommendations for those who have a medical condition

that could cause an adverse reaction if vaccinated, the risk may outweigh the benefit.
2. The participant will be able to understand, that unvaccinated people may spread the virus if infected, it is important to balance the individual desire and the need of general population health protection.
3. The audience will learn that Bell's palsy can be a complication of COVID-19 infection.

[63] CLINICAL CHARACTERIZATION OF MEDICAL CERTIFICATE HOLDERS WITH CONFIRMED SARS-COV-2 INFECTION REPORTED TO THE CIVIL AVIATION AUTHORITY OF COLOMBIA

Laura Maria Pineda Jimenez[1], Johana Giraldo Alzate[2], Maria Angelita Salamanca Benavides[2], Alexandra Mejia Delgado[2], Patricia Barrientos[2], Diego Manuel Garcia Morales[3]
[1]*National University of Colombia, Bogota, Colombia;* [2]*Civil Aviation Authority of Colombia, Bogota, Colombia;* [3]*Embry-Riddle Aeronautical University, Daytona, FL, United States*

(Original Research)

INTRODUCTION: The burden of the COVID-19 pandemic in working populations is still unknown. Safety-critical populations, such as aeromedical certificate holders, should be monitored to assess type, severity, and sequalae after the infection by Severe Acute Respiratory Syndrome Coronavirus-2 (SARS-CoV-2). The present study aimed to describe the clinical characteristics of medical certificate holders with confirmed SARS-COV-2 infection reported to the Civil Aviation Authority of Colombia (CAAC), 2020-2021. **METHODS:** Retrospective observational study on medical certificate holders with confirmed SARS-COV-2 infection who reported their condition to the CAAC and sent their medical records. Patient data was manually abstracted and exported to Microsoft Excel® (Office 2016). **RESULTS: C**AAC counts 14,089 aeromedical certificate holders, of which 679 (4.8%) reported for SARS-CoV-2 infection. Of those, 332 (48,8%) submitted complete data of their event**,** mostly men 206 (62,04%), mean age 38,29 years (SD 10,9), of which 87 (26,20%) were asymptomatic, 211 (63,55%) presented with mild, 28 (8,43%) with severe and 6 (1,80%) with critical infection. Three certificate holders (0,9%) were reported deceased. Most frequently reported symptoms were respiratory 213 (64,1%), comprising dry cough 137 (41,2%), odynophagia 125 (37,6%), rhinorrhea 114 (34,3%) and dyspnea 69 (20,7%); followed by general symptoms (197, 59,3%), such as adynamia 119 (35,8%), malaise 117 (35,2%), and fever (82, 24,6%); 149 (44,8%) reported neurological symptoms, including headache 111 (33,4%), dyssomnia 83 (25%) and 64 dysgeusia (19,2%). Finally, most complications were respiratory 38 (11,4%), including mild 29 (8,7%) and severe pneumonia 9 (2,7%) and infectious complications 10 (3%), such as bacterial superinfection, sepsis, and septic shock (2,1%, 1,5%, and 1,2% respectively). **DISCUSSION:** Clinical characteristics of SARS-CoV-2 infections in Colombian aeromedical certificate holders are similar to those reported in the literature for general populations, the long-term effects of this affectation is still being assessed. Knowing clinical characteristics of COVID-19 infections in this high-impact population will inform future actions, programs and policies for assuring top human performance in their safety-critical roles, and to improve certification decision-making processes.

Learning Objectives

1. The audience will be able to compare the frequency of SARS-CoV-2 infection during the pandemic (2020-2021) in medical certificate holders from the Civil Aviation Authority of Colombia with the published literature.
2. The audience will be able to go over the most frequent symptoms and complications of the SARS-CoV-2 infection in medical certificate holders during the pandemic (2020–2021) from the Civil Aviation Authority of Colombia.

[64] SPACE TECHNOLOGY AND THE MANAGEMENT OF PUBLIC HEALTH DISASTER: COVID-19 PANDEMIC AS A CASE STUDY IN THE MIDDLE EAST FOR IMPROVED PREPAREDNESS.

Ahmed Baraka[1], Anthony Yuen[2], Clara Moriceau[3]
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(Education - Program/Process Review)

Responding to public health disasters such as the COVID-19 pandemic is challenging and such pandemics might become more frequent in the future. Space technology can play an important role to support responses to public health disasters. Use cases of space technologies for terrestrial health include data and imagery from Earth Observation and remote sensing satellites, advanced communication supporting telemedicine applications from LEO constellations, and global positioning information. Increasing the role of space technology to support such a response is a must for better control and readiness for any possible future pandemics. Countries in the Middle East can implement such technologies in preparation for future pandemics. Based on recent experiences from the COVID-19 pandemic, we will focus on such responses in UAE, Israel, and Saudi Arabia as examples in the Middle East region and compare that with the other countries like the US, China, and the EU. In conclusion, we aim to highlight the lessons learned and the best strategies that could be implemented in countries in the Middle East for any future pandemics to make sure that all the countries can successfully control the spread of such contagious diseases in the future.

Learning Objectives

1. Assessing the response of the Middle Eastern countries to COVID-19 as a pandemic and how they applied space technology to the management of this public health disaster.
2. A comparison with other countries outside the Middle East describes the best practices that the Middle Eastern countries should follow and adapt to handle any future possible public health disaster using the available resources of the space assets.

[65] RISK ASSESSMENT FOR MEDICAL CERTIFICATION IN PREGNANCY - AN AUSTRALIAN MODEL

Kate Manderson
CASA Australia, Canberra, Australia

(Education - Program/Process Review)

BACKGROUND: ICAO Standards for medical certification state that flying and controlling duties during pregnancy must be ceased from 28 weeks' gestation. At the same time, individual states retain the ability to assess individual cases with an accredited medical conclusion process. **OVERVIEW:** Australia has historically applied a uniform approach of suspension of flying for private and commercial pilots from 30 weeks gestation, while controllers may continue with weekly review up to 38 weeks. With a move towards certification using less restrictive standards for flying, such as those for motor vehicle licenses, we are now exploring a risk-informed approach to allowing pilots to continue flying beyond 30 weeks gestation. **DISCUSSION:** We present a review of the current Australian data on high-risk pregnancy and pregnancy outcomes, and a proposed model for periodic review for pregnancies at lower risk. This approach will enable those pilots who wish to continue flying while pregnant to choose to do so, whether commercially or privately.

Learning Objectives

1. The participant will be able to consider the features of normal and high-risk pregnancies that present aeromedical risk.
2. The audience will learn about an approach to a collaborative approach to ongoing aviation risk assessment for pregnant pilots.
3. The participant will be able to plan an evidence-based risk assessment process for their pregnant pilots.

[66] THE FARNSWORTH F2 TRITAN PLATE: THE BEST EVER CONGENITAL RED/GREEN COLOR VISION (CV) SCREENING PSEUDOISOCHROMATIC PLATE (PIP) TEST?

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(Education - Tutorial/Review)

BACKGROUND: The epicenter for US Navy color vison (CV) research during and for several decades after WWII was the Naval Medical Research Laboratory (NRML), eventually the Naval Submarine Medical Research Laboratory (NSMRL), at the U.S. Naval Submarine Base New London in Groton, Connecticut. Vision research activities at New London were greatly enhanced by the assignment of Dean Farnsworth to active duty in 1943, transitioning remarkably from his research-associated activities within his post-graduate theatrical arts studies at New York University (NYU). Numerous CV testing devices evolved during his tenure at the NSMRL, most notably the Farnsworth Lantern (FaLant), which remains an integral part of military and civilian aviation CV screening methodologies to this very day. **OVERVIEW:** One of the lesser-known devices Farnsworth developed and produced at NSMRL was his F2 Tritan (blue/yellow) CV screening test plate (a follow-on to his F1 polychromatic plate depicted in a 1951 edition of *Picture Post* magazine) to help determine the incidence of blue/yellow CV deficits within the general United Kingdom (UK) population. Surprisingly, the F2 plate also became a widely acclaimed congenital red/green CV screening test based on its color-confusion design. It became an integral part of the pseudoisochromatic plate (PIP) four-test battery employed in the USAF's Enhanced/ Medical Flight Screening (EFS/MFS) Program for pilot candidate selection, once it became obvious that traditional single-edition CV PIP tests were compromised by widely known cheating scams. There were also new mission requirements and policy directives that demanded normal CV (red/green and blue/yellow) in future USAF pilot selectees. **DISCUSSION:** This paper will present historical background details about F2 plate design developments recently uncovered in archival NSMRL materials. We will also present historical comparisons about its effectiveness as a congenital red/green CV screening device, compared to the Dvorine and the Standard Pseudoisochromatic Plates (SPP I/SPP II tests), within a novice USAF pilot candidate pool undergoing EFS/MFS CV screenings. (The views in this presentation represent those of the authors and not the U.S. government nor its agencies. No U.S. Government endorsements are implied; Copyright protection not implied.)

Learning Objectives

1. The audience will learn about the legacy of the significant color vision testing contributions from Dean Farnsworth and his staff at the US Navy Submarine Medical Research Laboratory during and after World War II.
2. Attendees will learn about the history and design issues related to blue/yellow color vision testing and the effectiveness of the Farnsworth F2 Tritan color vision test plate.

[67] WORLD WAR I BRITISH FLYING ACE EXTRAORDINAIRE, MAJOR EDWARD "MICK" MANNOCK, VC, DSO, MC: DID HE REALLY HAVE ONLY ONE GOOD EYE?

Adrien Ivan[1], Douglas Ivan[2], Thomas Tredici (Posthumously)[3]
[1]*Vernon College, Wichita Falls, TX, United States;* [2]*ADI Consultants, San Antonio, TX, United States;* [3]*University of Texas Health Sciences, San Antonio, TX, United States*

(Education - Tutorial/Review)

How much depth perception capability is needed, particularly binocularly derived spatial awareness (stereopsis), to be a successful aviator has remained under perpetual debate ever since World War I (WWI). Good binocular function was continuously aggravated by additional stressors associated with combat operations of the day, including long periods of time at hypoxic altitudes without supplemental oxygen, the Oxygen Paradox, unrestrained flight hours, extreme fatigue, and psychasthenia. Compounding the problem was the general attitude amongst period pilots that facing such adversity was sport, a challenge to be met head-on without complaint. Field studies and laboratory investigations during WWI almost universally supported the need for good ocular muscle control, particularly to avoid double-vision or loss of stereopsis. Vision experts of that period on both sides of the conflict were absolutely convinced that pilots needed normal stereopsis to survive flying training and aerial combat. With rare exception, it is difficult to argue that two normal eyes are much better than one, especially when trying to avoid injury and stay alive. Nonetheless, a few notable exceptions to that premise emerged during WWI, often used to challenge that two normally functioning eyeballs might not necessarily be an absolute requisite. Two of the more well-known "exceptions," who later became combat aces, were American William "Bill" Thaw II with 5 confirmed aerial kills (possibly 7) and British ace Edward "Mick" Mannock with possibly 73 total enemy kills (61 confirmed/12 unconfirmed). Of the two, it was Mannock who was far more productive in terms of aerial warfighting tallies and nicknamed the "One-Eyed Ace." In reality, neither of these individuals was actually one-eyed, but each was thought to have impaired vision in one eye. However, some historians have recently challenged whether Mannock, in particular, had any persistent eye problem at all and that his boastful claim to have memorized the visual acuity test chart to avoid detection of a poorly seeing eye during his medical examinations may not have been accurate. This presentation will explore the available records and events, including Mannock's own diary entries, to help determine whether he had enough of an eye problem to warrant the "one-eyed" moniker, or that possibly, he may not have had any significant eye affliction at all.

Learning Objectives

1. The audience will learn about the pertinent historical background of the extraordinarily successful British World War I Ace, Major Edward Mannock, often labelled "The One-Eyed Ace," and the role that a longstanding eye problem may or may not have played in his aviation career.
2. The audience will learn about binocular function in the early days of combat flying and its role in vision performance in aerial dog-fighting during World War I.

Monday, 05/22/2023 ***2:00 PM***
Grand Chenier

[S-13]: SLIDES: SAFETY & SURVIVABILITY: WHAT WENT WRONG

Chair: Barry Shender
Co-Chair: Hadley Sulpizio

[68] FLYING BLIND? INVESTIGATING GLAUCOMA IN A FATAL MIDAIR COLLISION

Turan Kayagil
NTSB, Washington, DC, United States

(Education - Case Study)

INTRODUCTION: On the morning of July 31, 2020, a chartered de Havilland DHC-2 Beaver and a Piper PA-12 were destroyed in a midair collision near Soldotna, Alaska, fatally injuring both pilots and all five Beaver passengers. The investigation by the United States National Transportation Safety Board (NTSB) discovered that the Piper pilot had been denied aeromedical certification due to open-angle glaucoma. Investigating whether this condition contributed to the crash required collaboration among NTSB experts to interpret and connect medical and non-medical evidence. **BACKGROUND:** The NTSB is an independent United States government agency that investigates all domestic civil

aviation accidents with the goal of making recommendations to improve safety. Open-angle glaucoma is a condition that has potential to impair pilot performance insidiously, as optic nerve damage may progress unnoticed for years, with irreversible visual field loss. Decreased contrast sensitivity and increased susceptibility to glare may also pose hazards to pilots with glaucoma. **CASE PRESENTATION:** The NTSB medical investigation of the Piper pilot reviewed evidence including toxicology and autopsy reports, aeromedical certification records, personal medical records, and records from a commercial driver medical examination. Ophthalmology and optometry records, including reports from automated visual field testing, showed that the pilot had severe visual field defects in both eyes, with controlled intraocular pressures and good results on visual acuity testing. The NTSB medical officer worked with agency experts in human performance and crash reconstruction to develop an understanding of how the pilot's disease may have affected his interactions with his visual environment before the collision. **DISCUSSION:** The investigating NTSB medical officer will present this case in context of the agency's medical investigation process and will discuss aeromedical aspects of open-angle glaucoma.

Learning Objectives

1. Develop awareness of how the United States National Transportation Safety Board evaluates potentially impairing pilot medical conditions in crash investigations.
2. Review how open-angle glaucoma is assessed and how it can affect pilots.

[69] FAST JET HEAD INJURY BIOMECHANICS

Alasdair Mackay[1], Mazdak Ghajari[2]
[1]*RAF, Henlow, United Kingdom;* [2]*Imperial College, London, United Kingdom*

(Original Research)

INTRODUCTION: In the UK, military aircrew helmets are required to meet the Military Aircrew Helmet Impact Standard (MAHIS). This standard requires a helmeted headform to be dropped onto a metal anvil from a prescribed height, measuring the accelerations transmitted to accelerometers within the headform. The pass/fail threshold for MAHIS is a translational (linear) acceleration of 300G when impacting a flat or hemispherical anvil at 6 m/s. Translational injury protection as been shown to reduce the risk of frontal bone fracture, but its ability to reduce the risk of specific intracerebral pathologies is less well established. There is a growing scientific body of evidence that protection against rotational acceleration reduces the risk of the several brain pathologies, especially concussion, loss of consciousness and diffuse axonal injury. Internationally, several helmet impact standards now require helmets to pass a rotational threshold. To understand the risk of head injury faced by aircrew, this research aims to identify the types and severity of head injuries sustained during fast jet ejections. **METHODS:** A review of the ejection database held at the RAF Centre of Aviation Medicine from 1975 to the present day was completed. For each ejection, information was collected on the incidence of head injury, any pathological findings, and the mechanism of injury. **RESULTS:** There have been 268 fast jet ejection since 1975. 27 cases of significant brain injury were identified; these consisted of either a loss of consciousness or concussion lasting less than 20 minutes. There were no cases of skull fractures or significant intracerebral pathologies resulting from "in envelope" ejections. **DISCUSSION:** MAHIS requires that helmets demonstrate translational impact protection and yet there have not been any cases of pathology associated with this mechanism; this may be an indication that aircrew helmets are adequately protecting against translational impacts. This review provides evidence of the potential contribution of rotational acceleration to head injuries in aircrew. Unlike several international helmet standards, these are not currently accounted for in aircrew specific helmet standards. Even a brief loss of consiousness is a risk to life for aircrew ejecting over water, in a confilct zone or when parachute landing onto aircraft wreckage. A review of aircrew helmet impact standards is encouraged to ensure the risk of head injury is being adequately mitigated.

Learning Objectives

1. Understand that rotational acceleration is an important factor in the etiology of traumatic brain injury.
2. Learn about the common brain injuries sustained during ejection from a fast jet aircraft.

[70] MOLECULAR ASSESSMENT OF CARDIOVASCULAR PATHOLOGY IN AIRCRAFT ACCIDENT INVESTIGATION - STRATEGIES AND LIMITATIONS WITH A FOCUS ON MICRO-RNA ANALYSIS

Michael Schwerer
Air Force Centre of Aerospace Medicine, Cologne, Germany

(Original Research)

INTRODUCTION: Recognizing pathologic conditions in the heart of an aircraft accident victim can be challenging in autopsy and histology. Blunt or sharp force trauma, fire and/or decomposition frequently impair morphological examination. Studying molecular markers could be an alternative approach less prone to peri mortal or post mortal tissue changes. MicroRNA (miRNA) analysis could provide insight into a decedent's myocardial condition at the moment of the mishap. **METHODS:** Our current study involves left ventricular wall samples from aircraft accident victims along with control specimens from hospital patients which died from cardiovascular disease. The possibilities and limitations of molecular heart pathology are investigated. For this, automated RNA preparation is carried out using the Maxwell16® System (Promega, Mannheim, Germany). Semiquantitative demonstration of miRNAs employs the miScript® Technology (Qiagen, Hilden, Germany) and the $2^{-\Delta\Delta Ct}$ method. The first round of assessment presented here is based on eight decedents, four of them military pilots, the others heart disease casualties. MicroRNA-133a and -208b were evaluated with SNORD95 used as a reference. **RESULTS:** Between 2.6- to 6-fold (1.2- to 7.5-fold) increases in the expression of miRNA-133a (miRNA-208b) were detected in the myocardium of three military jet aviators compared to an army helicopter pilot. The control samples from heart disease patients revealed variable expression rates of miRNA-133a and -208b. Up-regulation of miRNA-133a was not observed in this group, whereas a subset of cases with significant myocardial necrosis and remodeling demonstrated 3.6- to 5.9-fold increases in miRNA-208b expression. **DISCUSSION:** These preliminary data reveal an increased expression of the myocardium-specific regulatory miRNA-133a along with miRNA-208b in military jet flyers. A previously unrecognized adjustment pattern to the physiological burdens of their type of aviation must be discussed. Up-regulation of miRNA-208b, an established marker for myocardial injury and repair in clinical patients, must not be misinterpreted for pre-existing disease in military jet pilots killed in aircraft accidents. Putatively, additional investigations will further recommend molecular pathology as a powerful tool in aviation medicine and pathology.

Learning Objectives

1. Knowing the limited value of autopsy and histology in aircraft accident victims.
2. Learning about the potential of molecular diagnostics in aeromedical practice.

[71] SUSPECTED HYPOXIA-LIKE PHYSIOLOGICAL EPISODES IN ADF 1990-2020: A SYSTEMATIC ASSESSMENT OF AIRCREW RESPONSE TO SUSPECTED HYPOXIA IN FLIGHT

Adrian Smith
RAAF Institute of Aviation Medicine, Adelaide, Australia

(Original Research)

INTRODUCTION: Hypoxia-like physiological episodes (PHYSEPs) remain a significant concern for military aircrew, especially those operating high-performance aircraft. Optimal response to a PHYSEP requires crewmembers to be aware of symptoms, recognize the significance and decide to act, correctly execute checklist actions in a timely manner, and

use their emergency equipment effectively. This study characterized aircrew response to suspected hypoxia to understand the impact of practical hypoxia training in shaping their behavior. **METHODS:** Australian Defence Force aviation safety reports were interrogated to identify 127 events in which aircrew reported 'hypoxia-like symptoms'. These events underwent a systematic assessment and classification. **RESULTS:** Awareness of symptoms was the trigger for aircrew response in only 54.3% of events; the remaining events involved symptoms after an aircraft warning (16.6%), a smell (7.9%), degraded performance (5.5%), or resistance to breathing (4.7%). The most-commonly reported symptoms were lightheadedness (30%), hot flush (28%), tingling of fingers or lips (19%), and confusion (14%); 39.4% of events described a hyperventilation-like syndrome. Hypoxia was the most-credible explanation in 48.1% of events, with others attributed to hyperventilation-like syndrome (14.2%), or 'critical event response' (11.8%). Although 27.6% of safety reports were complimentary of the value of hypoxia training, 39% were critical of hypoxia training in the recognition of and response to suspected hypoxia, in particular decision-making (44%), checklist discipline (31.5%), familiarity with and use of life-support equipment (29.1%). These issues complicated the PHYSEP in a significant proportion of events (29.1%). **DISCUSSION:** Aircrew response to unusual symptoms in flight requires a complex interaction of awareness of symptoms, decision-making, checklist discipline, and familiarity with life-support equipment. Traditional aeromedical training focuses of symptom awareness rather than response to symptoms. This study shows that lack of awareness of symptoms is not a primary consideration in hypoxia-like PHYSEPs, and that flawed response in aircrew who are aware of symptoms and suspect hypoxia can complicate a PHYSEP. **CONCLUSION:** Aircrew training should consider strategies to promote timely and effective recovery actions in addition to hypoxia 'awareness' experiences.

Learning Objectives

1. The audience will learn about the way aircrew respond to PHYSEPs in real-world scenarios.
2. The audience will learn about the importance of focusing aeromedical training on shaping aircrew response to PHYSEPs rather than symptom awareness.

[72] SURVIVAL AFTER DITCHING IN MOTORIZED AIRCRAFT – ANALYSIS OF THE NTSB DATABASE (1989-2022)

Jochen Hinkelbein[1], Volker Schick[1], Douglas Boyd[2], Catherina Hippler[1]

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(Original Research)

BACKGROUND: Ditching is a rare event and has not yet been systematically analyzed for General Aviation. The aim of the present study is to investigate ditching events and survival after ditching and their possible influencing factors. **MATERIAL AND METHODS:** Descriptive analysis of ditchings. Ditchings (1982-2022) in the United States were identified from the National Transportation Safety Board (NTSB) database. Occupant injury severity definitions per 14CRF 830.2 and accompanying factors including aircraft type, pilots flight experience, flight conditions and number of occupants and flight crew members were extracted. **RESULTS:** A total of 96 ditchings were identified under 14CFR 91 and 135 flight regulations. After detailed screening, 77 ditchings could be included in the analysis. Fatal injuries occurred in 26 (33.8%) of the reported flights. In total, 128 out of 169 (75.7%) occupants survived ditching and were rescued. Passengers were fatally affected more often (passengers 29.1% vs. flight crew 19.2%, p=0.08). The primary ditching event was survived by 94.7% of all occupants. Thirty (19%) occupants died secondarily after the ditching by drowning, hypothermia or unknown reasons. Information of life jackets are only provided in 22 (28.6%) of all reports. In these cases, life jackets were inadequately worn in 31.8% and not worn in 36.4%. **DISCUSSION:** The primary survival after an emergency ditching is high. External factors reduced overall survival in our study population to 75.7%. A possible influence of injuries from the water impact cannot be estimated. Missing data due to unobserved events, missing bodies and lack of their forensic investigation complicated the analysis.

Learning Objectives

1. Learn the causes of ditchings for General Aviation accidents (engine problems, run out of fuel etc).
2. Survivability after ditchings is usually quite high but decreses due to secondary factors.
3. Risk factors during ditching.

[73] SEDATING ANTIHISTAMINE USE IN GENERAL AVIATION ACCIDENTS: CASE REPORT AND TRENDS

Michelle Watters

NTSB, Washington, DC, United States

(Education - Case Study)

INTRODUCTION: This case report describes a general aviation accident where the probable cause was related to impairing effects of a non-prescription sedating antihistamine. **BACKGROUND:** The NTSB is charged by Congress with investigating every civil aviation accident in the US. Evaluation for pilot impairment typically includes interpretation of toxicology testing performed by the FAA Forensic Sciences Laboratory. Prior NTSB safety research studies on toxicology results for fatally injured pilots in the US have shown an increasing trend in the use of potentially impairing drugs. During 2013 through 2017, sedating antihistamines continued to be the largest category of potentially impairing drugs, with 11.9% of study pilots testing positive. Safety recommendations directed to FAA by NTSB have resulted in FAA publishing a safety briefing on antihistamines and guidance on how to evaluate over the counter medications for flying, including antihistamines. However, the NTSB continues to investigate accidents in which sedating antihistamines are identified as contributing. **CASE PRESENTATION:** In July 2020, a Cessna was substantially damaged when it was involved in an accident near Dustin, Oklahoma. The pilot who was performing aerial agricultural applications in his own aircraft was fatally injured. After taking on a load of herbicide, the airplane began its takeoff run, crested a hill, and impacted a power pole. The 62-year-old pilot held an FAA 2nd class medical certificate and had 17,100 total flight hours. Toxicology testing detected diphenhydramine at a high level in the pilot's blood. In the probable cause, the NTSB final report cited the pilot's likely diminished reaction time and flying performance due to effects of diphenhydramine. **DISCUSSION:** Potentially impairing non-prescription medications, such as sedating antihistamines, continue to represent a potential safety hazard in US aviation. In this accident, a pilot with years of experience and familiarity with his aircraft was fatally injured when using a sedating antihistamine. This case illustrates the importance of pilot outreach and education regarding appropriate medication choices and awareness of side effects and needed wait times when using over the counter medications.

Learning Objectives

1. Identify the flight safety risks posed by the use of sedating antihistamines.
2. Recognize the need for educating pilots on the use of potentially impairing non-prescription medications when flying and your role as a health care provider in educating them.

Monday, 05/22/2023 ***2:00 PM***
Napoleon Ballroom C1-C2

[S-14]: SLIDES: JUST LIKE THE AIRCRAFT!

Chair: Timothy Welsh
Co-Chair: Megan Gallo

[74] EVALUATION OF THE PHYSIOLOGICAL IMPACT OF FOUR DIFFERENT BASELINE ACCELERATIONS ON A HUMAN CENTRIFUGE

Bonnie Posselt[1], Joseph Britton[1], Adam Peters[2], Charlotte Thornton-White[2], Stephen Harridge[2], Nicholas Green[1], Ross Pollock[2]
[1]*RAF Centre of Aviation Medicine, Henlow, United Kingdom;* [2]*King's College London, London, United Kingdom*

(Original Research)

INTRODUCTION: Human centrifuges utilize baseline accelerations between high-G exposures to optimise mechanical performance and minimise motion sickness, with +1.4 and +1.6 Gz most frequently used. The physiological changes associated with these low levels of +Gz have not been characterized in detail, limiting analysis of their impact on trials and training. **METHODS:** 10 subjects (Age: 34 ± 10.2 yr; mean ± SD) participated in a human centrifuge trial (centrifuge arm length = 7.5m, seatback angle = 22°). 2-minute exposures to +1.2, +1.4, +1.6 and +1.8 Gz were performed in a random order, with 5 minutes at +1 Gz between runs. Blood pressure (Systolic; SBP and diastolic; DBP and mean arterial pressure; MAP) and cardiovascular variables (Cardiac output; CO, stoke volume; SV, total peripheral resistance; TPR) were assessed via the volume-clamp method. Heart rate (HR) was assessed from 3-lead ECG. Blood volume changes in the abdomen, thigh, knee and calf were measured via impedance plethysmography. Subjective motion sickness ratings were performed using the 11-point MIsery SCale (MISC) after each run. **RESULTS:** Between +1 Gz and the four baselines assessed there was an effect of acceleration on CO, SV, HR and TPR, MAP and DBP at both heart and head-level and SBP at head-level only. Compared to +1 Gz, at +1.8 Gz heart-level DBP was increased by 13.9 ± 8.3 %, TPR by 30.8 ± 18.6 % an HR by 11.9 ± 7.2%, whilst CO was reduced by 17 ± 8.5 % and SV by 27 ± 4.3%. Head-level MAP fell by 41.3% at +1.8 Gz. There was an effect of acceleration on blood volume in all segments with an increase of approximately 495 ml in total at +1.8 Gz. Changes in blood volume were greatest in the abdomen and thigh, with limited changes in the knee and calf segments. There was no difference in MISC score between baselines. **DISCUSSION:** The direction and magnitude of change in cardiovascular variables was of similar magnitude at +1.6 and +1.8 Gz as those previously reported to occur during postural change from supine (0 Gz) to standing (+1 Gz). Selecting baselines of +1.2 or +1.4 Gz reduces physiological priming. Decisions on which baseline to use will largely depend on the context, including importance of proximity to +1 Gz values and the requirement to minimise motion sickness.

Learning Objectives

1. The audience will learn about the physiological effects of different amounts of baseline +Gz.
2. The audience will learn about the factors that affect selection of an appropriate baseline +Gz level.

[75] THE ROLE OF JUGULAR VEIN RESISTANCE IN G-INDUCED LOSS OF CONSCIOUSNESS

William Fraser
Silatyuk Research, Toronto, ONT, Canada

(Original Research)

INTRODUCTION: A common explanation for G-Induced-Loss-of-Consciousness (GLOC) is the failure of the heart to overcome the elevated Gz force acting on the heart-to-head column of blood and to maintain sufficient perfusion of the brain. It has been a puzzle as to why the so-called siphon effect cannot maintain blood flow to the brain under Gz, as siphons function up to a height of 13m. Mechanical and computer simulations have indicated that the decrease in non-pulsatile cerebral blood flow during Gz exposure is due to the negative pressure-induced partial collapse and subsequent increase in the hydraulic resistance of the jugular vein. It is not clear whether this entirely explains GLOC given the pulsatile nature of flow in the cardiovascular system where blood in the left ventricle has to be accelerated against the gravitational force during systole. **METHOD:** A simple mechanical simulator of the pulsatile circulation consisting of an atrium, a ventricle, polyvinylchloride tubing, and a heart-to-brain distance of 1m was used to determine the impact of Gz on cerebral blood flow. The force applied to the ventricle and the blood flow was measured in horizontal and vertical orientations. In a second experiment, the return line to the atrium was replaced with compliant tubing simulating a thin-walled jugular vein. The two experimental conditions were also simulated with a mathematical model. **RESULTS:** With a non-compliant jugular vein, the force applied to the left ventricle to generate a given flow rate was identical for the horizontal and vertical positions. The compliant jugular vein analog partially collapsed in the vertical orientation and the flow rate was reduced in spite of an identical force acting on the ventricle. Simulations confirmed that the decrease in pulsatile blood flow is a function of the length and compliance of the jugular vein. **DISCUSSION:** Even during pulsatile flow the decrease in blood flow in the brain under Gz exposure is not due to a failure of the heart to pump blood uphill, but rather the indirect effect of the Gz-induced negative pressure increasing vascular resistance in compliant veins. Gz protection equipment acts to maintain cardiac output, maintain normal perfusion pressure, and minimize an increased resistance of the cerebral drainage vasculature. The non-linear, time-dependent biomechanical properties of the jugular and other neck veins may be critical in determining the risk of GLOC during complex Gz transitions.

Learning Objectives

1. The participant will be able to understand the potential of mechanical cardiovascular simulators in investigating the physiological responses to sustained acceleration.
2. The participant will be able to understand the role of the compliance of the jugular and other neck veins in the physiological mechanisms involved in G-induced Loss of Consciousness (GLOC).

[76] VALIDATION OF A NOVEL VISUAL ENDPOINT FOR ACCELERATION RESEARCH: EVIDENCE TO SUPPORT A REVISED MODEL OF VISUAL CHANGES UNDER +GZ

Joseph Britton[1], Desmond Connolly[2], Danielle Hawarden[1], Alec Stevenson[2], Stephen Harridge[3], Nicholas Green[1]
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(Original Research)

BACKGROUND: G-tolerance in human centrifuge research is often assessed using the Peripheral Light Loss (PLL) technique. This has several limitations including reduced accuracy at high levels of +Gz acceleration, subject training requirements and variations between research centres due to lighting conditions. A novel visual endpoint (BEAR; Britton Endpoint for Acceleration Research) was developed based on predicted changes in contrast sensitivity under +Gz and validated across a range of centrifuge exposures. **METHODS:** 12 subjects (34.1 ± 8.4 yr; mean ± SD) with confirmed normal visual acuity and colour sensitivity undertook centrifuge assessment to determine the repeatability and reliability of the BEAR in comparison with PLL measured at 60° arc. Gradual onset exposures (GOR; 0.1 G/sec) were performed twice on separate days and consisted of six repeats with (GOR-On) and without (GOR-Off) Full Coverage Anti-G Trousers activated. Rapid onset exposures (ROR), repeated four times, consisted of a single determination of PLL and BEAR. The usability of each endpoint was subjectively scored following each session. **RESULTS:** When used to measure G-thresholds, the BEAR had excellent test-retest repeatability (ICC; GOR-Off/On = 0.99, ROR = 0.92) and low within-subject variability. Between-subject variance was equal to PLL in all conditions. Between-session variance in GOR conditions was statistically but not biologically significant for both endpoints (Δ = 0.08 Gz). There was a strong correlation between BEAR and PLL in GOR-Off (r = .93), GOR-On (r = .95) and ROR (r = .86). Mean threshold values were significantly lower when using BEAR than when using PLL, by 0.3 Gz on average in GOR-Off and by 0.5 Gz in both GOR-On and ROR. Both tests were able to detect changes in G-protection status. Subjective

endpoint ratings were equal in all conditions. **DISCUSSION:** This study confirmed that the ability to detect a contrast stimulus is affected by +Gz acceleration and that this can be used to generate a visual endpoint. The BEAR demonstrated content and construct validity in assessment alongside the established PLL technique. This study also identified that central contrast sensitivity is affected at a lower +Gz than PLL. This provides evidence against the theory of +Gz related visual changes as a peripheral to central retinal failure and supports a more complex progressive shift in visual perception thresholds across the entire retina.

Learning Objectives

1. The audience will learn about the design, use and validation of a novel visual endpoint for use in G-tolerance determinations on a human centrifuge.
2. The audience will gain understanding of how the validation of this novel visual endpoint provides new evidence to the changes in vision under +Gz acceleration.

[77] EFFECT OF AGE AND FLYING EXPERIENCE ON HEART RATE RESPONSE OF FIGHTER AIRCREW DURING HIGH-G EXPOSURE IN THE HIGH PERFORMANCE HUMAN CENTRIFUGE

Ajay Kumar
Indian Air Force, Jodhpur, India

(Original Research)

INTRODUCTION: Institute of Aerospace Medicine Indian Air Force regularly conducts high G training in the human rated high performance human centrifuge (HPHC) for fighter aircrew. It was hypothesized that the cardiovascular response of young and inexperienced pilots who undergo training in the HPHC may be different from the elder and experienced pilots as age and flying experience may have some effect on the CVS response to high-G exposure. **MATERIAL AND METHODS:** A retrospective analysis of the heart rate data from the data bank of the Department of Acceleration Physiology and Spatial Orientation was done to understand differences in heart rate response between young and older fighter aircrew. **RESULTS:** A total of 624 successful HPHC runs were evaluated for the baseline heart rate (before high-G exposure), peak heart rate (during the exposure) and heart rate after the exposure of the run. The mean age, height and weight of the subjects were 27.62 ± 5.5 yr, 175.31 ± 4.8 cm and 72.81 ± 8.4 kg respectively. Student's t-test revealed a significant difference in the basal heart rate and peak heart rate during the high-G exposure between young, inexperienced and older experienced pilots. **DISCUSSION:** Higher basal heart rate and peak heart rate during high-G exposure among younger pilots could be explained by anxiety due to inexperience and a tendency to pull harder compared to other pilots who with experience tend to be more adjusted and pull slower to meet the desired G-level during the high G training. **CONCLUSION:** The cardiovascular response during exposure to high G environment significantly differs between young, inexperienced pilots and senior pilots.

Learning Objectives

1. Effect of heart rate on exposure to various G-profiles during high-G training.
2. Effect of age of the pilot on heart rate response during high-G training.
3. Effect of experience of the pilot on heart rate response during high-G training.

[78] WORK OF BREATH EFFECTS ON SUSTAINED ATTENTION & EXECUTIVE CONTROL PERFORMANCE

Rachel Goehring[1], Tim Halverson[2], Bruce Johnson[3], Robert Wentz[3], Christopher Myers[4], Nicholas Napoli[5]
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(Original Research)

INTRODUCTION: A pilot's work of breathing (WoB), the energy expended by the respiratory muscles to produce adequate ventilation, can negatively impact the aviator's cognitive performance. We evaluate how repetitions of applied breathing loads affect cognitive response times (RTs), and if there is any breathing adaptation when loads are reintroduced. **METHODS:** We analyzed data from a version of the conjunctive continuous performance task (CCPT) which is a sustained attention, executive control task. Participants were presented with a visual stimulus to respond to based on shape and color while different breathing loads at 0, 20, 40, and 60% of their maximum inspiratory pressure (MIP) were applied. There were 12 subjects that performed 48 combinations of varying MIPs over 2 visits examining inspiration and expiration respectively. Each consisted of 40 trials over approximately 4 minutes. **RESULTS:** Analyses focused on the effects of breathing load, time on task, and features shared between the 'right' and 'wrong' stimuli. Linear mixed-effect models (lme4) and post hoc comparisons (emmeans) were performed in the R environment. There was an interaction between breathing load and time on task ($p < 0.001$), where RTs with breathing loads were slower than without breathing loads. Interestingly, there was a greater time-on-task effect for low and no breathing loads. RTs started slower with greater breathing load but were fairly equivalent across all four conditions by the 40th trial. The effects of time-on-task were greater for the low and no breathing loads relative to moderate and heavy. All contrasts for heavy or moderate compared to light or no load were significant ($P < 0.001$), but there was no evidence for differences between heavy and moderate time-on-task effects, $P = 0.965$ or between light and none, $P = 0.270$. Errors of omission varied with breathing load ($P < 0.001$) in a manner consistent with RTs. **DISCUSSION:** The heavier two loads had slower RTs at the start, but the subjects RT time later adjusted to similar RTs of lighter two loads' RTs. There is evidence to support that through breathing adaptations, subjects can regain their cognitive abilities after learning how to adapt resistive respiratory loads.

Learning Objectives

1. Insights on adjusting your pattern of breathing during varying respiratory loads will be discussed in order to avoid increases in cognitive RT.
2. Trends of the RTs due to the stimuli's shared features are explored in relation to the breathing loads that the pilots are experiencing.

[79] AN ADAPTED MUSCULOSKELETAL MODEL TO PREDICT FAST JET PILOT NECK MUSCLE ACTIVATIONS AT +GZ

Dominic Pulford, Olivia Winther, Alec Stevenson, Rory Macintyre Merz
QinetiQ PLC, Farnborough, United Kingdom

(Original Research)

INTRODUCTION: Computational models can be used to predict neck muscle activations to inform musculoskeletal injury risk in fast jet pilots. The aim of this study was to adapt an existing musculoskeletal model, informed by in-flight head position and centrifuge electromyography data, and assess its predictive capability. **METHODS:** Eight flight sorties in the Typhoon aircraft were performed with pilots wearing a helmet-mounted display system which included head-tracking. +Gz acceleration, head angles and in-cockpit video footage were recorded. Head postures were characterized and four common pilot head movements identified. Four non-aircrew volunteers replicated the pilot head movements in a human carrying centrifuge at +1, +3 and +5 Gz wearing a head tracking device and surface electromyography (sEMG) electrodes on four neck muscles (bilaterally). Normalized sEMG data (% of maximum voluntary contraction; MVC) was used to inform modifications to an open source musculoskeletal model of the neck (OpenSim). **RESULTS:** On average, the pilots head was out of neutral (OoN) 60.1% of the time (62.9% when >2 Gz) while only a fraction of the flight sortie (14.5%) was spent above +2 Gz. During level flight, the majority of head movement was in flexion (49%). Whilst at +Gz, the majority of movements were in rotation (51%), then flexion (21%), followed by extension

with rotation (20%), and extension only (7%). The contribution of flexion to the OoN postures decreased with +Gz, being virtually absent at accelerations above +4 Gz. Overall, the error of the model predictions (root mean square error; RMSE) was reduced by 0.5% at +1 Gz, 2.7% at +3 Gz and 5.2% at +5 Gz. **CONCLUSION:** Exposure to +Gz acceleration accounts for a small proportion of sortie duration. Pilot's heads were positioned OoN for the majority of the sortie duration with adopted head postures influenced by +Gz (increase in extension and rotation movements with >Gz at the expense of flexion). sEMG showed the check-six movement elicited the largest mean neck muscle activation (34.5 ± 18.4% +5 Gz), followed by rotation (33.2 ± 24.7% +5 Gz), flexion (27.3 ± 14.9% +5 Gz) and extension (12.4 ± 0.31% +5 Gz). While the musculoskeletal model predictions were enhanced, there is scope for further improvement.

Learning Objectives

1. The audience will learn about typical fast jet (Typhoon) pilot movements/postures and exposure to +Gz acceleration.
2. The audience will learn about the typical neck muscle activations associated with flexion, extension, rotation and 'check 6' movements at various +Gz levels.
3. The audience will learn about the modifications made to a musculoskeletal model to improve it's capabilities to predict neck loading in the fast jet environment.

Monday, 05/22/2023 ***2:00 PM***
Napoleon Ballroom D1-D2

[S-15]: PANEL: OPERATIONAL VISION I: COLOR AND VISION STANDARDS

Chair: Steven Hadley
Co-Chair: Marc Winterbottom

PANEL OVERVIEW: *Multiple organizations are pursuing research through interservice and international collaborative efforts to examine the relationship between vision and operationally relevant performance. The objectives of this research include defining the visual performance capability that will contribute to success of the mission, developing operational based vision standards and waiver criteria, and identifying design factors that impact performance with the use of vision enhancement and vision protection devices. Operational Vision research across these organizations is presented in two panels: Operational Vision I: Color and Vision Standards and Operational Vision II: Visual Performance and Protection. The first panel focuses on color and color vision standards. The first presentation in Operational Vision I, from Defence Research and Development Canada (DRDC), provides an evaluation of color displays in Royal Canadian Air Force aircraft and importance of color vision standards. The second presentation, from the 711th Human Performance Wing (711 HPW) Operational Based Vision Assessment (OBVA) Lab, describes research examining the impact of filtered gamer glasses on simulated remotely piloted aircraft (RPA) operator performance. The third presentation, also from the 711 HPW OBVA Lab, describes research examining the impact of EnChroma glasses on simulated remotely piloted aircraft (RPA) operator performance. The fourth presentation, from the University of the Incarnate Word, describes additional research examining the effect of EnChroma color vision correcting lenses and new metrics for quantifying color performance. A fifth presentation, by the University of Waterloo and DRDC, describes research comparing screening outcomes for several color vision tests, including the cone contrast test at a pass/fail criterion of 55.*

[80] COLOR VISION DEMANDS FOR AIRCREW IN THE CANADIAN FORCES

Mackenzie G Glaholt[1], Jeffery K Hovis[2]
[1]*DRDC, Toronto, ONT, Canada;* [2]*University of Waterloo, Waterloo, ONT, Canada*

(Original Research)

INTRODUCTION: Color is used extensively in modern military aircraft to convey information to aircrew. The current Royal Canadian Air Force (RCAF) vision standard for pilots excludes individuals with severe color vision deficiency. This standard was derived 30 years ago, and since then, many new aviation displays incorporating color have been introduced into military cockpits. These displays potentially impose new demands for color vision upon RCAF aircrew that must be examined. **METHODS:** Eighteen aircraft from the RCAF fleet were investigated to identify the color-related tasks. We had discussions with the aircrew (at least two per aircraft) about the use of color in the aircraft and measured colors used in the aircraft displays with a Pritchard PR-670 spectrophotometer. The color data were analyzed to determine whether an individual with a severe color vision defect would likely make a mistake in identifying the colors used in a given display. **RESULTS:** Of particular interest were color-related tasks where color was the sole means of conveying information to the aircrew or redundant non-color cues were subtle. We found twelve of these tasks in the cockpit/cabin (e.g., identification of colors used in aircraft systems displays, navigation indicators, weather radar, ground avoidance systems, ground radar, and other digital displays in the cockpit) and nine tasks exterior to the aircraft (e.g., identifying colors of ground vehicles, signal lights, smoke, and flares). Analyses of measured colorimetric values showed that an individual with a severe color vision defect would have difficulty performing these tasks. **DISCUSSION:** The results confirm that color vision demands are prevalent in modern military aviation and that the RCAF should continue to screen for severe color vision deficiency. In addition, the data from this study can be used to develop task simulations based on colors common to many cockpit displays and common exterior signal lights. These task simulations could, in turn, be used to determine the appropriate cut-off score for newer quantitative color vision tests to ensure that candidates can successfully perform the color-related tasks encountered by RCAF pilots and other aircrew.

Learning Objectives

1. Understand which colors individuals with color vision deficiencies confuse.
2. Understand possible color vision demands in the military aircraft.

[81] EFFECT OF GUNNAR COMPUTER GLASSES ON SIMULATED REMOTELY PILOTED AIRCRAFT COLOR-CODED DISPLAY TASKS

Marc Winterbottom[1], James Gaska[2], Steven Hadley[1]
[1]*Airman Systems Directorate, Operational Based Vision Assessment Laboratory, Wright-Patterson AFB, OH, United States;* [2]*Retired, Airman Systems Directorate, Operational Based Vision Assessment Laboratory, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Remotely piloted aircraft (RPA) operators spend many hours viewing digital displays, thus have increased risk of digital eye strain (DES). Techniques to ameliorate DES include improving image quality, reducing glare, and frequent breaks. Eyewear can potentially reduce DES, and some RPA operators have reported using Gunnar glasses. We examined the effect of Gunnar Amber glasses on color test scores and performance on simulated RPA color display tasks. **METHODS:** Color deficiency and effect of eyewear on color discrimination was assessed using a cone contrast test (CCT) for 8 color normal and 10 red-green deficient participants. Sensor and system status ("STORM") displays simulated those in the MQ-9 ground control station. The sensor task required observers to locate red/green or blue/yellow vehicles; the STORM task required observers to respond to red, green, or yellow color-coded warnings. For one experiment, stimulus contrast was fixed, and speed/accuracy (throughput) was measured. In a second experiment, performed on the sensor display, target contrast was varied to estimate contrast sensitivity required. Throughput and contrast thresholds were compared with and without (Direct View) eyewear. **RESULTS:** Eyewear had little effect on CCT scores. For red/green cones, CCT thresholds for Gunnar – Direct View

= 0.04, SEM = 0.02. For blue cones, CCT thresholds for Gunnar – Direct View = - 0.068, SEM = 0.028. For sensor display contrast sensitivity, eyewear had little effect. The difference in throughput for red/green sensor targets was Gunnar – Direct View = 0.073, SEM = 0.04. Difference in throughput for blue/yellow sensor targets was Gunnar – Direct View = 0.057, SEM = 0.045. For STORM warning discrimination, difference in throughput was Gunnar – Direct View = 0.13, SEM = 0.039. **DISCUSSION:** Gunnar eyewear did not have a negative impact on the ability of observers to identify color coded information, including blue/yellow imagery. Little effect was found for color normal or color deficient individuals. Given the potentially beneficial effects of a small dioptric add, blue light filtering, and potentially reduced eye dryness, the use of eyewear such as the Gunnar glasses, should be given more consideration for RPA operators using digital displays for long periods of time to reduce DES.

Learning Objectives

1. The audience will learn about the effect of color deficiency on color coded display tasks, similar to those used in RPA ground control stations.
2. The audience will learn what effect color filter lenses, such as blue blocking lenses used in some computer/gamer glasses, have on the use of color coded displays.

[82] EFFECT OF ENCHROMA GLASSES ON COLOR VISION TESTING AND SIMULATED REMOTELY PILOTED AIRCRAFT COLOR-CODED DISPLAY TASKS

Steven Hadley, Marc Winterbottom, James Gaska
711th Human Performance Wing, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Historically, color vision deficiency (CVD) results in the highest USAF pilot applicant medical disqualification. EnChroma glasses are marketed to improve color perception for CVD. If effective, this technology could allow CVD applicants to qualify. We examined the effect of Enchroma glasses on color test scores and performance on simulated RPA color display tasks. **METHODS:** Fifteen participants (8 color normal, 7 CVD) completed this IRB approved study. CVD and effect of EnChroma glasses was assessed with the new CCT-HD. Verified simulation of the MQ-9 electro-optical sensor display and "STORM" was utilized. The sensor display task required the observer locate a red/green or blue/yellow car and the STORM task required observers to respond to a red, green, or yellow color-coded warning. The stimulus contrast was fixed then varied with speed/accuracy and contrast sensitivity thresholds required to identify the color target measured and compared for participants with and without (Direct View) eyewear. **RESULTS:** The EnChroma glasses had very little effect on CCT scores, for color normal or color deficient participants. For red/green cones, log contrast CCT thresholds for EnChroma – Direct View = 0.067, SEM = 0.021. For blue cones, log contrast CCT thresholds for EnChroma – Direct View = - 0.052, SEM = 0.032. Similarly, for simulated sensor display contrast sensitivity, EnChroma glasses had very little effect. The difference in throughput (speed/accuracy) for red/green sensor targets was EnChroma – Direct View = 0.12, SEM = 0.038. The difference in throughput (speed/accuracy) for blue/yellow sensor targets was EnChroma – Direct View = 0.10, SEM = 0.038. For the STORM warning discrimination, difference in throughput was EnChroma – Direct View = 0.17, SEM = 0.042. **DISCUSSION:** EnChroma glasses had no effect on either CCT-HD scores or contrast sensitivity to discriminate red/green or blue/yellow vehicles in a simulated RPA sensor display task. EnChroma glasses resulted in a small improvement in throughput for the simulated vehicle identification task and STORM color warning task. However, this improvement was very small and unlikely to result in an operationally relevant improvement in performance. This is consistent with previous research which similarly did not result in significantly improved color discrimination for color deficient individuals.

Learning Objectives

1. The audience will learn EnChroma glasses will not allow color deficient applicants that previously failed USAF color vision testing to pass with the glasses.
2. The audience will learn EnChroma glasses are not expected to improve color vision deficiency operational performance in color demanding tasks in the USAF MQ-9.

[83] NEW METRICS FOR QUANTIFYING COLOR: OPERATIONAL AND CLINICAL APPLICATIONS

Erica Poole, Frances Silva, Jeff Rabin
University of the Incarnate Word, San Antonio, TX, United States

(Original Research)

INTRODUCTION: Color vision deficiency (CVD) can reduce performance and delay response time in cue limited settings. A gap exists between the relation between CVD type/severity & real-world performance. Our purpose is to describe new metrics of color vision better matched to operational performance, occupational selection, and eye disease detection. **METHODS:** Subjects provided written informed consent in accord with IRB approved protocols and confirmed to be CVDs or color vision normal (CVNs) based on Ishihara and anomaloscope testing. Throughput (TP), response amplitude/response time, was evaluated for cone contrast sensitivity (Cone CS) and Cone VEPs (cVEPs). Cone CS TP was measured in 25 CVDs & 25 CVNs. Efficacy of Cone CS and cVEP TP for showing improvements in CVDs wearing EnChroma color correcting lenses (CCLs) was assessed in 13 CVDs. Lastly, we developed and validated the Cone Contrast Naming Test (CCNT) which combines Cone CS and color naming accuracy (CN) in 20 CVDs & 26 CVNs. ANOVA, t-tests, Wilcoxon, Bland-Altman, and regression analyses were used. **RESULTS:** In 25 CVNs mean/SD Cone CS TP: R cone 36.8 ± 7.4, G 36.7 ± 8.7, B 54.5 ± 10.0; no difference between R & G cone TP (P=.96) but higher B cone TP due to B CS ceiling effect. In 25 CVDs: Protan Red Cone CS TP 2.7 ± 1.4 < CVNs (36.8; 4.6 SDs below normal) and Green Cone CS TP in same subjects (30.5, P<0.001); Deutan Green Cone TP 10 ± 5.6, < CVNs (36.7; 3.1 SDs below normal) and Red Cone TP in same subjects (30.5, P<0.001). Examples of how Cone CS TP enhances occupational selection & disease detection are included. Our pilot study of CCLs showed immediate & long-term improvements in CVDs with greatest enhancement of cVEP TP (P<.0001) and Cone CS TP for the CVD cone type (P<0.001). 100% of CVDs showed increased TP (P<0.001). No subjects showed differences in TP with or without CCLs for the normal cone type (P>0.61). In CVDs CCNT Cone CS scores correlated with Innova CCT scores (r^2 = 0.8, P<.001) as did CVN Cone CS (r^2 = 0.3, P<0.001) & with anomaloscope matching range (P<0.03). CCNT Cone CS and CCNT CN sensitivity for detection of CVD were 100% and specificity of CVD normal cone types and CVNs were 100%. CCNT composite scores (mean of CS & CN) yielded greater diversity of scores (70%) in CVDs vs. CS alone. **CONCLUSIONS:** Both TP & the CCNT are important additions to color testing using dual metrics to potentially improve occupational selection and earlier detection of acquired CVD in disease.

Learning Objectives

1. The audience will learn about throughput as a metric which may show utility as a more sensitive tool for quantifying color deficiency in operational settings.
2. The audience will learn about a new cone contrast test which quantifies cone contrast sensitivity as well as the accuracy of color naming.

[84] A COMPARISON OF COMPUTER-BASED COLOR VISION TESTS USING THE "55" SCORE

Jeffery K Hovis[1], Ali H Almustanyir[1], Mackenzie G Glaholt[2]
[1]University of Waterloo, Waterloo, ONT, Canada; [2]University of Waterloo, Waterloo, ONT, Canada; [3]DRDC, Toronto, ONT, Canada

(Original Research)

INTRODUCTION: The common color vision standard for the United States Military Aviators is that the candidate must obtain a score of at

least 55 on the Rabin Cone Contrast Color Vision Test (RCCT). However, other computer-based tests can also estimate the severity of the defect by measuring chromatic thresholds on a gray background, but there is little information on how they compare with the RCCT using the <55 failure criterion. **METHODS:** We compared the Operational Based Color Vision Test (OBCVT), Cambridge TriVector (CTV), and Color Assessment and Diagnosis (CAD) with RCCT. Sixty individuals with normal color vision and 68 subjects with red-green color vision deficiencies participated. The Rayleigh color match was used to classify the subjects' color vision. The RCCT and CTV were performed monocularly, and the CAD was performed binocularly. The OBCVT was performed monocularly and binocularly. For the monocular tests, the data from each eye were averaged for this comparison. Receiver Operator Curves (ROC) analysis was used to establish cut-off scores for the CTV and CAD tests. Correlations and agreements with RCCT were determined. **RESULTS:** All color-normals passed the RCCT using the 55 cut-off score. They also passed the other tests using the corresponding pass/fail values. For the color-defectives, the correlations between the RCCT and the other tests ranged from r=0.5 for the CTV to r=0.8 for OBCVT performed binocularly. The AC1 pass/fail agreement values of the RCCT with the other tests varied from AC1=0.56 for the CAD to AC1=0.79 for the OBCVT viewed binocularly. The primary reason for the less-than-ideal agreement is that the other tests had a low (~0.50) specificity relative to the RCCT. The other finding related to the relatively low specificity was that 7.5% of the dichromats passed the RCCT but not the other tests. **CONCLUSIONS:** The agreement of other computer-based chromatic threshold tests with the RCCT when using a criterion that allows "mild" color-defectives to pass is moderate-to-good. The agreement is highest with the OBCVT, which used similar stimuli. The primary source of discrepancies is individuals who pass the RCCT but fail the other tests.

Learning Objectives

1. Understand the design of several color vision tests that measure chromatic thresholds.
2. The audience will learn how several computer-based color vision tests compare when individuals with a mild color vision defect are allowed to pass.

Monday, 05/22/2023 ***2:00 PM***
Napoleon C3

[S-16]: PANEL: DISORIENTATION AND OPERATIONAL PERFORMANCE IN LAYPERSON CENTRIFUGE-SIMULATED SPACEFLIGHT

Chair: Rebecca Blue
Co-Chair: Karen Ong

PANEL OVERVIEW: *Individuals considering participation in commercial suborbital spaceflight represent a varied population inclusive of a wide range of medical conditions, ages, and degrees of preparation for flight. The majority of the knowledge of the human body and performance in high-performance environments is based upon studies of healthy individuals well-trained for such activities. However, prospective commercial spaceflight participants will self-select based upon financial means and opportunity, factors which are often inversely related to youth and physical fitness. With very little data regarding the effects of spaceflight on individuals with known medical conditions, the screening and training of commercial passengers is currently an area of much discussion and debate. To address these issues, a study was conducted under funding from the FAA Center of Excellence for Commercial Space Transportation in which layperson volunteers were exposed to high-fidelity centrifuge-simulated suborbital spaceflight. This panel will review key findings from this study, addressing tolerance, performance, and accommodation of needs specific to the layperson and spaceflight participant populations.*

[85] LAYPERSON PHYSIOLOGICAL TOLERANCE IN CENTRIFUGE-SIMULATED SUBORBITAL AND ORBITAL SPACEFLIGHT

Kristi Ray[1], Karen Ong[1], Anil Menon[2], Jaime Mateus[3], Serena Auñon-Chancellor[1], Ronak Shah[1], William Powers[1], Rebecca Blue[1]
[1]*UTMB, Galveston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*SpaceX, LLC, Hawthorne, CA, United States*

(Original Research)

INTRODUCTION: Prior study has indicated that individuals of varied age and limited-to-no experience in an operational environment, including those with well-controlled medical conditions, can tolerate spaceflight and analog conditions. Here we sought to expand upon the understanding of how individuals of varied age and medical history respond to hypergravity conditions expected in spaceflight. We sought to expose laypersons without introductory step-wise hypergravity exposure, to centrifuge-simulated, high-fidelity spaceflight profiles representative of both capsular and winged vehicle designs. **SUBJECTS:** Volunteer subjects participated in up to five centrifuge runs in an 8-hour period, simulating both winged and capsule spaceflight. Maximum exposures included $+4.0G_z$, $+4.5G_x$, 6.1G resultant, and maximum onset rate $<0.5G_z$/sec and $+1G_x$/sec. Profiles included two simulated "flights" in a winged spacecraft, with sequential and combined +Gx/+Gz exposures, and two simulated capsule profiles representing nominal +Gx launch and reentry forces. The final profile simulated a capsule launch with abort and activation of the launch escape system; with a more dynamic cycling of +Gx exposures and oscillatory multi-axis exposures simulating parachute swing and capsule motion after water landing. **RESULTS:** Forty-six subjects participated in the study including 4 participants with diabetes mellitus, 9 participants with significant cardiac history, and other variable medical histories. Subjects tolerated centrifuge profiles reasonably well, though notably there was a significant increase in the frequency of nausea symptoms associated with capsule-type profiles that exceeded rates of motion sickness reported in prior studies of this kind. Similarly, there was a significant increase in the frequency of subjects voluntarily terminating participation prior to completion of all profiles. Subjects most frequently cited nausea or motion sickness as the reason for non-completion, and often attributed symptoms to discordant visual cues during capsule runs as contributing to discomfort or prompting withdrawal. **DISCUSSION:** This study further adds to the available literature basis for understanding of layperson tolerance in commercial spaceflight analog conditions. The inclusion of capsular profiles broadens the applicability of findings to multiple vehicle designs and provides additional understanding of layperson responses to variable hypergravity environments.

Learning Objectives

1. The audience will learn about layperson tolerance to commercial spaceflight exposures.
2. The audience will learn about the applicability of research findings to multiple vehicle designs.

[86] LAYPERSON TASK PERFORMANCE IN SPACEFLIGHT-ANALOG CONDITIONS

Rebecca Blue[1], Karen Ong[1], Kristi Ray[1], Anil Menon[2], Jaime Mateus[3], Serena Auñon-Chancellor[1], Ronak Shah[1], William Powers[1]
[1]*UTMB, Galveston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*SpaceX, LLC, Hawthorne, CA, United States*

(Original Research)

INTRODUCTION: Inclusion of laypersons in the spaceflight environment has raised questions regarding the performance capabilities of such individuals in critical situations. Prior study has lacked tangible evidence regarding operational performance of laypersons, particularly during exposure to space-analog environmental stressors such as hypergravity.

We sought to expand the understanding of minimally trained layperson performance in simulated operations during and immediately following hypergravity exposure. We examined subject task performance on a touchscreen tablet before, during, and after centrifugation. **METHODS:** Pattern-replication tasks were administered to volunteer subjects participating in a larger centrifuge study. Subjects participated in up to five centrifuge runs in one day, with profiles simulating commercial spaceflight. Maximum exposures included +4.0G_z, +4.5G_x, 6.1G resultant, and maximum onset rate <0.5G_z/sec and +1G_x/sec. Tablet tasks included pressing tablet buttons to recreate a predetermined light pattern as indicated by cue-cards available for reference in the gondola. Subjects received familiarization training and were instructed to treat tablet tasks as simulated emergency procedures. They were informed that they would be scored based on time and accuracy, with the goal of perfect accuracy at the fastest pace possible. **RESULTS:** Subjects reported feeling comfortable with the simulated tasks, with adequate time for practice. Most subjects did not continue to practice after the first exam, though practice effort was not associated with exam performance. Average time to complete the tests and to deploy the lightboard under hypergravity conditions were linearly associated with age. There was no association between any time metric or accuracy and sex. Errors were common, including wrong entries, wrong cue-card references, and wrong identifier entries. **DISCUSSION:** The frequency of lightboard error in this study highlights the potential for mistakes in operational activities when performed by laypersons. While entry mistakes represent low-risk events in an analog environment, similar mistakes (referencing wrong cue-cards, entering wrong actions) in an operational environment could be catastrophic. These findings highlight the need for further study to determine the best approach to training, procedural design, and simplicity of actions to best accommodate critical actions of laypersons in the case of operational emergency.

Learning Objectives

1. The audience will learn about layperson operational performance in simulated spaceflight environments.
2. We will discuss frequency of error and types of errors in simulated emergency tasks performed by layperson in simulated spaceflight environments.

[87] EVALUATION AND ACCOMMODATION OF MOBILITY LIMITATIONS IN CENTRIFUGE-SIMULATED SPACEFLIGHT

Quinn Dufurrena[1], Allison S. Burrell[2], Rebecca Blue[1], Michael Harrison[3], Ronak Shah[1], Serena Aunon-Chancellor[1], William Powers[1]
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(Original Research)

INTRODUCTION: The burgeoning commercial space industry has provided the possibility for differently-abled persons to travel to space. As this population includes individuals with functional limitations, there is a need to evaluate safety, operational performance, and accommodation of medical and physiological limitations in spaceflight environments. Early study has demonstrated feasibility of accommodation of broader physiological abilities in microgravity; however, spaceflight stressors are more broad and involve hypergravity transitions and other physical stressors. Such factors must be evaluated to determine the comprehensive impact of physical and environmental challenges on those with differing physical needs. We present two cases of individuals with mobility limitations participating in centrifuge-simulated spaceflight. **METHODS:** Two subjects volunteered to participate in human centrifuge research at the National Aerospace Training and Research Center (NASTAR). Subjects included a 69yo female with limited ambulatory ability (bilateral knee replacement, spinal arthritis, partial blindness, use of mobility aid) and a 40yo female with limited mobility requiring crutches (diastematomyelia, central syrinx, lower extremity partial paralysis, multiple and recent surgeries). Subjects were given the opportunity to participate in multiple centrifuge runs simulating commercial spaceflight. Maximum exposures included +4.0G_z, +4.5G_x, 6.1G resultant, and maximum onset rate <0.5G_z/sec and ≤1G_x/sec. The 69y subject additionally participated in stepwise +Gx and +Gz familiarization exposures. **RESULTS:** Participants demonstrated variable tolerance to centrifugation. Both subjects experienced challenges entering and exiting the gondola and required assistance in this process. One subject (40y) successfully completed all centrifuge profiles; the second (69y) reported chest discomfort during familiarization +Gx exposures and declined further participation. Subjects experienced no adverse physiological outcomes related to centrifuge exposure. **DISCUSSION:** Accommodation of varied physical abilities is an important step in the development of the commercial spaceflight industry. Consideration must be given to vehicular mobility requirements, hypergravity stressors, and physical requirements associated with operational or contingency actions. Ultimately, accommodation of differing physical needs is possible with appropriate design and operational modifications.

Learning Objectives

1. The physiologic stressors of spaceflight can be tolerated by differently-abled persons and those with physical limitations.
2. Design considerations and operational modifications may be necessary to accommodate those with limitations in the spaceflight environment.

[88] NEUROVESTIBULAR DYSFUNCTION IN CENTRIFUGE-SIMULATED COMMERCIAL SPACEFLIGHT

Kristi Ray, Rebecca Blue, Karen Ong, Serena Aunon-Chancellor, Ronak Shah, William Powers
UTMB, Galveston, TX, United States

(Original Research)

INTRODUCTION: With increasing commercial access to space, the subjective experience of potential customers or spaceflight participants is of particular interest. Neurovestibular disorientation symptoms, including vertigo and motion sickness, are subjectively unpleasant and can lead to physical hazards including emesis or operational performance impacts. Individuals with preexisting neurovestibular conditions may be predisposed to discomfort or more serious sequelae; however, such individuals may still pursue commercial spaceflight opportunities. Here we present a case series of three individuals with various neurovestibular disorders experiencing centrifuge-simulated spaceflight. **METHODS:** Three subjects with a history of neurovestibular dysfunction volunteered to participate in ongoing human centrifuge research at the National Aerospace Training and Research Center (NASTAR). Subjects included a 55y female with a history of Meniere's disease, a 30y female with a history of recurrent barotrauma and resultant vestibular imbalance, and a 69y female with a history of vestibulo-ocular impairment. Subjects were given the opportunity to participate in up to five centrifuge runs in an 8-hour period, with profiles simulating commercial spaceflight. Maximum exposures included +4.0G_z, +4.5G_x, 6.1G resultant, and maximum onset rate <0.5G_z/sec and +1G_x/sec. Physiologic data included hemodynamics, neurovestibular exams, and post-run symptom questionnaires. **RESULTS:** The participants demonstrated variable tolerance to centrifugation. Hemodynamic parameters remained within expected ranges compared to an age-matched cohort. However, all three subjects opted out or reduced intensity of one or more of the centrifuge experiences, citing dizziness and motion sickness as factors driving them to limit their experience. In follow up, subjects experienced no adverse physiological outcomes related to centrifuge exposure. **DISCUSSION:** In centrifuge analog, individuals with neurovestibular dysfunction demonstrated symptoms ranging from anxiety related to their concern regarding their own performance to frank vomiting. In an operational environment, symptom exacerbation may ultimately pose a risk to spaceflight activities, as individuals suffering from neurovestibular dysfunction may find themselves incapacitated during critical operational periods such as dynamic flight phases. Further study of mitigation techniques, desensitization, and pharmacological solutions is warranted.

Learning Objectives
1. The audience will learn about the relationship between neurovestibular dysfunction and symptoms during analog spaceflight.
2. The participant will be able to understand the physiologic changes that occur in those undergoing analog spaceflight with neurovestibular disorders.

[89] INVERSION DISORIENTATION INDUCED BY CENTRIFUGE-SIMULATED CAPSULE ABORT ACCELERATION

Rebecca Blue[1], Karen Ong[1], Michael Harrison[2]
[1]*UTMB, Galveston, TX, United States;* [2]*Axiom Space, Inc, Houston, TX, United States*

(Original Research)

INTRODUCTION: Spaceflight-analog environments are known to be invaluable for the screening and preparation of individuals prior to actual spaceflight experience. High-fidelity centrifuge simulation is standard for the training of career astronauts; in the commercial industry, human centrifuge training has similarly been used for training before commercial spaceflight participation. However, centrifugation is an imperfect analog. Centrifuge motion may cause motion sickness or spatial disorientation that could have an adverse training effect or result in a negative experience. Here we will discuss spatial disorientation experienced as an enhanced inversion sensation by layperson participants in a centrifuge-simulated capsule launch abort. **METHODS:** Volunteer subjects participated in a simulated capsule launch with abort and activation of a launch escape system, with dynamic cycling of $+G_x$ and oscillatory multiaxis exposures simulating parachutes and water landing. Subjects were primarily maintained in ~0° body positioning for non-acceleration periods but were exposed to transient $-G_z$ (mean $-0.2G_z$ (–13°) with each accleration sustained <5sec) during simulated drogue deployments. Subjects were asked to report any inversion sensation; following completion, subjects indicated perceived body positioning on polar coordinates. **RESULTS:** Subjects universally reported a sensation of body inversion generally exceeding the actual body positioning within the capsule (average –42°). Onset correlated with simulated drogue deployment and persisted through much of the simulated descent, beyond the time at which subjects had returned to 0° positioning. Subjects that were prewarned about the potential illusion demonstrated improved subjective tolerance of the profile compared to those without advance warning. **DISCUSSION:** Classic inversion illusions are somatogravic illusions most commonly experienced during $+G_x$ acceleration accompanied by sudden alterations of pitch. In this case, the illusion is thought to be most likely induced by the flat to transient head-down position exacerbated by rapid cycling of +Gx acceleration and multiaxis oscillation (including pitch alterations). The ubiquitous experience of the illusion highlights the potential for disorientation in a centrifuge analog; further, this highlights the need for export review of analog profiles to identify illusions. Inadequate preparation could result in aversion to other spaceflight or analog experiences.

Learning Objectives
1. The audience will learn about the classic somatogravic inversion illusion and a unique inversion illusion experienced during centrifuge-simulated spaceflight.
2. The audience will learn about the variable tolerance of individuals trained regarding potential illusion vs. those without advance warning.

Monday, 05/22/2023 ***2:00 PM***
Nottoway & Oak Alley

[S-17]: SLIDES: CLINICAL CONSIDERATIONS IN AEROSPACE MEDICINE

Chair: Elisabeth Eekhoff
Co-Chair: Steve Vander Ark

[90] DIAGNOSTIC PERFORMANCE OF CT FRACTIONAL FLOW RESERVE IN ADDITION TO CT CORONARY ANGIOGRAPHY IN PATIENTS, PILOTS, AND ASTRONAUTS

Paul Martin Bansmann[1], Hans-Jürgen Noblé[2], Nadine Mühlbauer[2], Ehling Josef[2], Lennard Ostrop[2]
[1]*Hospital Porz am Rhein, Cologne, Germany;* [2]*Department of Imaging Diagnostics, German Air Force Centre for Aerospace Medicine, Cologne, Germany*

(Original Research)

INTRODUCTION: Heart disease is the major cause of disease related death in western civilized populations as well as in pilots and astronauts worldwide. Coronary artery disease (CAD) is found in 85% of pilot autopsies after fatal accidents [1-3]. CAD screening standards vary widely among different aviation organizations. With increasing mean age of active pilots early diagnosis and risk stratification of CAD is crucial. AI-based CT fractional flow reserve (FFRCT) is a physiologic simulation technique that models coronary flow from routine coronary CT angiography (CTA) and has been introduced in Germany in 01/2022. The diagnostic performance of CT fractional flow reserve (CT-FFR) in addition to CT coronary angiography (CTCA) is being examined. **METHODS:** A retrospective case review was carried out for the first 120 consecutive German patients (39 female, 81 male) with a mean age of 62 ± 8 years at Hospital Porz am Rhein, Cologne, Germany, who had CTCA on a 256-slice CT System (GE Revolution Apex) and CT-FFR analysis (HeartFlow, Redwood City, CA) between January and September 2022. **RESULTS:** Patients with CT-FFR > 0.8 were significantly less likely to require further examinations with coronary angiography (p: < 0.00001) than those with CT-FFR < 0.8. The use of CT-FFR significantly reduced need for further functional imaging (8% vs. 14%) (p: 0.00012). A strong correlation was found in a total of 7 patients who had both CT-FFR and invasive FFR. **DISCUSSION:** This retrospective study demonstrates that the additional use of CT-FFR significantly reduces the need for invasive coronary angiography in patients with CT-FFR > 0.8 and also reduces the need for further functional testing. In an aging pilot/astronaut population with increasing prevalence of CAD additionally derived functional information can support risk stratification. Randomized prospective multicenter studies are needed to further examine the strong correlation of CT-FFR and invasive FFR.

Learning Objectives
1. Understanding of new AI-based CT derived fractional flow reserve in correlation with invasive catheter based fractional flow reserve.
2. Relevance of coronary artery disease in patients, pilots, and astronauts as well as its non-invasive diagnostic, with regard to clinical outcome.

[91] SENSITIVITY AND POSITIVE PREDICTIVE ACCURACY OF EXERCISE ELECTROCARDIOGRAPHY TEST AMONG AIRMEN IN INDONESIA

Inne Yuliawati[1], Reynold Agustinus[2], Ferdi Afian[1], Dasti Anditiarina[1]
[1]*Faculty of Medicine Universitas Indonesia, DKI Jakarta, Indonesia;* [2]*Aviation Medical Center, DKI Jakarta, Indonesia*

(Original Research)

INTRODUCTION: Inflight incapacitation due to cardiovascular disease may be insidious, thus an early detection for subtle cardiovascular disease is required for airmen. Exercise electrocardiography (ECG) test is one of the less invasive predictors for the presence of coronary artery disease with sensitivity 60 to 70 percent. The aim of this study is to investigate the sensitivity and positive predictive accuracy of exercise ECG among airmen in Indonesia. **METHODS:** The data were collected from medical records at Aviation Medical Centre, Indonesia, from December 1st 2019 until 28th February 2022. Subjects were 1st class medical certificate airmen who underwent exercise ECG test while conducting routine medical assessment. The exercise ECG test were performed using approved wireless testing system devices, to complete three stages of Bruce protocol for at least nine minutes or to achieve an oxygen uptake equivalent

to 11 metabolic equivalents (METs). Subjects were divided into negative response test and positive/suggestive positive response test. We investigated the specificity and positive predictive accuracy for subtle coronary artery disease. Data were analyzed using SPSS. **RESULTS:** From the 1559 subjects that underwent exercise ECG, 1360 subjects had negative stress test, 196 subjects had positive or suggestive positive stress test and 3 subjects had inconclusive results. The result showed 14 subjects from negative stress test result who had history of coronary artery disease, and 31 subjects from positive stress test who had no coronary stenosis result. The sensitivity from exercise ECG was 92.2 percent and positive predictive accuracy from the subjects was 84.2 percent. **DISCUSSION:** The sensitivity and Positive predictive Accuracy of exercise ECG test at Aviation Medical Center in Indonesia was higher than the predictive capability in detecting subtle coronary artery disease. It detected higher percentage of subjects with coronary artery disease. Completing at least three stages of Bruce protocol for at least nine minutes or achieving an oxygen uptake equivalent to 11 metabolic equivalents (METs) was suggested to be applied in conducting exercise ECG as a predictor for coronary heart disease.

Learning Objectives

1. The audience will learn about the diagnostic value of exercise ECG that has been conducted in The Aviation Medical Centre as a predictor for coronary heart disease among pilots in Indonesia.
2. The audience will learn about the specificity of exercise ECG that has been conducted in The Aviation Medical Centre and its importance as a predictor for coronary heart disease among pilots in Indonesia.
3. The audience will learn about the positive predictive value of exercise ECG that has been conducted in The Aviation Medical Centre and its importance as a predictor for coronary heart disease among pilots in Indonesia.

[92] SURVEILLANCE AND CERTIFICATION OUTCOMES AFTER MYOCARDIAL INFARCTION OR CORONARY REVASCULARIZATION IN U.S. FIRST-CLASS PILOTS

Rahul Suresh[1], Rebecca Blue[2], Charles Mathers[3], Leigh Speicher[4], Thomas Flipse[4], Ann Noris[3], Valerie Skaggs[3]
[1]*NASA, Houston, TX, United States;* [2]*UTMB, Galveston, TX, United States;* [3]*FAA, Oklahoma City, OK, United States;* [4]*Mayo Clinic, Jacksonville, FL, United States*

(Original Research)

INTRODUCTION: Myocardial infarction (MI) and coronary revascularization are considered disqualifying for certification by the Federal Aviation Administration (FAA). However, pilots demonstrating adequate disease control on follow-up surveillance coronary angiography (CA) and myocardial perfusion imaging (MPI) may be eligible for a Special Issuance (SI) of a First-Class Medical Certificate (FCMC). The objectives of this study were to determine certification outcomes in pilots after an index cardiac event based on a retrospective chart review of FAA case records. **METHODS:** Clinical and demographic data, results of surveillance MPI and CA following the initial event, consult reports from the treating cardiologist, and FAA consultant or panel review and recommendations were reviewed to determine outcomes of certification in those pilots holding a FCMC that developed a first time MI or after revascularization between 2005-2009 and 2013-2015. National Death Index and the FAA inflight incapacitation database were reviewed to ascertain mortality statistics and inflight incapacitation events. **RESULTS:** A total of 660 pilots met inclusion criteria of which 571 submitted all follow-up documentation. Most pilots successfully pursued an SI. Prognostic factors associated with likelihood of successful SI and time to issuance included lower extent and severity of coronary disease, fewer comorbidities, and favorable findings on initial follow-up testing. Data on incidence of symptomatic events, asymptomatic disease recurrence, inflight incapacitation, and mortality were also identified. **DISCUSSION:** In most cases, those pilots who submitted all required medical records in the appropriate follow-up time frames were found to be qualified for an SI of FCMC. Although the FAA requires additional testing and evaluation for certification compared to current clinical treatment standards, this approach aligns with the FAA's mandate to protect public safety by ensuring pilots remain at low risk for sudden or subtle incapacitation during piloting activities.

Learning Objectives

1. Understand how current FAA evaluation requirements for special issuance after an acute coronary event differ from established clinical guidelines.
2. Describe those prognostic factors that are associated with increased likelihood of a successful special issuance after myocardial infarction or revascularization.

[93] THE EFFECT OF HYPERBARIC OXYGEN THERAPY ON BLOOD PARAMETERS AND BIOCHEMICAL MARKERS IN PATIENTS WITH DIABETIC FOOT

Erdinc Ercan[1], Gamze Aydin[1], Bulent Erdogan[2]
[1]*University of Health Sciences, Ankara, Turkey;* [2]*Gulhane Training and Research Hospital, Ankara, Turkey*

(Original Research)

INTRODUCTION: Diabetes is a metabolic disease with a high morbidity and mortality and increasing in prevalence all over the world. Diabetic foot is the most common complications of diabetes caused by the combined effect of diabetes-related vascular disease and neuropathy. Hyperbaric Oxygen Therapy (HBOT) increases angiogenesis, fibroblast proliferation and activity of leukocytes, while reduces tissue edema and suppresses the inflammation. Because of these positive clinic and physiological outcome of this treatment, HBOT has been used as an adjunct treatment for diabetic foot ulcers for many years. The purpose of this study was to evaluate effects of HBOT on blood parameters and biochemical markers in patients with diabetic foot. **METHODS:** Patients who applied to the Yunus Emre State Hospital's Hyperbaric Oxygen Treatment Center between September 1, 2016, and December 31, 2020, and received HBOT with a diagnosis of a diabetic foot disease constituted the study group. Patients' files were analyzed retrospectively, and files did not include results of the blood assays taken both before and after HBOT were excluded from the study. **RESULTS:** 103 male and 36 female patients' files analyzed within the scope of this study. There was no statistical significance between genders in the parameters of age, total number of the HBOT sessions, elapsed time of the blood tests taken before and after HBOT. In men group, WBC, Neutrophil, Monocyte, PLT, and PCT levels decreased ($p<0.05$), and an increase in LYM, EOS, MCHC, and RDW levels were detected ($p<0.05$) after the treatments. Female patients had lower WBC, neutrophil, PLT, and PCT values ($p<0.05$) after the HBOT. A decrease in the glucose and CRP levels were detected after HBOT ($p<0.05$) in both genders. No clinically significant results were founded in the levels of the blood lipid profile, and markers of kidney & liver functions in both genders. **DISCUSSION:** In our hospital, a multidisciplinary treatment approach is used to treat diabetic wound patients, and it has been determined that HBOT applied adjunct to the medical and surgical treatments has positive effects on the blood parameters and inflammatory markers.

Learning Objectives

1. The participant will be able to understand physiology of Hyperbaric Oxygen Therapy.
2. The audience will learn about positive effects of Hyperbaric Oxygen Therapy in diabetic foot ulcers.
3. The audience will learn about effects of Hyperbaric Oxygen Therapy on blood parameters.

[94] OSTEOPETROSIS IN A MILITARY HEAVY PILOT: A CASE REPORT

Cody Hedrick, Luke Menner
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military heavy pilot who was diagnosed with autosomal dominant osteopetrosis type II. **BACKGROUND:** Autosomal dominant osteopetrosis (ADO) type II is a rare skeletal dysplasia characterized by increased bone density caused

by a heterozygous pathogenic variant CLCN7 gene. Complications result from increased bone thickening and abnormal architecture. Clinical manifestations include degenerative arthritis, cranial neuropathies (e.g., optic or auditory), increased fracture risk of ribs or long bones (e.g., femur), cytopenias (e.g., anemia), and disruptions in calcium homeostasis. Such complications may have a significant impact on flight safety. **CASE PRESENTATION:** A 30-year-old male USAF military heavy pilot was evaluated for left knee pain. There were no preceding injuries or chronic musculoskeletal-related conditions. Initial radiographs revealed bone thickening in a sclerotic pattern concerning for osteopetrosis. Further radiographic imaging via skeletal survey demonstrated diffuse calvarial thickening and sclerosis, sclerotic vertebral endplates, and diffuse pelvic and hip bone sclerosis concerning for ADO. Genetic testing revealed a heterozygous pathogenic variant mutation in the CNCL7 gene, confirming the diagnosis. Brain and orbital MRI revealed mild calvarial thickening but without evidence of osseous crowding of the orbits, orbital canals, or auditory canals. Laboratory testing was without evidence of abnormal calcium-homeostasis. Audiology and extensive ophthalmologic evaluation were normal. Member was returned to flight status with restriction from ejection seat platforms. **DISCUSSION:** This case highlights multiple flight safety concerns. Degenerative arthritis may result in physical impairments that negatively impact performance or hinder emergently egressing an aircraft. Certain aviation environments may increase the likelihood for sustaining pathologic fractures. Abnormal bone architecture in the skull may result in cranial nerve impingement resulting in visual and auditory impairments. Complications such as anemia (secondary to bone marrow encroachment) can negatively impact performance and G-tolerance. The aeromedical community must be cognizant of ADO's associated complications in order to mitigate aeromedical risk by periodic laboratory monitoring, annual audiology and ophthalmologic evaluations, and appropriate occupational restrictions if indicated.

Learning Objectives

1. The aeromedical community will better understand the pathophysiology and associated complications of autosomal dominant osteopetrosis.
2. The aeromedical community will be equipped with mitigation strategies to reduce or detect complications of autosomal dominant osteopetrosis that pose a flight safety risk.

[95] RISKS OF INCREASED EARTH INDEPENDENCE

Alonso Vera, Kaitlin McTigue, Tina Panontin, Megan Parisi, Shuchieh Wu
NASA Ames Research Center, Mountain View, CA, United States

(Original Research)

As human space exploration begins to extend beyond the immediate vicinity of Earth, the ability of expertise on the ground to support operations will progressively decrease. Ground control expertise has been the primary countermeasure preventing loss of life and mission over the past sixty years and it will be gradually stripped away as expeditions reach further into space. The large, flexible and adaptive teams of experts on the ground, provide not only engineering analysis and problem-solving but also greatly increased work capacity. Monitoring of the large and fast moving stream of telemetry data is carried out around the clock by 20-30 flight controllers per shift. Analysis of that data and troubleshooting is carried out by an additional 50-100 engineers per shift. Artificial intelligence capabilities will need to be part of the solution but will not the entire solution. As progress continues to be made on intelligent systems, especially those for use in complex, dynamic environments where humans will remain a part of the activity, there is an ever increasing need to focus on how those systems will interact with the humans. Although capabilities such as natural language processing and facial recognition have become common place, even basic aspects of problem-solving, causal reasoning and generative decision-making remain well-beyond of our current capabilities. Advanced data visualization, procedure execution support, and new training approaches will be needed to close the gap between what is currently provided by experts on the ground and what the crew will need to do in increasingly autonomous ways with greater distance from Earth.

Learning Objectives

1. The audience will learn about the new challenges facing human space exploration beyond low-Earth orbit as ground support decreases due to communication, resupply and evacuation challenges.
2. The audience will learn about the human research and technology roadmaps being pursued to close the gaps introduced by decreased ground support for missions beyond low-Earth orbit.

Monday, 05/22/2023 ***4:00 PM***
Grand Ballroom A-B-C

[S-18]: PANEL: THE SPACEX INSPIRATION4 MISSION: RESULTS OF THE MOST COMPREHENSIVE MULTISCALE OMICS PROFILING OF SHORT-DURATION SPACEFLIGHT TO DATE

Chair: Michael Schmidt

PANEL OVERVIEW: *The SpaceX Inspiration4 mission conducted in 2021 presented an opportunity for extensive biospecimen collection in order to study the impact of spaceflight on the human body (N=4). Biospecimen samples were collected from the crew before (L-92, L-44, L-3 days), during (FD1, FD2, FD3), and after (R+1, R+45, R+82, R+194 days) spaceflight in order to create a longitudinal sample set. These samples included blood from venipuncture, dried blood spot cards, saliva, urine, stool, microbiome body swabs, capsule swabs, and skin biopsies. Blood was further processed to obtain aliquots of serum, plasma, extracellular vesicles, and PBMCs. One study objective was to establish a foundational set of methods for biospecimen collection on commercial spaceflight missions that are suitable for multi-scale omics analysis and translational across different missions. A second objective was to conduct the most extensive untargeted multi-scale omics profiling effort to date (genome, transcriptome, proteome, metabolome, skin microbiome, etc.) of short-duration orbital human spaceflight. This was done in order to develop a more complete catalog of human molecular and cellular responses to short-duration spaceflight. This panel will review some of the novel molecular and cellular patterns identified during the mission. It will also explore the complexities of such comprehensive biospecimen sampling and analysis, lessons learned from the all-civilian crew, future directions aimed at refining these methods, and its potential implications for precision medicine.*

[96] A COMPREHENSIVE REPORT OF ALL BIOSPECIMENS AND MULTI-OMIC MEASUREMENTS FROM THE INSPIRATION4 MISSION

Eliah Overbey[1], Krista Ryon[1], JangKeun Kim[1], Julian Schmidt[2], Caleb Schmidt[2], Sunny Narayanan[3], Chris Mason[1]
[1]*Weill Cornell Medicine, New York, NY, United States;* [2]*Advanced Pattern Analysis & Countermeasures Group, Boulder, CO, United States;* [3]*Florida State University College of Medicine, Tallahassee, FL, United States*

(Original Research)

INTRODUCTION: The commercial spaceflight sector is entering a renaissance, with renewed interest in crewed missions. In order to leverage these crewed spaceflight opportunities for understanding the impact of spaceflight on the body, the standard omics measures for astronauts (SOMA) initiative was created. During 2021, the crew of the Inspiration4 mission became the first participants in SOMA, an initiative which will continue for future crewed missions. In this talk, we will present the spectrum of biospecimen samples collected, the breadth of omics assays that were performed, and lessons learned for improving sample collection both on the ground and in microgravity. **METHODS**: Biospecimen samples were collected from the crew before (L-92, L-44, L-3

days), during (FD1, FD2, FD3), and after (R+1, R+45, R+82, R+194 days) spaceflight in order to create a longitudinal sample set. These samples included blood from venipuncture, dried blood spot cards, saliva, urine, stool, microbiome body swabs, capsule swabs, and skin biopsies. Blood was further processed to obtain aliquots of serum, plasma, extracellular vesicles, and PBMCs. **RESULTS:** Over 2000 sample aliquots were collected throughout the duration of the study. Omics assays performed include whole genome sequencing, direct RNA-seq, spatially resolved transcriptomics, single-cell RNA-seq, single-cell ATAC-seq, T-cell and B-cell immune repertoire sequencing, metagenomics, and metatranscriptomics. **DISCUSSION:** The objective of this project was to establish a foundational set of biospecimens and multi-omic approaches to perform consistently commercial spaceflight crews. This sample collection was a success, but also encountered challenges due to the unique nature of spaceflight studies. Challenges in sample collection include small crew sizes and inconsistent biospecimen collection locations. These issues can be mitigated with biospecimen sampling and protocol standardization. Challenges were also encountered when performing sample collection in microgravity due to differences in fluid dynamics. These changes altered the protocols for skin and capsule swabbing, saliva collection, and dried blood spot card collection during flight. These considerations should be addressed in biospecimen collection for future flights.

Learning Objectives

1. The audience will learn what types of biospecimens are collected from commercial astronaut crews.
2. The audience will learn the breadth of multi-omic assays used to study astronaut health.

[97] A BIOBANK TO SUPPORT THE FEDERATED STUDY OF PRIVATE ASTRONAUTS

Christopher Mason, Eliah Overbey
Weill Cornell Medicine, New York, NY, United States

(Original Research)

The New Space Era has expanded participation in crewed missions to include a higher proportion of civilian astronauts. Before July of 2021, only eight civilians had crossed the Kármán Line to view the Earth from space. Since then, 29 private astronauts have launched on a variety of vehicles, built and operated by multiple private companies, to suborbital and orbital destinations. With the prospect of high demand for commercial crewed missions, the ability to support the health and well-being of an increasingly diverse cohort of astronauts is imperative. Catalyzed by the formation of the Inspiration4 mission in 2021, the Space Exploration Company (SpaceX) embarked on a collaboration with investigators at Weill Cornell Medicine, the Translational Institute of Space Health (TRISH), and the University of Southern California to form the first Private Aerospace Biobank. This was the first attempt to collect biological specimens from an exclusively civilian crew on a mission operated entirely by a private launch provider. Over two thousand specimens were collected, including venous and capillary blood, saliva, stool, urine, skin biopsies, and microbial swabs using collection protocols suitable to the mission that were developed in close collaboration with the crew. These longitudinal samples were used for a multi-omic analysis of the crew, including genome, epigenome, transcriptome, proteome, microbiome, metabolome, exosome, telomere, single-cell V(D)J immunophenotyping and epitope maps, and spatial transcriptome analysis. This repository of biobanked specimens collected from the start of training to several months following splashdown, along with raw data, processed data, and metadata, will enable the global spaceflight community a means of studying private astronauts and offer an initial roadmap for specimen collection throughout the commercial space sector.

Learning Objectives

1. The participant will be able to list several types of omics protocols and analyses.
2. The audience will learn about the biospecimens that are banked for future research and the analyses that have been performed on the samples collected to date.

[98] INSPIRATION4: COMPREHENSIVE AND INTEGRATIVE SINGLE CELL MULTI-OMICS ANALYSIS OF THE IMMUNE SYSTEM OF SPACEX INSPIRATION4 MISSION CREWS

JangKeun Kim[1], Eliah Overbey[1], Jiwoon Park[1], Remi Klotz[2], Veronica Ortiz[2], Michael Schmidt[3], Deena Najjar[1], Krista Ryon[1], Jaime Mateus[4], Min Yu[5], Christopher Mason[1]
[1]*Weill Cornell Medicine, New York, NY, United States;* [2]*University of Southern California, Los Angeles, CA, United States;* [3]*Sovaris Aerospace, Boulder, CO, United States;* [4]*SpaceX, Los Angeles, CA, United States;* [5]*University of Southern California, New York, NY, United States*

(Original Research)

INTRODUCTION: Immune dysregulation during spaceflight is a well-known biological change during long and short-duration missions. However, high-resolution, single-cell studies in model organisms exposed to spaceflight are limited and single-cell studies performed on astronauts are scant. In 2021, the SpaceX Inspiration4 mission enabled single-cell multi-omics analysis of four astronauts, which enabled a state-of-the-art, multi-omic, single-cell profiling to address the gaps in our knowledge of the cellular response to space. **METHODS:** To comprehensively monitor and analyze the biological impact of 3-day short-term spaceflight on the astronaut immune system longitudinally, we generated single-cell multi-omics gene expression (GEX), transposase-accessible chromatin accessibility (ATAC), and V(D)J sequencing data from peripheral blood mononuclear cells (PBMCs) across 6 total pre- and post-flight timepoints. In addition, we comprehensively analyzed and integrated these multi-omics data with complete blood count (CBC) clinical test results and biochemical profiles. And we integrated single cell PBMC data with plasma proteomics, exosome proteomics, and skin spatial transcriptomics to compare the changes in different samples. **RESULTS:** Across a total of 140,916 cells, we found cell proportion, gene expression, chromatin accessibility, overrepresented DNA motifs in differentially accessible regions, clonal lineage, mutation profile, and trajectory change after spaceflight. Also, we found that those biological changes mostly revert back to normal within a few months after spaceflight. It is noted that immune-related pathways were up-regulated, and oxidative phosphorylation and metabolism-related pathways were down-regulated in most of the subpopulations. And we've found secretome (plasma and serum) responded differently, however, there are common changes between PBMCs and skin transcriptomics. **DISCUSSION:** These data represent the first integrative, single-cell, multi-omics analysis (GEX, ATAC, V(D)J) from an astronaut cohort, which is additionally supplemented with changes with CBC and cytokine measurements. We can leverage these data for future missions and to assist with risk mitigation and countermeasure development.

Learning Objectives

1. Understand the overview of single cell multi-omics study of Inspiration4 mission.
2. Understand the biological changes after 3-day space mission with multi-omics perspective.
3. Understand the biological meaning and potential therapeutic approach for the biological change from spaceflight.

[99] SPATIAL TRANSCRIPTOMICS AND MULTI-OMICS REVEAL HUMAN SKIN RESPONSES TO SPACEFLIGHT

Jiwoon Park[1], Christopher Mason[1], Eliah Overbey[1], Sunny Narayanan[2], JangKeun Kim[1], Braden Tierney[1], Evan Afshin[1], Krista Ryon[1], Namita Damle[1], Deena Najjar[1], Matthew MacKay[1]
[1]*Weill Cornell Medicine, New York, NY, United States;* [2]*Weill Cornell Medicine, Tallahassee, FL, United States*

(Original Research)

INTRODUCTION: During spaceflight, the human body is exposed to various factors unique to the space environment, and significant physiological adaptations and overall shifts in biological homeostasis

occur. The skin is a key physiological system sensitive to environmental change and serves multiple functions, including physical and immunological protection, microbiota homeostasis, fluid retention; however, only a few studies exist of the spaceflight's impact on the skin, and observations to-date are limited. **METHODS:** We performed 4 mm skin biopsies on the SpaceX Inspiration4 crews before (L-44) and after (R+1) spaceflight and used GeoMx™ Digital Spatial Profiler to quantitatively analyze spatially resolved, whole transcriptome gene expressions across 95 regions of interest and four compartments: outer epidermis, inner epidermis, outer dermis, and vasculature. From the transcript-level findings, we matched metagenomic and metatranscriptomic data from skin swabs obtained prior to biopsy, as well as single-cell sequencing data from isolated Human peripheral blood mononuclear cells. **RESULTS:** We observed the upregulation of genes related to general inflammatory responses and KRAS signaling across all regions in post-flight samples. We located the molecular and cellular microenvironment changes (e.g. interferon responses, DNA damages, epithelial barrier disruption, impaired regeneration) to specific tissue compartments. While all regions show consistent enrichment in inflammation-related pathways, damage and repair pathways were primarily in the outer epidermal regions. We also correlated the epithelial layer disruption with microbe changes from skin swab metagenomics and immune cell (macrophage and T) activation with PBMC single-cell data. **DISCUSSION:** These data represent the first-ever collection and multi-modal analysis of astronaut skin across skin spatial, metagenomic, metatranscriptomic, and single-cell sequencing data. From spatial data, compartment-specific changes in damage/repair-related pathways from the expected stressors and changes occur during spaceflight, primarily in the outermost epidermis and related to epithelial barrier disruption. We correlated some of these molecular changes to previously known and novel skin microbial changes and validated these observations by comparing the immune composition and expression from PBMC data. The findings can inform future mission planning and countermeasures for inflammatory and immune system responses.

Learning Objectives

1. The participants will be able to understand the molecular impact of spaceflight on skin tissue
2. The audience will learn about the standardized omics collection approaches for spaceflight samples

[100] THE METAGENOMIC AND METATRANSCRIPTOMIC ARCHITECTURE OF HUMAN AND SPACECRAFT MICROBIOME ALTERATIONS DURING SHORT-TERM SPACEFLIGHT

Braden Tierney, Chris Mason
Weill Cornell Medical College, New York, NY, United States

(Original Research)

INTRODUCTION: The drivers of variation in host-microbe interactions during spaceflight are not fully understood. Given the substantial role both spaceflight and microbes play in altering human physiology, understanding the dynamic interactions therein is of the utmost import. However, identifying how host-microbe relationships change in space has proven difficult due to limited datasets of sufficient sample size. **METHODS:** During the 2021 Inspiration4 mission we collected the largest-to-date, longitudinal, metagenomic and metatranscriptomic cohort from four individuals before, during, and after spaceflight across a total of 8 timepoints. In total, this dataset comprises 360 samples from 10 human body sites and 10 environmental sites from the Dragon capsule. **RESULTS:** We generated a series of resources for the community, including (1) non-redundant gene catalogs, (2) microbial taxonomic abundances, and (3) functional annotations (i.e., antimicrobial resistance genes) data. We identified the landscape of bacterial and viral activation in flight, noting substantial, pan-phyletic viral activation during flight. We additionally found consistent loss and gain and biomedically relevant microbial taxa before and after flight, indicating potential long-term impacts of space travel on the human microbiome. Finally, we quantified the nature of inter-individual variation in the host microbiome as a function of environmental (i.e., capsule microbiome) context. **DISCUSSION:** In summary, the consistent variations we observed in this longitudinal data resource indicate the utility of tracking metagenomic data while in space to estimate how its changes may impact astronaut health.

Learning Objectives

1. The participant will understand content of the microbiome resource we constructed relating to short-term spaceflight and its long-term impacts.
2. The audience will learn about the composition of and drivers of microbiome (bacterial and viral) shifts during spaceflight and how they may impact host health. We will specifically highlight consistent shifts in bacterial and viral composition that are relevant for human health.

[101] PROTEOMICS ANALYSIS FROM BLOOD PLASMA AND EXOSOMES OF I4 ASTRONAUTS REVEALS DISTINCT RESPONSES AFTER SPACEFLIGHT

Nadia Houerbi[1], Eliah G. Overbey[1], Jaden J.A. Hastings[1], Laura Iona Patras[1], Irina Matei[1], JangKeun Kim[1], Aaron S. Gajadhar[2], Daniel Hornburg[2], David C Lyden[1], Jaime Mateus[3], Christopher E Mason[1]
[1]*Weill Cornell Medicine, New York, NY, United States;* [2]*Seer Inc, Redwood City, CA, United States;* [3]*SpaceX, Hawthorne, CA, United States*

(Original Research)

INTRODUCTION: The human body has a broad range of responses to spaceflight, and some of the fastest changes occur in the vasculature, blood, and plasma during the first day in microgravity. Yet, limited data exists about the entire set of proteins (proteome) in blood, and there is almost no data on astronauts' exosome proteome. To address this gap in knowledge, we performed deep quantitative proteome profiling on four astronauts from the Inspiration4 mission, from both before and after flight. **METHODS:** Plasma from 4 astronauts was isolated at 3 timepoints pre-flight (L-92, L-44, L-3 days) and 3 timepoints postflight (R+1, R+45, R+82 days) from cell processing tubes (CPTs) and processed with Seer's Proteograph Analysis Suite. Briefly, Seer's standard 5-nanoparticle panel was used to enrich for low abundance proteins followed by LC-MS/MS proteomics analysis with data-independent acquisition (DIA) strategy. Exosomes were purified from plasma by sequential ultracentrifugation and proteins were isolated and measured with LC-MS/MS. **RESULTS:** We identified a total of 23,164 peptides mapping to 2,992 unique protein groups in the plasma. We compared identified 60 proteins that had significant differences in abundance immediately postflight (R+1) compared to preflight. Longitudinal analysis showed that most proteins return to preflight levels at R+82 while others remain dysregulated at R+82. Gene ontology enrichment analysis for the differentially abundant proteins showed an association with production of reactive oxygen species, collagen and extracellular matrix as well as lipid metabolism and lipoproteins. LC-MS/MS analysis of the isolated exosomes identified a total of 636 unique proteins with an average of 585 proteins per sample. Focusing on proteins differentially packaged immediately post return to Earth, we identified 8 proteins (HAGH, NUTF2, ACHE, ART4, PTPA, MPST, RUVBL1 and LXN) exclusively packaged in exosomes of R+1 samples. When comparing all postflight to all preflight samples, we identified 22 differentially abundant proteins in the exosomes. These proteins showed enrichment for inflammatory and immune response pathways as well as different metabolic pathways. **DISCUSSION:** Our results show that even short duration spaceflight can have a measurable impact on plasma protein abundance and exosome packaging that need further investigation.

Learning Objectives

1. The audience will learn about the effect of short-duration spaceflight on plasma proteome and exosomal proteome and which pathways are most affected by short-duration spaceflight.

2. The audience will learn about the effect of short-duration of spaceflight on the plasma metabolome and examine what the main metabolic changes that occur are.

Monday, 05/22/2023 ***4:00 PM***
Grand Ballroom D-E

[S-19] PANEL: THE RISK MANAGEMENT IN AVIATION MEDICINE

Sponsored by SOFRAMAS

Chair: Olivier MANEN
Co-Chair: Jonathan Monin

PANEL OVERVIEW: *The first objective of aeromedical examiners (AME) working alone or being part of aeromedical centers (AeMC) is to make a decision for every kind of health problem and every type of aircrew specialty. AME should not be attempted to declare someone fit to fly too rapidly, but also unfit too easily as an excessive way of management, all the more as there are professional constraints to take into consideration: military aircrews are frequently working in tense operational circumstances including high level of qualification and overseas deployments, and civilian aircrews have commercial and financial constraints that have not decreased in the post-Covid context with a present wish or a need to recover the same flying activity as in 2019. All these professionals do not hesitate to make pressure on their AME during the time of periodical examinations. As a consequence, in the continuation of progress in medicine, it is a necessity that AME regularly question themselves about their aeromedical practice, including for health problems that could be considered as well known and so well managed. Key elements to consider include the evolution in the diagnostic and therapeutic methods, the new medications and the increasing part of instrumental technics particularly, sometimes a change in the philosophy of expertise and potentially new risks to imagine. In this context, this panel will present the updated management of different situations which are part of the daily activity of AME in Percy AeMC: kidney stone disease, atrial fibrillation, self-medication, vestibular disorders, and psychological troubles in UAV pilots.*

[102] FLIGHT SAFETY RISK ASSESSMENT OF SELF-MEDICATION AMONG FIGHTER PILOTS

Thomas Chiniard[1], François Guénot[2], Elise Dib[3], Mathilde Du Baret de Limé[4], Sébastien Bisconte[5], Olivier Manen[5], Jonathan Monin[5]
[1]*Bégin Military Hospital, Saint-Mandé, France;* [2]*Nuclear Missile Submarines Squadron, Brest, France;* [3]*1st Medical Center, Vincennes, France;* [4]*Legouest Military Hospital, Metz, France;* [5]*Percy Aeromedical Center, Clamart, France*

(Original Research)

INTRODUCTION: Fighter pilots are a specific population in which any adverse drug reaction (ADR) can interact with aeronautical constraints in unpredictable ways. Hence, self-medication may compromise flight safety. However, data on this issue are scarce and have never been considered from the perspective of a risk assessment process. This study aimed at providing a semi-quantitative evaluation of the risk to flight safety of self-medication in fighter pilots. **METHODS:** This was an ancillary study of a cross-sectional survey that aimed at identifying the determinants of the practice in this population. A pre-specified secondary objective was to list all medications reported to have been consumed in the 8 hours preceding a flight. Using a modified healthcare Failure Mode and Effects Analysis process, any ADR reported in the French marketing authorization of a drug was considered as a failure mode. The likelihood and presumed impact were evaluated using specific scales to assign each of them to three risk criticality categories: acceptable, tolerable, and unacceptable. **RESULTS:** Of the 170 fighter pilots who responded to the initial study, 78 reported having ever used self-medication in the 8 hours preceding a flight. Thirty-nine different drug trade names, encompassing 48 different international nonproprietary names, were listed. A total of 107 different semantic groups of ADRs were identified, for a total of 694 ADRs. The risk criticality was considered unacceptable for 10 ADRs from 6 different drugs, tolerable for 152 ADRs from 31 different drugs, and acceptable in the remaining cases. **DISCUSSION:** This analysis suffers from numerous limitations. First, the retrospective, declarative and non-dedicated design of the study introduces many biases. Second, the data collection from the marketing authorizations often fails to provide a robust assessment of ADR frequency "in real life". Third, the qualification of ADR severity still relies on experts' opinions rather than objective criteria. Fourth, the 8 hours time frame before a flight may not be relevant, depending on the drug. Nevertheless, this is the first attempt to provide a semi-quantitative evaluation of the risk to flight safety of self-medication in fighter pilots. This analysis suggests that the overall risk may be tolerable.

Learning Objectives

1. This study proposes a modified healthcare Failure Mode and Effects Analysis process to evaluate the risk to flight safety of self-medication in fighter pilots.
2. This analysis suggests that the risk to flight safety of self-medication in fighter pilots may be tolerable.

[103] RISK ASSESSMENT IN AVIATION WHEN A VESTIBULAR PATHOLOGY OCCURS: THE IMPORTANCE OF EQUITEST.

Salomé Marty
Percy Military Hospital Aeromedical Centre, Clamart, France

(Education - Tutorial/Review)

INTRODUCTION: Equilibration is a multimodal function based on information given by 3 sensorial systems: vision, proprioception and vestibule in the terrestrial referential. Vestibular nuclei integrate this information, and analysis occurs in vestibular centers in the cortex. When information matches, spatial orientation is possible without dizziness or instability. In a plane, the sensorial system is based on the plane and not on the terrestrial environment. Because of this different referential, sensorial illusions will be able to happen with spatial disorientation. Therefore, it is essential that aircrew member have a good equilibration function. **TOPIC:** Equitest, computerized dynamic posturography is the only test permitting the study of the 3 sensorial pieces of information used for equilibration. It allows paraclinic evaluation of equilibrium disorders, diagnosis, and reeducation orientation. It is a test rarely used in France; it is only used in ENT service in the Percy aeromedical center (AeMC Percy). When a patient describes dizziness or instability or presents a vestibular dysfunction, Equitest is essential to evaluate compensation strategies. **APPLICATION:** Our study encompasses all aircrew members with vestibular disease necessitating Equitest realization between 2014 and 2022 for aptitudes in AeMC Percy (vestibular schwannoma, vestibular neuritis, superior canal dehiscence syndrome). Some patients were temporarily prohibited to fly because of initial pathological Equitest results. After vestibular reeducation, Equitest results normalized allowing for positive aptitude files. In all cases presented to the commission with normal Equitest results, aircrew members were able to obtain for flight aptitude sometimes without limitation. Our presentation will be illustrated with demonstrative clinic cases. **RESOURCES:** Voorhees RL. The role of dynamic posturography in neurotologic diagnosis. Laryngoscope. 1989 Oct;99(10 Pt 1):995-1001.

Learning Objectives

1. The audience will learn about importance of vestibular function for aircrew members.
2. The audience will learn about the paraclinical exam of vestibular function.

[104] RISK MANAGEMENT OF KIDNEY STONES IN AVIATION MEDICINE

Jonathan Monin[1], Gaëtan Guiu[1], Sébastien Bisconte[1], Thomas Chiniard[2], Eric Perrier[1], Olivier Manen[1]
[1]*Aeromedical Center, Percy Military Hospital, Clamart, France;* [2]*French Military Health Service Academy, Paris, France*

(Original Research)

INTRODUCTION: The occurrence of renal colic is very frequent in the general population, with approximately 120,000 episodes of renal colic per year in France. For aircrew members, the low hygrometry and the lack of hydration during flight may favor the crystallization of urine in predisposed subjects. In addition, some studies tend to show that accelerations and vibrations could favor stone migration. The occurrence of renal colic in flight is a rare but not exceptional phenomenon, which may jeopardize flight safety in case of in-flight incapacitation, but which may also be a loss of chance for the health of the pilot. Thus, we decided to perform a study to assess the risk management of kidney stones in aircrew members. **METHOD:** This is a retrospective study including all aircrew members with a history of urinary lithiasis at risk of recurrence, who performed a visit in our aeromedical center between 2011 and 2021. We decided to exclude cabin crews in order to have a homogeneous population about consequences on flight safety. Numerous data were collected including flight duty, military/civilian status, lithiasis characteristics (size, localization, symptoms, treatment, recurrence risk factor…) and fitness assessment. The evolution of stones during the follow-up was also studied. **RESULTS:** Nearly one hundred aircrew members were included in this study mostly male, civilian pilots. The fitness assessment is correlated with the recurrence risk assessment, with, for example, a multi pilot limitation and an unfitness for overseas deployments in case of residual kidney stones. Thus, a fit decision is less likely in jet fighter pilots and/or solo pilots. Indeed, renal stone migration or renal colic were not uncommon phenomena in case of residual lithiasis. **DISCUSSION:** The study underlines the logical link between fitness assessment and recurrence risk assessment. Fighter pilots, solo pilots, and military aircrew members who may be deployed overseas are a particular issue in this context. It is important to remember the role of the flight surgeon or the aeromedical examiner in advising aircrews with kidney stones, especially regarding treatment.

Learning Objectives

1. To know the specific risk factors of renal colic in aircrew members.
2. To understand the elements leading to a fit or unfit decision in aircrew members with kidney stones.

[105] PSYCHOLOGICAL RISK MANAGEMENT IN REMOTELY PILOTED AIRCRAFT "DRONE" OPERATORS IN THE FRENCH AIR FORCE

Laëtitia Marion[1], Myriam Leon[2], Frédérique Gignoux-Froment[3]
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(Education - Case Study)

INTRODUCTION: The first remotely piloted aircraft (RPA) was developed during the First World War by a French engineer and an officer. The need to develop unmanned observation aircraft arose because of the loss of airmen in combats. Today, the French Air Force uses various RPA for intelligence, surveillance and target designation. The most complex missions are carried out with the MQ-9 reaper RPA. In addition to the operators' confrontation with the viewing of violent images, these devices have been armed for several years which could arise the risk for the pilots' mental health. **CASE DESCRIPTION:** Through the experience acquired during the follow-up of crews and the occurrence of a rare aeronautical event, the crash of one of these RPA, during which both individual and collective psychological debriefings were carried out in the immediate aftermath, we will describe the psychological manifestations that can occur within the crews. We will detail the protective factors we found and also the elements we are looking for in risk management on the medical-psychological level, in particular the elements allowing the early detection of the manifestations of psychological distress, their management and the evaluation of the operational fitness. **DISCUSSION:** After a serious aeronautical event, anxiety and signs suggestive of a traumatic encounter can appear. Outside this context the disorders most likely to be highlighted are polymorphous and are not necessarily linked to a characterized psychological disorder. On the other hand, these elements must be considered in the context of fitness assessment, in order to avoid a health deterioration of the airman, to preserve group functioning and flight safety. A medico-psychological support is provided by the military health service and the French air force for RPA crews. This dynamic and continuous support begins at the time of their selection, and ends when they leave the army, including training, preparation and return from an operational mission, as well as dealing with any difficulties that may arise during their professional career.

Learning Objectives

1. To better understand the specific mental health risks in remotely piloted aircraft crews.
2. To underline the need of specific medico-psychological support and fitness assessment in this population.

Abstract #106 was moved to Poster session: Clinical Medicine & Safety, Thursday, May 25, at 10:00 AM in Nottoway and Oak Alley.

[107] IMPACT OF MODERN MANAGEMENT OF ATRIAL FIBRILLATION ON THE DECISION-MAKING PROCESS IN AIRCREW

Olivier Manen[1], Anthony Delalande[2], Jonathan Monin[1], Gaëtan Guiu[1], Jean-François Oliviez[1], Caroline Brescon[1], Sébastien Bisconte[1], Eric Perrier[1]
[1]*Percy Military Hospital Aeromedical Centre, Clamart, France;* [2]*Bégin Military Hospital, Saint-Mandé, France*

(Original Research)

INTRODUCTION: Atrial fibrillation (AF) is the most frequent sustained arrhythmia. Previous studies had shown a young age in the French aircrew hospitalized for AF. The flight safety may be jeopardized and +Gz accelerations can act as a modulating factor of recurrence. However, the last decade has shown in Europe an increasing place of direct oral anticoagulants and ablation procedures in care medicine, the acceptance of anticoagulation in the EASA regulations as well. **METHODS:** We present a descriptive observational retrospective study. The inclusion criteria of the cohort were to be an aircrew or ATC, to have presented AF episode(s) from April 2013 to April 2022 and to have been examined in Percy military hospital AeMC after treatment. The main objective was to describe the aircrew population with AF episode(s), to observe the key elements for the final decision and to analyze the impact of operational limitations on the career or the leisure flying activity. The secondary objective was to compare the methods of treatment between aircrew and the general population (including the use of radiofrequency ablation), and to evaluate the impact of modern therapy in the return to flying/working duties. **RESULTS:** Preliminary results show a population of 60 aircrews: 58 men and 2 women, 52 pilots and 8 with other functions, 49 civilian and 11 military individuals. Most of them were experienced aircrews but 17 had less than 1,000 flying hours. The mean age of diagnosis was 55 years old, with no symptom in 60% of cases, and an occurrence at rest for 52 aircrews, during exercise for 7 or during a flight for 1. Investigations were in favor of one etiology for 12 aircrews, predisposing factor(s) for 14 and idiopathic AF for 34. CHA_2DS_2Vasc score (from 0 to 4) was ≥1 in 55% of aircrews. Seven aircrews recovered a normal rhythm spontaneously, 22 required a cardioversion, 28 were prescribed anti-arrhythmic drugs or betablockers, 4 were initially referred to ablation. Finally, 42% have been

using a long-term anticoagulant treatment. Other results will focus on the decision to return flying solo and/or on high-performance aircrafts by the competent aeromedical authority. **DISCUSSION:** It is important to give information to aircrew with AF about the link between treatment and decision, not to incite to an aggressive treatment but to help them to make the best choice.

Learning Objectives

1. To know the determinants of the decision-making process in aircrew suffering from AF.
2. To be aware of the possible impact of modern therapeutic approach in the aeromedical decisions and limitations.

Monday, 05/22/2023 ***4:00 PM***
Grand Chenier

[S-20]: SLIDES: MISC: CANCER RISK, HIV, WAIVERS, DCS, & URTICARIA

Chair: Paul Young
Co-Chair: Warren Silberman

[108] DELIVERING GENETICS AND CANCER RISK ASSESSMENT TO ASYMPTOMATIC, DISEASE-FREE AVIATORS FOR PREVENTATIVE MEASURES

Halle Lindsay
David Grant Medical Center, Fairfield, CA, United States

(Education - Program/Process Review)

BACKGROUND: Aircrew have an occupational cancer risk due to ionizing radiation exposure, circadian rhythm disruption and air quality. There is a need to mitigate risks through cancer screenings and lifestyle modifications. However, a barrier to genetic cancer risk assessment is delivering information to patients. This presentation will provide aerospace practitioners an approach to genetic counseling and testing to develop countermeasures. **OVERVIEW:** Flight crew are exposed to gamma, x-ray and ultraviolet radiation at aviation altitude. In further investigation, a study found U.S. Air Force (USAF) aviators have increased incidence in testicular cancer, melanoma skin cancer and prostate cancer when compared to other USAF officers. Another study, found higher cancer prevalence of breast, melanoma, and other skin cancers among flight attendants when compared to other participants with the same race and socioeconomic status. Due to occupational cancer risks, there is a need to increase surveillance and modify lifestyles risks among aircrew. For the U.S. general population, the U.S. Preventive Services Task Force recommends certain cancer screening guidelines be based on individual discussion between patient and provider. Therefore, it would be beneficial to enhance cancer screening, identify pre-disposing cancer genes, and encourage lifestyle changes for modifiable risks. The expected gains can be weighed against potential patient anxiety. Effective delivery of information is vital for educating, testing, interpreting results and providing support. There are various models to deliver genetic risk cancer assessment varying in professionals involved and presentation type, such as, group presentation or individual counseling. For the population at-risk, we will provide a group presentation to discuss occupational cancer risks. In addition, there will be an opportunity for genetic testing for the results to guide lifestyle changes. This process will include oncologist and geneticist to advise interpretation of results. **DISCUSSION:** With increased cancer incidence among aircrew, there is importance in cancer surveillance and lifestyle modifications to optimize aerospace medical readiness. These efforts have value in providing a targeted approach to educate and support the aircrew in order to develop countermeasures.

Learning Objectives

1. The audience will review the various types of cancer risks associated with aviation.
2. The audience will gain methods to deliver genetics and cancer risk assessment counseling to aviators.

[109] ESTIMATION OF CANCER RISK (SOLID TUMORS) FOR THE ACTIVE CREW MEMBERS OF A MAJOR AIRLINE: A SIMPLE METHOD FOR THE OCCUPATIONAL PHYSICIAN

Michel Klerlein
Air France, Roissy Charles de Gaulle, France

(Original Research)

OBJECTIVES: To provide an acceptable estimate of incidental cancer risk for a currently working crewmembers population, based on occupational health data available in the intern occupational medicine database. **METHODS:** We used the French incidence data to calculate the expected number of cases in a stable population of about 20,000 flight crews for 20 years, and to estimate the risk by the standardized incidence ratio (SIR) from solid tumor cases reported to the occupational physician. SIRs and their Confidence Intervals were based on the Byar's approximation of the exact Poisson distribution and the Chi square test. The study included 384148 person-years (204,199 women – 179,948 men) from 2000 to 2020, in 7 age groups. 459 solid tumors cancer were reported (283 in women – 179 in men). **RESULTS:** The data were used to calculate the incidence ratio in relation to the French population for a period of 20 years (2001 - 2021) and show an overall under-incidence for the main solid tumors of interest in flight personnel (melanoma - breast cancer - prostate cancer - thyroid cancer). The standardized incidence ratios all remained significantly lower than 1. More precisely, the figures were: For women: 0.47 (All cancer sites) - 0.48 (Breast) - 0.48 (Melanomas) - 0.26 (Thyroid) - 0.33 (Kidneys). For men: 0.36 (All cancer sites) - 0.25 (Prostate) - 0.67 (Melanoma) - 0.47 (Thyroid) - 0.54 (Kidneys). **DISCUSSION:** These reassuring results are biased mainly by the healthy worker effect, and by possible under-reporting, but nevertheless indicate the absence of a clear hazard signal. The main objective of the study is also met, since it demonstrates the possibility of making an acceptable estimate of the incidence ratios thanks to the data published in France which provide estimates of incidence by age group allowing the standardization of our calculations.

Learning Objectives

1. Getting knowledge of the level of cancer incidence among active aircrews in a major airline.
2. Understanding a simple method to estimate the standardized incidence ratios and their confidence intervals.

[110] EVIDENCE BASED AEROMEDICAL RISK ASSESSMENT OF CUTANEOUS MELANOMA USING UPDATED STAGE SPECIFIC PROGNOSTIC DATA FROM THE AJCC 8TH EDITION

Ganesh Anbalagan
CASA Australia, Canberra, Australia

(Education - Program/Process Review)

BACKGROUND: Australia has the highest age standardized incidence rate of melanoma in the world. Although the incidence of melanoma in Australia has increased in the last decade, the melanoma mortality rate has declined recently. As the prognosis of melanoma skin cancer is improving, prognostic data from the current 8th edition American Joint Committee on Cancer (AJCC) international melanoma database was used to estimate the stage-based risk of recurrence and risk of incapacitation for aircrew diagnosed with cutaneous melanoma skin cancer. **OVERVIEW:** Recent evidence in the literature was reviewed to update the prognostic data on risk of recurrence, sites of recurrence especially the central nervous system as it can present with incapacitating symptoms, and the risk of mortality. The melanoma specific survival data from the International Melanoma Database (AJCC cohort) was used to estimate the annualised risk of mortality, which was used as a surrogate marker for risk of recurrence as the progression free survival or distant metastases

free survival was not available for the larger international melanoma database cohort. One of the key aeromedical concerns of melanoma is its ability to metastasise to virtually any organ or tissue and melanoma has the highest risk of brain metastasis among common solid tumours. As the incidence of brain metastasis increased with the stage and the risk remained elevated in the early years after diagnosis, stage specific 5-year cumulative incidence of CNS metastasis was used to estimate the risk of brain metastases. Brain metastases was given a 100% incapacitation risk weighting in risk of incapacitation estimation. Stage- specific annualised percentage risk of incapacitation for melanoma was calculated as a product of risk of recurrence in each year, risk of brain metastases and weighting factor of 100. **DISCUSSION:** Using the Civil Aviation Safety Authority (CASA) of Australia's acceptable risk threshold for aviation medical certification, AJCC 8th edition stage specific certification assessment guidance chart was developed based on the updated prognostic data. This presentation will cover the aeromedical concerns of melanoma, CASA's approach to aeromedical decision making of melanoma and the risk assessment guidance chart.

Learning Objectives

1. The participant will learn about the principles of aeromedical risk assessment of melanoma.
2. The participant will learn about the estimated risk of incapacitation for each stage of melanoma and when does the risk drops below the acceptable level of certification for advanced melanoma.

[111] PRESSURE URTICARIA IN A CAREER ENLISTED AVIATOR FOLLOWING A HIGH-ALTITUDE RAPID DECOMPRESSION

Christina Ingram, David Blum, Whitney Doiley Hawkins
U.S. Air Force, Joint Base San Antonio-Lackland, TX, United States

(Education - Case Study)

INTRODUCTION: This case report described pressure urticaria presentation in a airborne mission systems operators following a high-altitude rapid decompression. **BACKGROUND:** The patient was a 35-year-old male with no previous history of pressure related disorders. He had an insignificant flying physical prior to technical school and no DNIFs outside of acute colds or soft tissue injuries. He had roughly 1,700 hours at the time of the event. The patient was a regular high-altitude research subject for 9 months prior to the event. He had participated in 9 rapid decompressions to altitudes up to FL300 prior to the event. **CASE PRESENTATION:** The patient participated in a rapid decompression to FL450 in preparation for a planned high-altitude research activity. The patient had no adverse presentations immediately post-exposure and returned home. The next day, the patient woke up and was notified by his spouse of "lumps" along his back. The patient contacted the research coordinator and was advised to go to BAMC for a suspected decompression sickness presentation. He was dove in the hyperbaric chamber for 1.5 hours and put on steroids for two weeks by the treating flight surgeon. After the course of steroids, the patient experienced a return and increase in severity of symptoms. The patient was prescribed three different types of antihistamines to be taken twice daily. The patient experienced relief from symptoms but severe degradation in quality of life. During this time, the patient was diagnosed with uncontrollable pressure urticaria. **DISCUSSION:** Under treatment by a flight surgeon, the patient was prescribed cyclosporine which was unsuccessful, but also started a waiver process prematurely. The patient was disqualified by the MAJCOM SGP and ultimately prescribed Xolair (300mg) to control his symptoms.

Learning Objectives

1. The audience will learn about development of pressure urticaria following a rapid decompression.
2. The audience will learn about treatment following pressure urticaria in a career enlisted aviator.

[112] UK CAA'S UPDATED HIV POLICY AND REVIEW OF UK LICENSED PILOTS LIVING WITH HIV

Ewan Hutchison
UK Civil Aviation Authority, Crawley, United Kingdom

(Education - Program/Process Review)

BACKGROUND: The UK CAA initially published guidance for the assessment of pilots living with HIV in 2008. There have been significant advancements in the management of HIV since, with improved life expectancy and quality of life. From 2015, all people with newly diagnosed HIV infection in the UK are offered anti-retroviral therapy (ART). As a result, most applicants applying for certification now have short periods between seroconversion and commencing therapy, normal CD4 counts and undetectable viral loads. **OVERVIEW:** Fitness assessments for aeromedical certification are based on assessing functional ability and incapacitation risk associated with any medical conditions an applicant has declared. With HIV seropositivity, the risks arise from secondary infections/AIDS defining conditions and associated co-morbidities such as mental health conditions, cardiovascular disease and the adverse effects of medication. There are also concerns about the development of neurocognitive impairment (NCI) and a number of risk factors have been identified for this. The UK CAA has updated its policy for assessing applicants living with HIV with co-operation and expert input from the British HIV Association. It is possible for applicants with well controlled infection, no demonstrable NCI and/or low risk for developing NCI to obtain unrestricted Class 1 certification. Publishing our guidance improves the transparency of our assessments and helps applicants living with HIV to make decisions about training for a commercial pilot's licence. The UK CAA announced a period of reset, where certificate holders who had previously failed to declare their HIV seropositivity could do so without risk of enforcement action. The medical history of 28 Class 1 applicants/certificate holders living with HIV, including 18 currently flying, were reviewed against the new policy. **DISCUSSION:** The issuance of medical certificates to applicants living with HIV who wish to start training for a commercial pilot's licence remains controversial in some parts of the world, as does the need for regular formal neurocognitive testing. We believe that the UK policy provides a safe and pragmatic assessment of fitness and makes it more likely that pilots will declare their status so that they can have a proper and fair assessment of their fitness.

Learning Objectives

1. The audience will learn about the risk factors for incapacitation that arise from HIV infection.
2. The audience will learn about the UK CAA's updated policy for assessing fitness of applicants living with HIV.

Monday, 05/22/2023 ***4:00 PM***
Napoleon Ballroom C1-C2

[S-21]: SLIDES: NEW ANGLES IN HUMAN SYSTEMS INTEGRATION

Chair: Jamie Harvey
Co-Chair: Connie Ramsburg

[113] INFLUENCE OF SEAT BACK ANGLE AND FLIGHT JACKET WEAR ON WORK OF BREATHING

Ross D Pollock[1], Mani Coonjobeeharru[1], Ilya Bychkov[1], Leann Maanum[1], Aiden Coffey[2], Camille Bilger[2], Gerreard F. Rafferty[1], Caroline J. Jolley[1], Peter D. Hodkinson[1], Thomas G. Smith[1]
[1]King's College London, London, United Kingdom; [2]Martin-Baker Aircraft Company, London, United Kingdom

(Original Research)

INTRODUCTION: Altering the seat back angle in a fast jet may be considered as a mean to improve G-tolerance or comfort, however, the altered gravitational vector could increase work of breathing (WoB). The additional mass of a flight jacket and the items stored within it could further increase this load. Given the suggested relationship of some unexplained physiological events with WoB and the potential for seat back angle to influence this the current study aimed to determine the effect of seat back angle and flight jacket mass on WoB. **METHODS:** Eight healthy participants (3 males, 5 female) were secured in an ejection seat reclined to 20°, 35° and 50° using a 5-point harness. Testing was performed with and without a flight jacket which had a 5kg mass distributed in 2 pockets over the lower thorax. A gastro-oesophageal pressure catheter was used to determine transdiaphragmatic pressure-time-product (PTP_{di}) providing an index of WoB. Neural respiratory drive index (NRDI) was determined from surface electromyography of the parasternal intercostal muscles. Tidal volume (Vt), respiratory rate (RR) and minute ventilation (Ve) were recorded using a pneumotachograph. Each test condition lasted 3 mins with the participant breathing normally. All procedures were approved by a local ethics committee. **RESULTS:** PTP_{di} increased significantly (up to 60%) with more reclined seat back angles. Wearing a flight jacket increased PTP_{di} by 38% at a seat back angle of 50°. No effect was observed at 20° and 35°. Overall NRDI was significantly greater when wearing a flight jacket but was unaffected by seat back angle. Seat back angle and use of flight jacket had no effect on any other respiratory variables. **DISCUSSION:** Overall, WoB was increased with more reclined seat back angles, and further exacerbated at greater angles of recline (50°) when using a flight jacket. There was minimal effect of wearing a flight jacket on WoB in more upright postures. If ejection seats with greater angles of recline are to be used consideration should be given to lowering or redistributing the mass of the flight jacket (and associated equipment) to limit the impact on WoB.

Learning Objectives

1. Understand the influence of ejection seat back angle on work of breathing.
2. Describe the influence of fight jacket use in combination with changes in seat back angle on work of breathing.

[114] BREATHING RHYTHM COMPLEXITY AS AN INDICATOR TO RESPIRATORY COMPROMISE FOR FUTURE FLIGHT DECK SYSTEMS

Nicholas Napoli[1], Jeremy Prieto[1], Rheagan Pratt[1], Chad Stephens[2], Kellie Kennedy[2]

[1]*University of Florida, Gainesville, FL, United States;* [2]*NASA Langley Research Center, Hampton, VA, United States*

(Original Research)

INTRODUCTION: Detecting the impact of respiratory loads and stressors on the respiration system is critical to understanding the dynamics within the respiratory system and the stresses imposed on the human within flight deck systems. Analysis of breathing rate, frequency, and period has been a commonly conflated terminology that is utilized in evaluating breathing. We propose a new approach to analyzing respiratory compromise using the induction of hypoxia, called Breathing Rhythm Complexity. **METHODS:** Professional pilots served as test subjects (n=57, 49 males) in a study involving simulated altitudes of sea level (21.0% O2) and 15,000 feet (11.2% O2) induced by an Environics, Inc. Reduced Oxygen Breathing Device (ROBD). Each subject experienced both non-hypoxic and hypoxic (SPO2 <= 95%) exposures while performing three 10-minute tasks (computerized neuropsychology tests, computerized multitasking battery, and fixed-based flight simulation). The quantitative approach leverages our understanding that the respiratory signal is not composed of a pure sinusoidal wave. The waveform is decomposed at its zero-crosses to calculate individual inspiratory and expiratory times. The difference between these times is calculated using sample entropy, producing Breathing Rhythm Complexity. **RESULTS:** Preliminary results comparing the hypoxic and non-hypoxic cohorts demonstrated no significant changes in time of inspiration and time of expiration variance and complexity (sample entropy). However, when observing respiratory rhythm complexity, a comparison between the cohorts demonstrated significant changes in respiratory rhythm complexity (sample entropy), achieving $p < 0.0214$. **DISCUSSION:** The preliminary results indicate the induction of hypoxic events and their impact on breathing rate, frequency, period, and rhythm under respiratory stress. The implications of these results suggest that a subject's breathing rate, frequency, and period may not always distinguish respiratory stress, but the dynamic nature of the breathing rhythm can. This understanding of breathing rhythm complexity can provide beneficial information into the nature of how human physiological systems (e.g. respiration) compensate under respiratory stress.

Learning Objectives

1. [The audience will learn about...] the importance of breathing rhythm complexity and its impact on respiratory compromise.
2. [The audience will learn...] the importance of extrinsic loads and environmental factors, such as hypoxia, and their impact on the respiratory system.

[115] ENDOTRACHEAL INTUBATION EFFICACY IN HELICOPTER CABIN VS. GROUND: A SYSTEMATIC REVIEW AND A META-ANALYSIS

Lydia Johnson Kolaparambil Varghese[1,2], Jochen Hinkelbein[3], Edoardo De Robertis[4], Jan Schmitz[3]

[1]*Università degli Studi di Perugia, Terni, Italy;* [2]*European Society of Aerospace Medicine Space Medicine Group, Cologne, Germany;* [3]*University Hospital Cologne, Cologne, Germany;* [4]*Università degli Studi di Perugia, Perugia, Italy*

(Original Research)

BACKGROUND: Pre-hospital endotracheal intubation (ETI) is a sophisticated procedure with a comparatively high failure rate. Especially, ETI in confined spaces may result in higher difficulty, longer times, and a higher failure rate. The aim of the present study was to analyze if HEMS intubation success and time are influenced by noise, light, restricted space in comparison to the ground intubation. The availability of literature reporting these parameters was very limited, thus we analyzed the reported differences between ETI in helicopter vs. ground by confronting parameters such as time to secure airway, first attempt success rate, visual Analog Scale (VAS) and Cormack-Lehane Score. **METHODS:** PUBMED, Cochrane Library and Ovid were consulted to perform a systematic review and meta-analysis in October 2022. Randomized control trails (RCTs) comparing ETI in helicopter to ground were included in the meta-analysis. The study was registered at the International Prospective Register of Systematic Reviews (PROSPERO) with number CRD42022361793. The database search provided 1049 studies, of which 3 studies met inclusion and quality criteria for the meta-analysis. **RESULTS:** The mean duration of intubation on helicopter was around 17,65 seconds vs. the 18,83s on ground. The median time to secure airway ± SD on helicopter was 217,00 s ± 16,00 vs 184,50s ± 46,50 on ground. The mean ± SD of the Visual Analogue Scala (VAS) on helicopter was 2,00 ± 1,00 vs 2,40 ± 0,40 on ground. Cormack-Lehane Score saw instead a mean ± SD of 1,33 ± 0,33 on helicopter compared to 1,26 ± 0,26 on ground. The difference of intubation success between each seems not to be significant. **CONCLUSION:** Further research is needed to assess the impact of environmental factors on the quality of ETI on HEMS.

Learning Objectives

1. The audience will learn about the differences in the airway management between a helicopter cabin and ground.
2. The participant will be able to learn the factors impacting the ETI in both environments, and the efficacy of each.

[116] DERIVING HELMET SYSTEM MASS PROPERTY REQUIREMENTS THAT MITIGATE AIRCREW NECK PAIN

Philip Farrell

DRDC, Toronto, ONT, Canada

(Original Research)

INTRODUCTION: Aircrew helmet systems have been designed primarily for blunt and crash protection. Over time, the helmet itself has become a key platform for communication, breathing, and enhanced vision systems, thus altering its mass properties with unintended consequences of unacceptably high aircrew neck pain prevalence rates. Recognizing that this debilitating pain negatively impacts mission success and aircrew careers, the Royal Canadian Air Force (RCAF) Hornet Extension Programme required that any newly acquired helmet system must reduce the risk of developing or aggravating aircrew neck pain. **METHODS:** A linear relationship is initially proposed between neck pain prevalence rates and mass properties for deriving helmet system mass property requirements. Known mass property values and prevalence rates were used from current in-service helmet systems – i.e., Joint Helmet Mounted Cueing System has higher inertia and prevalence rate (74%) than the 190A with Night Vision Googles (NVGs) that has lower inertia and prevalence rate (68%) – to define the slope of the line. The mandatory new helmet system inertia criteria was set at the inertia value of the 190A with NVGs. The point-rated criteria was based on the slope of the line: that is, the lower the proposed helmet system inertia, the more points were awarded to the proposal. **RESULTS:** This derivation yields two key observations. First, as the helmet system inertia moves down the positively sloped line, the prevalence rate also decreases proportionally, but at some point a helmet system with very low inertia, which also provides protection and a platform, becomes technologically infeasible. Second, the prevalence rate and mass property relationship is unlikely linear but more likely curvilinear (an S-shape). More than two points are needed to determine this relationship. Unfortunately, air forces may have only two points, namely, day- and night-configured helmet systems and associated prevalence rates. **DISCUSSION:** Despite these limitations, the RCAF successfully employed these requirements to assess industry proposals and make acquisition decisions for the fast air community. This represents a shift towards neck pain mitigation as a primary helmet system requirement. Perhaps several nations can pool their prevalence rate and mass property data points to better estimate this relationship.

Learning Objectives

1. Understand a shift in defining helmet system requirements based primarily on mitigating neck pain, secondly on a key platform for communication, breathing, and enhanced vision systems, and lastly on blunt and crash protection.
2. Understand that a linear relationship is not likely the true relationship and will yield a situation where the curve will reach a point where it is technologically infeasible to build a helmet system with very low inertia.
3. Understanding that finding a relationship between prevalence rates and helmet system mass properties is an empirical endeavor, and there may not be enough data points to adequately find this relationship.

[117] PREVALENCE OF BACK PAIN AND PREVENTIVE MEASURES IN THE SWISS AIR FORCE - EVALUATION OF THE LAST 10 YEARS

Denis Bron, Janine Rochelt, Nadja Saba, Sven Rochelt
Fliegerärztliches Institut, Dübendorf, Switzerland

(Original Research)

INTRODUCTION: The normal function of back and neck muscles is essential for Swiss Air Force pilots. In case of an imbalance, back pain may be a consequence. The results of a first examination in 2012 in the status of a student pilot were implemented to perform a regular preventive training. To review the measures taken, the data collected over the last 10 years on trunk strength testing and subjective back pain were evaluated. Furthermore, correlation analysis on aircraft, trunk stability and back pain has been done. **METHODS:** 454 male Swiss Airforce pilots participated in an annual standardized trunk strength test over the last 10 years. Additionally, they provided information about subjective back pain. To analyze the correlation between subjective and objective parameters, a linear regression was performed. **RESULTS:** 63.4% of all Swiss Airforce pilots suffer from back pain at least once in their lives. Of these, 44.1% have acute pain and 55.9% have chronic pain. 36.1% report feeling their pain in the lumbar spine, 20.8% in the cervical spine and 6.6% in the thoracic spine. 36.5% complain of pain in multiple locations in the back. No significant correlation was found between occupation and pain ($p=0.39$), as well as aircraft type and pain ($p=0.15$). There is a significant negative correlation between dorsal performance on the trunk strength test and subjective back pain ($p\leq0.05$) as well as between age and performance achieved ($p\leq0.01$). **DISCUSSION:** Almost two-thirds of pilots suffer from back pain at least once in their life. This high prevalence may be due to the occupationally related higher loads on the musculoskeletal system. Higher performance of the dorsal muscle chain has a positive effect on back health. The performance of the lateral and ventral muscle groups shows no significant correlation. The younger the pilots, the higher their performance on the trunk strength test. The regular coaching of the young pilot classes and the associated awareness of prevention may provide an explanation for this. Based on these findings, preventive training focusing on the dorsal muscle chains for student pilots will be continued and extended. In addition to this, even more specific mentoring of the existing flying professional personnel of the Swiss Air Force will be pursued.

Learning Objectives

1. Understand the correlation between performance on the trunk strength test and subjective back pain.
2. Learn about the measures taken to prevent back pain within the Swiss Airforce.

[118] LOGIC ANALYSIS OF PHYSIOLOGICAL AND SYSTEM MONITORING FOR HIGH PERFORMANCE JET AIRCRAFT

Aiden Coffey[1,2], Peter Hodkinson[1], Ross Pollock[1], Pete Marston[2]
[1]*Kings College London, London, United Kingdom;* [2]*Martin-Baker Aircraft Company Ltd., London, United Kingdom*

(Education - Program/Process Review)

BACKGROUND: Military aviation exposes aircrew to stressors that, without effective protection and mitigation, may degrade their ability to operate the aircraft and endanger their lives. Over the past 20 years there has been a rise in Unexplained Physiological Events (UPEs). However, in the absence of pilot physiological data, or often life support system data, investigators may be left to make inferences about UPE causation based on limited data, including how aircrew are affected by the event. UPEs have, therefore, renewed interest in pilot physiological monitoring, although targets for monitoring have yet to be widely agreed upon. Attempts at monitoring often lack adequate consideration of what is feasible to monitor, whether meaningful, accurate and reliable data can be obtained throughout the flight envelope, and how to use the gathered data. **OVERVIEW:** This presentation will challenge the role of physiological monitoring and advocate that, in many settings, systems monitoring is a more appropriate solution. This is based on a logic analysis to assess both system and physiological monitoring options, with the intent being to identify the best solution for the risk being addressed and associated operational use case. There will also be a proposal of a novel process and set of governing principles for the selection, test, and development of physiological and system monitoring. Operational use-cases will be discussed ranging from detection of physiological phenomena for a variety of in-flight uses through to post-flight analysis for e.g. training, incident or accident investigation. The different confidence levels in the system or physiological data required for each use-case will be compared. **DISCUSSION:** The implementation of monitoring systems will require adherence to an evidence-based development process. This process will require a set of principles to operate within, at the forefront of which is a critical logic-based analysis of what variable(s), be it system or physiological monitoring, is most appropriate. Where physiological monitoring is the best solution, it is vital that the measuring system be appropriately validated to have confidence in data gathered in the challenging environment of high-performance jet aircraft. Successful implementation of

these systems may improve safety of flight through access to previously unavailable in-flight physiological or system data. This work is of interest to both military and civilian aerospace professionals.

Learning Objectives

1. The attendee will understand how the military aviation environment complicates monitoring of human physiology.
2. The attendee will understand the different use-cases for physiological monitoring and why, in some cases, system monitoring is more appropriate.
3. The attendee will understand the different use-cases for physiological data collected in-flight.

Monday, 05/22/2023 ***4:00 PM***
Napoleon Ballroom D1-D2

[S-22]: PANEL: OPERATIONAL VISION II: VISUAL PERFORMANCE AND PROTECTION

Chair: Micah Kinney
Co-Chair: Adam Preston

PANEL OVERVIEW: *This panel will be part two in a two panel series on operational vision topics. Part two will review current research from the U.S. Air Force Operational Vision Assessment Lab (OBVA), Naval Medical Research Unit Dayton (NAMRU-D), and Australian Defense Science and Technology Group (DSTG) on topics related to visual performance and protection. First, OBVA will present results from a test-retest study of a novel vision screening apparatus, the Automated Vision Tester (AVT; Hedgefog Research Inc., San Pedro, CA). Results on the ability of the AVT to predict operational performance will be presented. Second, data will be presented from OBVA involving a multivariate analysis of AVT vision metrics from a large sample of USAF participants and how this may impact aviation selection. The third presentation will discuss NAMRU-D's research on gaze patterns and information-processing abilities of aviators in a flight simulator. These eye tracking metrics could be applied to gauge when visual performance enhancement plateaus in a training environment or to assess mental workload and task difficulty with eye tracking. Fourth, a presentation by DSTG on progressive multifocal lenses and their impact on aviator visual performance. Finally, a presentation from DSTG will discuss how laser eye protection impacts color vision performance among normal and color deficient aircrew. The implications from these findings stress the importance of balancing vision protection with visual performance.*

[119] VISION SCREENING PARAMETERS PREDICT OPERATIONAL PERFORMANCE IN A REMOTE 3D TASK

Jonelle Knapp, Margaret Hollander, Eleanor O'Keefe, Marc Winterbottom, Eric Seemiller
U.S. Air Force Research Lab, Dayton, OH, United States

(Original Research)

INTRODUCTION: Current United States Air Force (USAF) vision screening methods are based on WWII-era tests and are poor predictors of an Airman's ability to succeed in today's complex environments. Here, we investigate the test-retest reliability of a novel vision screening apparatus, the Automated Vision Tester (AVT; Hedgefog Research Inc., San Pedro, CA) and its ability to assess relationships between vision and performance. **METHODS:** Test-retest reliability data were collected from 43 participants (mean age 36 ± 8 years) using the AVT. Threshold-level metrics for AVT vision tests (visual acuity, achromatic contrast sensitivity (ACS), cone contrast sensitivity (CCS), stereo acuity, and vertical and horizontal phoria) were collected at near (16 inches) and far (20 feet) for each subject on two different days. Bland-Altman analyses were used to evaluate test-retest reliability for each AVT test; vision tests were considered reliable if its internal variance (95% limits of agreement) was less than its external variance (1.96 standard deviations). Next, we investigated the operational usefulness of AVT metrics to predict performance for a stereo 3D remote vision system (S3D RVS) virtual task. In the task, 13 participants were required to accurately align a mechanical gripper to drop a ball into a cup, placed at random positions horizontally and in depth as many times as possible within a 30-minute session. **RESULTS:** Most AVT tests (visual acuity, ACS, CCS, stereo acuity, and phoria) had good test-retest reliability. Two AVT tests had borderline acceptable test-retest reliability: low spatial frequency ACS at near (bias = 0.00; 95% limits of agreement = –0.12 to +0.10) and high spatial frequency ACS at far (bias = +0.02; limits of agreement = –0.20 to +0.24). Five AVT vision tests correlated with task performance: visual acuity (r=0.78); ACS low spatial frequency (r=0.43); ACS high spatial frequency (r=0.42); far horizontal phoria (r=0.47); and near vertical phoria (r=–0.52). **DISCUSSION:** The Automated Vision Tester provides reliable measures of visual acuity, CCS, stereo acuity, and phoria, though users should exercise caution when using ACS measures. The AVT's threshold-level vision metrics may be useful to investigate relationships between vision and performance; however, more data is needed to confirm the reliability and usefulness of AVT vision metrics given our small study sample.

Learning Objectives

1. Understand the utility of Automated Vision Tester (AVT) vision metrics for aeromedical applications, such as a remote vision system 3D virtual task.
2. Understand what characteristics vision tests/vision metrics need to be of use to investigate relationships between visual function and operational performance (e.g., good test-retest reliability, minimal ceiling floor effects, good granularity).

[120] MULTIVARIATE APPROACHES TO VISION SCREENING

Eric Seemiller[1], Jonelle Knapp[1], Eleanor O'Keefe[2], Marc Winterbottom[1], Steven Hadley[1]
[1]*U.S. Air Force, Wright-Patterson AFB, OH, United States;* [2]*KBR, Inc, Beavercreek, OH, United States*

(Original Research)

INTRODUCTION: Due to time constraints and test limitations, only a select number of vision tests can be administered to measure ocular health and assess medical fitness for duty. Personnel can be disqualified by failing a single test, even though they may score well above normal on the other tests. And, of course, there's considerably more to visual processing than one's ability to read a 20/20 letter on a chart. Thus, it may be more beneficial to consider the observer's visual system as a whole unit, rather than assessing fitness for duty using individual pass/fail criteria. It is increasingly feasible through big data methods to compile multivariate characterizations of the entire visual system, creating more powerful and predictive screening metrics. Here, we present two such methods and demonstrate their aeromedical screening utility. **METHODS:** The Automated Vision Tester (AVT) provides threshold level estimates of visual processing across 14 vision tests: achromatic contrast sensitivity at 3 optotype sizes, acuity, cone contrast sensitivity for 3 cones, 2 tests of motion coherence, and 5 tests of binocular function. 192 participants (including 22 USAF aerial refueling boom operators) provided data for each test. Estimated threshold values were used for multivariate analyses. **RESULTS:** A factor analysis revealed 5 latent factors in the dataset that explained 82% of the variance. They were related to 1) high spatial frequency vision, 2) binocular function, 3) color vision, 4) motion processing and 5) low spatial frequency vision. Comparing boom operators to the general public, factors 1 (d' = 1.611) and 2 (d' = 0.930) discriminated group membership better than their constituent variables. A second approach, discriminate function analysis, created a full dataset factor (d' = 1.262) that outperformed all individual variables for discriminating group membership. **DISCUSSION:** We present two multivariate approaches that treat simple vision screening metrics as parts of a more powerful whole. Both approaches created factors that discriminated the visual profile of an occupation better than single variables alone. This approach, combined with precise, threshold level vision tests, provides a method to identify redundancy and thus reduce the time required for aeromedical

vision screening. Additionally, treating the visual system as a whole, using multivariate factors, may predict operational performance better than single vision metrics alone.

Learning Objectives

1. The audience will learn to use and interpret big data methods for analyzing vision screening metrics.
2. The audience will learn to consider the visual system as a system rather than a series of individual measurements.

[121] QUANTIFYING AVIATOR VISUAL SCAN PATTERNS AND INFORMATION PROCESSING PROCIENCY IN A SIMULATED FIXED WING AIRCRAFT

Roy Hoffman, Lucas Haberkamp, Charles Weisenbach, Michael Reddix
U.S. Navy, Dayton, OH, United States

(Original Research)

INTRODUCTION: Aviators develop a more structured visual scan pattern and increased efficiency in extracting cockpit instrument information as they gain experience. Visual performance may be quantifiable by measuring eye movement and then calculating sample entropy and fixation duration. Sample entropy evaluates the visual scan pattern by measuring the degree of disorder or randomness over time, while fixation duration measures the information processing proficiency. Our study aimed to evaluate the validity of using these metrics to assess the aviator's visual performance. We hypothesized that while landing compared to other phases of flight, a more predictable gaze pattern (lower sample entropy) and higher fixation duration would occur. **METHODS:** Using a collimated-display flight simulator configured as a T-6A Texan II USN/USMC/USAF turbo-prop training aircraft, fourteen aviators with current or previous turbo-prop flying experience were directed to perform a five-phase flight. The phases consisted of 1) takeoff 2) new heading and altitude change 3) constant rate turn 4) new heading and altitude change 5) landing. Eye tracking data were collected with Smart Eye Pro (Smart Eye, Inc., Gothenburg, Sweden). Sample entropy and mean fixation duration were calculated for each phase. A repeated measures ANOVA and pairwise *t* post-hoc tests were used to evaluate differences between phases of flight. **RESULTS:** Sample entropy and mean fixation duration showed significant differences ($p<0.001$) between phases of flight. Pairwise *t* post-hoc tests found significant differences between landing and all other phases of flight. No independent significant differences were found between phases of flight 1-4, except for sample entropy between phases 2 and 4. **DISCUSSION:** Aviators appeared to have more predictable scan patterns and higher fixation durations during landing compared to other phases which supported our hypothesis. These results reflect the increased task difficulty and mental workload during landing. Sample entropy and fixation duration may be useful metrics to quantify the gaze patterns and information-processing abilities of aviators. These metrics could be applied to gauge when visual performance enhancement plateaus in a training environment or to assess mental workload and task difficulty with eye tracking.

Learning Objectives

1. Understand how visual performance, by measuring eye movement, is related to entropy and fixation duration.
2. Understand the differences and predictability during phases of flight of aviators' scan patterns and fixation durations in the cockpit and outside of the cockpit.

[122] METHODOLOGY TO EVALUATE OPTICAL LENS DESIGNS FOR MILITARY ROTARY WING PLATFORMS

Amanda Douglass[1], Renee Karas[2], Kate Coffey[1], Larry Abel[1], John Parkes[3], Maria Gavrilescu[2]
[1]*Deakin University, Geelong, Australia;* [2]*Defence Science and Technology Group, Melbourne, Australia;* [3]*University of Melbourne, Melbourne, Australia*

Original Research)

INTRODUCTION: Progressive multifocal lenses (PML) were prohibited for military aircrew when they first became available due to large peripheral aberrations, with operators restricted to bifocal lenses. Lens designs have improved significantly, with less aberrations therefore some services have recently allowed PMLs. Some concern has persisted for rotary wing (RW) aircrew, therefore a method to evaluate operationally relevant differences was developed. **METHOD:** In-depth interviews were conducted with instructor pilots to identify critical day and night vision tasks (including interaction with night vision devices and symbology) and current issues with optical correction within the cockpit in 3 rotary wing platforms. The size of critical elements in each task were recorded. Free-form PMLs and bifocals were made based on the optical prescription required for the distances identified. In lab and ground cockpit psychometric vision testing was developed to evaluate the different lens designs. **RESULTS:** The majority of cockpit tasks identified require intermediate distances correction (60-80cm). In some operational roles near vision overhead (25-50cm) is required. NVDs significantly narrow the field of view (FOV) to 40 degrees and require the exit pupil of the NVD and the far vision portion of the lens design to align precisely. Bifocal and trifocal lenses not set precisely were reported to create sharp demarcations of blurred symbology. Critical elements were 9.6 arc min or larger. In lab mesopic contrast sensitivity was evaluated on axis, 17 degrees off axis horizontally, and with a chin tilt to align each participant in the addition segment of the bifocals. For ground trials, a dynamic visual acuity task undertaken at different contrast levels was developed for a small screen placed in the cockpit. Distance visual acuity was measured with symbology and cockpit lighting on to provide an accurate lighting environment. No clinically significant differences were seen between PMLs and bifocal lenses in any of the near visual assessments. PMLs display improved results relative to the bifocals for the tilt test. All thresholds measured for both PMLs and bifocals were significantly better than that required for the critical elements. **CONCLUSION:** A method for evaluating optical correction designs has been identified and may be used to evaluate future designs.

Learning Objectives

1. The participant will understand the complexity of the human, optical system interface in different rotary wing systems.
2. The participant will develop an understanding of how to evaluate different optical lenses for rotary wing pilots.

[123] MODERNISING COLOUR VISION TESTING FOR INCLUSION WHILST MAINTAINING SAFETY WHEN LASER EYE PROTECTION IS REQUIRED

Maria Gavrilescu[1], Kate Coffey[2], Renee Karas[1], Larry Abel[2], Amanda Douglass[2]
[1]*Defence Science and Technology Group, Melbourne, Australia;* [2]*Deakin University, Geelong, Australia*

(Original Research)

INTRODUCTION: Current standards for aviation color vision were established in WW2 when the color vision requirements were very different. These standards have been challenged in civil aviation. Modern color vision testing should take into account specific task requirements and make use of technology to individualize tasks where possible. An application of increasing relevance in the current geopolitical context is the use of laser eye protection (LEP) in military aviation while also processing complex visual information that is presented in color from on-board instrumentation. **METHODS:** The effect of wearing LEP on color vision normal (CVN) and colorvision deficient (CVD) individuals was examined using the Konan CCT-HD, CAD, and FM100. Participants' task performance on a driving simulation with standard colors versus tailored colors to compensate for LEP effects was compared. The driving task included a primary task following a colored map in a head down display (HDD) and obeying road rules. Participants were also asked to respond to HAFU colored symbols

that were overlayed on the driving scene. Participants were required to correctly identify the color of the HAFU symbols. **RESULTS:** Ten CVN and five CVD participants were recruited and their color perception was examined across a range of LEPs. The use of LEPs resulted in a significant change in color perception which were highly LEP specific. For CVNs the average change from baseline in CCT-HD scores were L-75 M-50 S-54.3 for LEP1, L-52.8 M-35.4 S-9.7 for LEP2, L+7.4 M+7.6 S-34.8 for LEP3 and L-22.7 M-32.4 S-62.7 for LEP 4. CVD observers showed mixed results for CCT-HD. Changes in L, M, S scores for CVD were specific to the type of color vision deficiency and were LEP specific. Task performance significantly improved with customized colors. The CAD and CCT-HD were more sensitive to changes than the FM100. **DISCUSSION:** Color requirements should use modern color assessment techniques to determine if support to create an inclusive workforce is possible. Customized color displays can be used to compensate for color filters used in vision protection devices such as LEPs. Future research will examine whether customized color palettes can potentially be used to improve performance for CVD individuals.

Learning Objectives

1. The participant will develop an understanding of which color vision tests are appropriate for evaluating color perception in an aviation context.
2. The participant will develop an understanding of how laser eye protection affects color perception.

Monday, 05/22/2023 ***4:00 PM***
Napoleon C3

[S-23]: PANEL: CARDIOVASCULAR, HEMATOLOGY, AND ENDOCRINE CONSIDERATIONS FOR COMMERCIAL SPACEFLIGHT AND ANALOG ENVIRONMENTS

Chair: Rebecca Blue
Co-Chair: Karen Ong

PANEL OVERVIEW: *The coming of the commercial age of spaceflight portends a paradigm shift concerning the medical qualifications of future spaceflight participants. Conditions such as diabetes mellitus and cardiovascular disease may be prevalent in the population of potential future spaceflight participants and may present additional risk factors in the hypergravity environment, from acceleration tolerance to the ability to carry out moderately complex tasks in emergency or high-stress operational scenarios. While certain disease-related sequelae are likely to represent criteria for exclusion from near-future spaceflight activity, the inclusion of individuals with well-controlled disease without significant sequelae is desirable in the commercial spaceflight industry. To address some of these issues, a study was conducted under funding from the FAA Center of Excellence for Commercial Space Transportation in which layperson volunteers were exposed to high-fidelity centrifuge-simulated suborbital spaceflight. This panel will discuss approaches to risk stratification of various cardiovascular, hematological, and endocrine conditions as they relate to inclusion of individuals with such conditions in commercial spaceflight activities.*

[124] CARDIOVASCULAR, HEMATOLOGY, AND ENDOCRINE CONSIDERATIONS FOR COMMERCIAL SPACEFLIGHT AND ANALOG ENVIRONMENTS

Ronak Shah, William Powers, Serena Auñon-Chancellor, Rebecca Blue
UTMB, Galveston, TX, United States

(Original Research)

The coming of the commercial age of spaceflight portends a paradigm shift concerning the medical qualifications of future spaceflight participants. Conditions such as diabetes mellitus and cardiovascular disease may be prevalent in the population of potential future spaceflight participants and may present additional risk factors in the hypergravity environment, from acceleration tolerance to the ability to carry out moderately complex tasks in emergency or high-stress operational scenarios. While certain disease-related sequelae are likely to represent criteria for exclusion from near-future spaceflight activity, the inclusion of individuals with well-controlled disease without significant sequelae is desirable in the commercial spaceflight industry. To address some of these issues, a study was conducted under funding from the FAA Center of Excellence for Commercial Space Transportation in which layperson volunteers were exposed to high-fidelity centrifuge-simulated suborbital spaceflight. This panel will discuss approaches to risk stratification of various cardiovascular, hematological, and endocrine conditions as they relate to inclusion of individuals with such conditions in commercial spaceflight activities.

Learning Objectives

1. This panel will discuss the tolerance of individuals with significant medical history, including recent cardiac surgery and hemophilia, experiencing hypergravity.
2. This panel will discuss the development of a mathematical model for prediction of hypergravity tolerance in laypersons.

[125] A DYNAMIC MATHEMATICAL MODEL FOR THE PREDICTION OF CARDIOVASCULAR RESPONSE TO HYPERGRAVITY

Karen Ong[1], Alanna Kennard[2], Zan Ahmad[3], Charles Peskin[4], Rebecca Blue[1]
[1]*UTMB, Galveston, TX, United States;* [2]*New York University, New York, NY, United States;* [3]*Johns Hopkins Whiting School of Engineering, Baltimore, MD, United States;* [4]*New York University Courant Institute of Mathematical Sciences, New York, NY, United States*

(Original Research)

INTRODUCTION: Expansion of the commercial spaceflight industry will allow individuals with a variety of pre-existing medical conditions and limited aerospace experience and training to engage in spaceflight and analog activities. As cardiovascular conditioning is directly associated with hypergravity tolerance, the ability to predict cardiovascular response to hypergravity conditions could allow for improved risk profiling. Previously, we created a minimal steady-state mathematical model using anthropometric measurements to individualize +Gz-tolerance prediction. While a useful preliminary effort, steady-state modeling cannot truly predict real-world performance, as G-tolerance depends not only on the maximum G force experienced but also the rate of onset and the hypergravity context. We present a dynamic model of the cardiovascular system under hypergravity designed to use individualized parameters and variable G-profile data for improved predictive outcomes. **METHODS:** This ordinary differential equation model is comprised of a thoracic compartment and upper and lower body compartments, with compartment heights determined by subject-specific measurements (eye-heart and heart-seat distances). The model treats the heart as a continuous flow device, with a time-dependent flow representing cardiac output. Notable features of the model include an idealized controller that maintains pressure in the upper compartment by changing heart rate and venous reserve volume. Additionally, we model partial venous collapse in the systemic veins entering the thoracic compartment. **RESULTS:** Simulations and model accuracy will be discussed in the context of human space-flight and available analog test data from human centrifuge exposure, including time-dependent physiological data such as cardiac output and heart rate. **DISCUSSION:** A dynamic model allows for inclusion of anthropometric inputs as well as acceleration profile parameters, including G-onset rate and variation of acceleration exposures over time. Accurate prediction of individual G-tolerance may allow for stratification of risk for individuals with varied medical history. Further uses include the prediction of which spaceflight participants may require use of anti-G straining maneuvers for prevention of symptoms related to hypergravity exposures exceeding cardiovascular tolerance. Implications for medical risk stratification and decision-making will be discussed in the context of human spaceflight.

Learning Objectives
1. To understand the advantages and disadvantages of steady state versus dynamic mathematical models.
2. To understand a dynamic mathematical model of cardiovascular circulation under hypergravity.
3. To understand how this dynamic mathematical model compares with existing human centrifuge data.

[126] TOLERANCE OF CENTRIFUGE-SIMULATED COMMERCIAL SPACEFLIGHT IN A SUBJECT WITH HEMOPHILIA A

Isaiah Reeves[1], Rebecca Blue[1], Serena Auñón-Chancellor[1], Ronak Shah[1], William Powers[1], Michael Harrison[2]
[1]*UTMB, Galveston, TX, United States;* [2]*Axiom Space, Inc, Houston, TX, United States*

(Original Research)

INTRODUCTION: With increasing engagement of commercial spaceflight participants in spaceflight activities, of particular concern is the evaluation of individuals with medical conditions not previously characterized in the spaceflight environment. In addition to physiologic changes of spaceflight, factors such as acceleration forces experienced during launch, reentry, and landing of spacecraft could pose an altered risk profile in those with known disease. Bleeding diatheses present a unique concern in the spaceflight environment given hypergravity exposure and, in particular, the injury potential from transient or impact acceleration. **METHODS:** A 26-yr-old Caucasian man with severe hemophilia A and no detectable endogenous Factor VIII (FVIII) volunteered for participation in hypergravity exposures simulating suborbital spaceflight. At the time of the study, his treatment regimen included 50 IU/kg FVIII-Fc fusion protein intravenous administration every 96 hours, with supplemental FVIII administration as needed for any injury or bleeding episodes. The subject participated in 2 centrifuge profiles at the National Aerospace Training and Research Center (NASTAR) human centrifuge approximating suborbital and orbital spaceflight, with maximum exposure +4.0G_z, +4.5G_x, 6.1G resultant, and maximum onset rate <0.5G_z/sec and +1G_x/sec. His baseline medical regimen was unchanged for centrifuge exposure. **RESULTS:** The subject reported no abnormal events during the simulated flights other than brief, mild vertigo and transient disorientation, which resolved prior to profile completion. No petechial hemorrhage, ecchymosis, joint discomfort, effusion, or other bleeding was noted during or after acceleration exposures. Supplemental FVIII was not required at any time. **DISCUSSION:** From the perspective of commercial spaceflight, inherited bleeding disorders present several potential concerns that must be evaluated prior to participation. We discuss this subject's tolerance of simulated spaceflight, risk profile analysis, and generalizability of this case report to other hematological considerations and disorders. Cautious review and management of medical history, adherence to and barriers to treatment, duration of spaceflight and longitudinal management concerns, and a thorough and detailed risk/benefit assessment may provide a future pathway for inclusion of individuals with hematological disorders in commercial spaceflight.

Learning Objectives
1. The audience will learn about centrifugation of an individual with a medical condition as an analog to spaceflight.
2. The audience will learn about aeromedical considerations of inherited bleeding disorders in commercial spaceflight.

[127] CENTRIFUGE-SIMULATED ORBITAL AND SUBORBITAL SPACEFLIGHT IN A SUBJECT WITH RECENT MEDIAN STERNOTOMY FOR AORTIC VALVE REPLACEMENT

William Fernandez[1], Rebecca Blue[1], Michael Harrison[2], Karen Ong[1], Ronak Shah[1], Serena Auñón-Chancellor[1], William Powers[1]
[1]*UTMB, Galveston, TX, United States;* [2]*Axiom Space, Inc, Houston, TX, United States*

(Original Research)

INTRODUCTION: Human access to space is growing rapidly in the commercial environment, with private companies offering a variety of orbital and suborbital spaceflight experiences to spaceflight participants (SFPs). SFPs are far more likely than career astronauts to have medical conditions novel to spaceflight and may not have undergone as rigorous a medical screening process as that used for career astronauts. This case report details the experience and physiological responses of a subject with recent median sternotomy for aortic valve replacement and atrial septal defect (ASD) closure to centrifuge acceleration simulating orbital and suborbital commercial spaceflight. **METHODS:** A 40-year-old male with a history of congenital bicuspid aortic valve and atrial septal defect with successful repair six months prior to centrifuge participated in ongoing human centrifuge research at the National Aerospace Training and Research Center (NASTAR). The subject had the opportunity to participate in up to five centrifuge runs in an 8-hour period, with profiles simulating commercial spaceflight. Maximum exposures included +4.0G_z, +4.5G_x, 6.1G resultant, and maximum onset rate <0.5G_z/sec and +1G_x/sec. Physiologic data acquisition included hemodynamics, electrocardiogram, neurovestibular exams, and post-run questionnaires covering motion sickness, disorientation, and similar symptoms. **RESULTS:** The participant tolerated the physiological aspects of centrifuge exposure well, though he noted progressive sternal pain with increasing G_z, leading him to opt out of the final profile. Post-spin electrocardiograms demonstrated no changes from prior tracings and point tenderness of the sternum suggested a musculoskeletal origin of discomfort. Hemodynamic parameters remained normal for an age-matched cohort. He reported no adverse events before, during, or after any profile exposure. He pursued follow-up evaluation and imaging with his cardiologist after the experience, with no adverse outcomes. **DISCUSSION:** We will discuss cardiac and operative considerations related to layperson hypergravity exposure. Post-cardiothoracic-surgery risks to SFPs are largely unknown, especially within twelve months of a surgical procedure, with limited to no data available for review. This case provides an approach for risk stratification, pre-participation evaluation, and medical management of a post-surgical patient with significant cardiac history in spaceflight and analog environments.

Learning Objectives
1. The audience will learn a potential strategy for risk stratifying, evaluating, and medically managing a post-surgical patient with cardiac history for spaceflight and analog environments.
2. The audience will learn the effects of centrifuge-simulated orbital and suborbital spaceflight on a post-surgical cardiac patient.

[128] HANDHELD SONOGRAPHIC CARDIOVASCULAR IMAGING UNDER HYPERGRAVITY CONDITIONS

Rebecca Blue, Karen Ong, William Powers
UTMB, Galveston, TX, United States

(Original Research)

INTRODUCTION: Tolerance of hypergravity depends on a number of factors including cardiovascular performance, though real-time cardiovascular imaging during hypergravity exposure has been historically limited by technological and physical challenges. Previous efforts at sonographic hypergravity imaging have used fixed probes; the use of hand-held technique particularly when performed by minimally-trained laypersons has been less explored. Here we discuss handheld sonography of carotid vascular and cardiac windows during hypergravity. **METHODS:** Three subjects with variable ultrasound experience (attending-level with extensive experience, resident-level minimal training, and no sonographic experience) used handheld ultrasound at rest and under stepwise +G_z hypergravity exposures (maximum +3.8G_z) to visualize carotid vasculature. Subjects had variable prior hypergravity experience; all were trained in anti-G straining technique (AGSM). The two sonographically-inexperienced subjects underwent a brief <5min familiarization with the ultrasound probe, user interface, and desirable viewing window immediately prior to centrifugation; real-time coaching was provided. Ultrasound images were correlated to symptoms, audiovisual monitoring, and hemodynamic data. **RESULTS:** All subjects were successful at obtaining ultrasound images with adequate capture of windows of

interest. The handheld ultrasound performed as desired, though probe overheating prematurely ended imaging efforts during all attempts. Subxiphoid cardiac ultrasound was additionally obtained by only the most experienced subject, with imaging efforts again limited by probe overheating. Subxiphoid imaging was associated with variable quality of imaging due to probe displacement from AGSM-related muscle contraction and the subject noted transient (<1d) discomfort after imaging in the subxiphoid region. **DISCUSSION:** We provide a successful demonstration that handheld sonographic technique is compatible with hypergravity exposure, and even individuals with minimal or no ultrasound experience can obtain usable images under centrifuge conditions. We further demonstrate video visualization of AGSM's effects on vasculature. Cardiovascular ultrasound images under hypergravity can be used for training and visualization of effectiveness of AGSM as well as better understanding of the physiological changes occurring under hypergravity including anatomical cardiovascular deformation in hypergravity conditions.

Learning Objectives

1. The audience will learn about challenges associated with sonographic imaging during centrifugation.
2. The audience will have the opportunity to see video results of sonographic efforts performed under human centrifugation.

[129] CONTINUOUS GLUCOSE MONITORING IN ASTRONAUTS ON INSPIRATION4

Nicolas Heft, Charles Tsao, Jaime Mateus, Anil Menon
SpaceX, Hawthorne, CA, United States

(Original Research)

INTRODUCTION: This case report describes the use of continuous glucose monitoring during space flight. Traditionally, astronaut candidates have undergone a rigorous selection process and have been subject to a range of disqualifying medical conditions, including diabetes mellitus. With the maturation of commercial spaceflight there is an opportunity to expand the envelope of medical conditions that are safely manageable in space. **METHODS:** In this case we discuss the use of a continuous glucose monitor (CGM), as worn by two of the Inspiration4 crew while in-flight. Two Dexcom G6 CGM devices were used to record data during this 3-day mission. The CGM devices were donned on flight day (FD) 2 and worn for about 2 days. The devices successfully transmitted data every 5 minutes, as programmed. **RESULTS:** The devices operated successfully and levels ranged from 62 to 151, with an average and standard deviation (SD) of 97 ± 16 mg/dL for one crew member; and from 55 to 156 with an average and SD of 95 ± 20 mg/dL for another. Both crewmembers exhibited two noticeable spikes in glucose levels on FD3 ranging from 150 to 160 mg/dL. **DISCUSSION:** While a precise record of the timing of food consumption per crew member is not available, the spikes appear to follow meals on FD 3. The biggest limitations in this report are that no pre-flight baseline data collection was obtained and no-inflight finger prick calibration was available. This makes it difficult to infer the accuracy of glucose readings. However, the overall range is within what might be expected and the glucose spikes correlate to the largest meals that the crew consumed while on-orbit. Future work can expand on this by validating the accuracy of the CGM in-orbit by comparing readings with a finger-prick calibration, this is especially relevant since the Dexcom 6 device measures glucose levels in the interstitial fluid and those could be affected by microgravity-induced fluid shifts. If validated, the ability to provide real-time glucose analysis such as that provided by continuous glucose monitoring would allow flight surgeons to have the confidence in being able to treat and monitor 10.4% of the world's population currently barred from spaceflight due to their diabetes.

Learning Objectives

1. The audience will learn that interstitial glucose levels in astronauts were within the normal physiological range over the 2 days the data was recorded.
2. The audience will learn that there were no major hypo- or hyperglycemic events recorded with this method of data collection.

Monday, 05/22/2023 ***4:00 PM***
Nottoway & Oak Alley

[S-24]: PANEL: SELECTED CASES AND NOVEL SOLUTIONS FROM JUNIOR FLIGHT SURGEONS

Chair: Robert Barbera

PANEL OVERVIEW: *This panel is meant to highlight the accomplishments and perspectives of Junior Flight Surgeons in the Department of Defense. We will present a range of topics to include interesting aeromedical cases, highlight unique problems and their solutions, and provide a platform for discussion of these topics. The Junior Flight Surgeons have a unique perspective on how institutional policy is implemented at the clinic level to deliver readiness to the warfighter. It offers an opportunity for experienced and the inexperienced in the field to speak to one another directly as we chart a course together to the future of flight medicine. From these presentations, we hope to link these junior physicians with stewards interested in their perspective for future projects and AsMA contributions. In the past, this panel has been widely anticipated and well attended by previous AsMA delegations. We hope to continue this tradition through the quality submissions, lectures, and lessons identified from this panel.*

[130] MAINTAINING A MILITARY TREATMENT FACILITY BLOODBORNE PATHOGEN PROGRAM

Robert Barbera[1], Joseph Yabes[2]
[1]*San Antonio Uniformed Services Health Education Consortium, San Antonio, TX, United States;* [2]*Infectious Disease Department, Brooke Army Medical Center, San Antonio, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Protecting healthcare workers from bloodborne pathogens is an essential topic of occupational medicine that can land within the responsibilities of junior flight surgeons. Understanding the underlying concepts of bloodborne pathogens and needle stick injuries can help providers set up or maintain their institution's bloodborne pathogen program in accordance with AFI 44-108 (Infection Prevention and Control Program) and OSHA 29 CFR (Occupational Safety and Health Standards). **OVERVIEW:** Due to a series of needle stick incidents at a medium size military treatment facility, staff were asked to analyze the incidents and update the base bloodborne pathogen program. Cause analysis showed an in-place program with limited shared knowledge and unavailable resources to take correct measures to protect healthcare workers. Study was conducted including military infection control courses and national clinician consultation center. This education emphasized the importance of early recognition, source patient testing for rapid HIV, and urgent counseling of healthcare worker on post-exposure prophylaxis. The process was also updated to support compliance with reporting, increased availability of resources, and access to appropriate follow up care. This effort led to compliance with AFI/OSHA requirements and safe working environments for the MTF personnel. **DISCUSSION:** Needle sticks are a common medical workplace injury; flight surgeons and occupational physicians need to understand the basics of appropriate urgent action to mitigate risks of bloodborne pathogens. With this knowledge junior flight surgeons can tackle this occupational health challenge with confidence and maintain their base infection control program. The specifics of this presentation will be applicable to any U.S. healthcare facility and the underlying concepts are true at all global institutions.

Learning Objectives

1. The audience will learn about the requirements in AFI 44-108 and OSHA 29 CFR to provide for healthcare worker protection in bloodborne pathogen incidents.

2. The audience will learn about the health threats of common blood-borne pathogens; furthermore appropriate preventive measures, post-exposure prophylaxis, and clinical follow up will be discussed.
3. The audience will learn about challenges in maintaining a blood-borne pathogen program at a MTF and recommendations in process improvement and communication of resources.

[131] LESSONS FROM A FIRST ASSIGNMENT FLIGHT SURGEON AT A GEOGRAPHICALLY SEPARATED UNIT

Spencer Fray
U.S. Air Force, APO, Armed Forces - Europe, Canada, Middle East, Africa, United States

(Education - Case Study)

BACKGROUND: The flight surgeon career field in the U.S. Air Force (USAF) is currently undermanned. The USAF has developed and implemented the Operational Graduate Medical Education (OGME) program to increase the number of residency-trained flight surgeons in the service. Due to the high demand for residency-trained assets, OGME graduates may find themselves being placed in remote, high-priority assignments directly out of the medical school and residency training pipeline. Some of these assignments include working at Geographically Separated Units (GSUs), which typically only have one flight surgeon billet. While the OGME program incorporates dedicated flight medicine training, there are many aspects of working in a GSU that OGME graduates may not encounter until practicing in the field. **OVERVIEW:** I graduated from the OGME program in 2021 with my first assignment being a two-year tour at a GSU in Europe as the squadron's only flight surgeon. Some of the challenges that I encountered included completing mission qualification upgrade training, obtaining flying hours, establishing clinic operating instructions to include aeromedical evacuation planning for critical and psychiatric patients, validating the host nation's secondary healthcare facilities for U.S. military use, coordinating cold chain shipment and storage of the COVID-19 vaccine, and figuring out how to conduct sexual assault medical forensic exams (SAMFE) without any SAMFE-trained providers in country. Many of these challenges are not altogether uncommon for providers at GSUs. This presentation will discuss lessons learned over the past year of working at a GSU to help highlight the unique challenges young flight surgeons can face in that practice setting. **DISCUSSION:** More USAF flight surgeons will matriculate through the OGME program as it continues to develop. The transition from training to operational practice may continue to have unique challenges for OGME graduate due to the positions for which they are needed. Having discussions about what those challenges are will help shape the training in OGME programs and better prepare graduates to practice flight medicine in remote settings.

Learning Objectives

1. The audience will learn about challenges of working as a flight surgeon in a remote, military environment.
2. The audience will be able to better understand how to equip young flight surgeons for practicing in remote military environments.

[132] SELECTED CASES AND NOVEL SOLUTIONS FROM JUNIOR FLIGHT SURGEONS - AVT-SQUADRON AFFILIATION AT NAS PAX

Michael Yue
U.S. Naval Test Pilot School, Patuxent River, MD, United States

(Education - Program/Process Review)

BACKGROUND: Recent alignment of clinic-based AVTs with squadrons has increased the overall ability of Naval Health Clinic Patuxent River (NHCPR) to provide a higher standard of care more efficiently. NHCPR is the health clinic at Naval Air Station Patuxent River (NAS PAX), home to five test squadrons with both military and civilian staff. At clinic, each squadron's Flight Surgeon works with six Aviation Medical Technicians (AVTs) who are navy corpsmen assigned to the clinic. AVTs are aviation-medicine specialized corpsmen. Prior to AVT alignment to squadrons, the transition to the Defense Health Agency reduced clinic staffing and resulted in schedule changes, increased time to complete flight physicals, and decreased appointment availability. While this new affiliation with squadrons does not formally assign AVTs to specific squadrons, their specialization leads to benefits for patients, the clinic, and military operations. **OVERVIEW:** Different commands and flight surgeons have different flight medicine needs, which are particularly complex given the military and civilian composition of test squadrons. To streamline care, flight surgeons at NAS PAX worked with clinic leadership to have each AVT affiliated with a squadron. While the AVTs still belong to clinic, they specialize in the administrative knowledge for specific squadrons. **DISCUSSION:** This effort has benefitted squadrons, corpsmen, and the clinic. Squadron medical readiness has increased. Flight physical processes are smoother. Visit volume and wait times at clinic have decreased. In turn, AVTs have become familiar with flight operations, experience increased job satisfaction, and have opportunities to do aviation-related training. At clinic, corpsmen affiliated with squadrons coach and mentor other corpsmen, increasing skill and capacity at the clinic at large. This structure provides higher-quality care across the base, improving operational planning and readiness. This paper further details the challenges and solutions of implementing AVT-squadron affiliation and details potential application to other military medicine clinics.

Learning Objectives

1. The audience will appreciate the challenges of a centralized healthcare staffing structure for a military medical clinic serving multiple operational commands.
2. The audience will understand the benefits of affiliating non-provider medical staff with tenant commands.

[133] ESSENTIAL FLIGHT SURGEON KNOWLEDGE AND ACTIONS IN CASE OF A CASE OF CAISSON'S DISEASE

Joel Reimer, Gregory Trifilo, Jeffrey Kinard
460th Medical Group, Buckley Space Force Base, Aurora, CO, United States

(Education - Case Study)

INTRODUCTION: This case report describes a USAF fighter pilot who experienced a Type II Spinal Decompression Sickness (DCS) injury while SCUBA diving, resulting in lower extremity paralysis and urinary retention. **BACKGROUND:** While the concern for neurological DCS from aviation decompression events is frequently discussed and vigilantly monitored, hyperbaric decompression events from recreational underwater activities are less frequently encountered but can pose a significant risk for aviators. Both have an intricate recovery and aeromedical waiver process, requiring the involved Flight Surgeons to be familiar with procedures for emergency and follow-up care along with return-to-fly guidelines. **CASE PRESENTATION:** The subject is a previously healthy 48-year-old F-16 pilot who suffered a SCUBA related Spinal DCS injury while on vacation in Guam. Immediately upon exiting the water, he was noted to have an ataxic gait and altered mental status. He was brought to the local medical facility, where he underwent emergency hyperbaric O2 therapy (TT6) with eventual return to normal mentation but persistent lower extremity weakness and urinary retention. He returned to his home station, where he underwent intensive progression of inpatient and outpatient physical therapy with gradual return of motor function over the course of 4 months. Neurologic bladder dysfunction also improved with time, requiring progression from foley to scheduled intermittent self-catheterization, and eventually to full independent urination without evidence of abnormal postvoid residual urine or hydroureteronephrosis. At 6 months post-injury and after near complete recovery, an aeromedical waiver was granted for return to flying class II duties. **DISCUSSION:** This case highlights the risks associated with SCUBA diving to the military aviator, as well as the need for Flight Surgeons to be prepared for the emergency management of neurological DCS and to be knowledgeable of local resources to aid in the recovery. This case also provides the opportunity to discuss the pathophysiology of decompression events, contributing factors to risk and recovery, as well as aeromedical concerns and nuances for safely returning a flyer to duty.

Learning Objectives

1. The audience will understand the criteria for diagnosis of acute Type II (Neurological) DCS and the required treatment for the condition.
2. The audience will gain an understanding of the long-term clinic management and resource requirements for aviators with continued neurological sequelae of Type II DCS.

3. The audience will understand the clinical requirements and process for USAF aeromedical waiver approval for neurological DCS.

[134] OPERATIONAL TO EDUCATIONAL, SME TO SGP

Angelica Fullerton
U.S. Air Force, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This presentation discusses the varying roles junior flight surgeons find themselves in, and some tips for success. **BACKGROUND:** Junior flight surgeons, including those straight out of training and without a residency, find themselves in a variety of assignments. This can be overseas, involve a variety of special duties, and involve every possible mission. With only months of training, these flight surgeons often struggle to succeed, resulting in burnout, suboptimal care, and detriments to the mission and flying safety. **CASE PRESENTATION:** My first assignments out of my flight surgeon training were a short tour with a fighter squadron in Kunsan, South Korea, and then as SGP of the Air Force Undergraduate Combat System Officer training program. The first assignment was very mission focused, with a strong historical culture, and small patient population. The second assignment is a large training group, with significant MAJCOM level visibility and a young population without experience on flying status. Both assignments required significant learning and adaptation to deal with unique populations and requirements. **DISCUSSION:** While every assignment will be unique, there are common themes for what young flight surgeons can do to grow and what more senior flight surgeons can do to help them succeed. Seeking out (or being) mentors, humility, and adaptability are essential to the success of junior flight surgeons. Finally, there are some key opportunities when dealing with young flyers, especially the opportunity to build a healthy trust and relationship with flight medicine, that are not to be missed in any assignment.

Learning Objectives

1. Appreciate the variety of assignments and responsibilities that junior flight surgeons undertake.
2. Understand some keys to success for junior flight surgeons, both universally and in a training environment, and how senior flight surgeons can aid in their growth.

TUESDAY, MAY 23, 2023

Tuesday, 05/23/2023 ***8:30 AM***
Grand Ballroom A-B-C

9TH REINARTZ LECTURE

Ansa Jordaan, M.B.Ch.B., B.Sc.(Hons.)
Aerospace Medicine, DOMH

"Civil Aviation in the Future: Key Issues to be Addressed"

Tuesday, 05/23/2023 ***10:30 AM***
Grand Ballroom A-B-C

[S-25]: PANEL: CLINICAL AND RESEARCH INSIGHTS INTO SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS)

Chair: Tyson Brunstetter
Co-Chair: Mary Van Baalen

PANEL OVERVIEW: *First discovered in 2005, Spaceflight Associated Neuro-ocular Syndrome (SANS; formerly known as "VIIP") is a condition unique to long-duration spaceflight. SANS is associated with a multitude of signs such as optic disc edema and retinal nerve fiber layer thickening; globe flattening; shifts in refractive error; and chorioretinal folds. Other potential signs include brain anatomical changes, retinal cysts, retinal pigment epithelial detachments (PEDs), and optic nerve sheath distention; however, it is unclear whether these signs are truly associated with SANS. While the pathogenesis and pathophysiology of SANS remain elusive, several theories exist. This panel will explore the latest technologies in detecting, diagnosing, and monitoring SANS; present recent SANS/neuro-ocular clinical surveillance and research findings from long-duration crewmembers and terrestrial subjects; and explore potential physiological factors that may contribute to the generation of additional neuro-ocular risk during exploratory spaceflight.*

[135] SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME (SANS): 2023 CLINICAL UPDATE

Tyson Brunstetter[1], Sara Mason[2], Wafa Taiym[3], C. Robert Gibson[4], Mary Van Baalen[1], Ann Tsung[3], William Tarver[1]
[1]*NASA JSC, Houston, TX, United States;* [2]*Aegis Aerospace, Inc., Houston, TX, United States;* [3]*KBR, Houston, TX, United States;* [4]*South Shore Eye Center, League City, TX, United States*

(Original Research)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) is unique to long-duration spaceflight (LDSF). Two-thirds of LDSF astronauts present with the earliest indication(s) of SANS, defined as development of any of the following in ≥1 eye during or immediately following spaceflight (SF): 1) optic disc edema (ODE; ≥20 micron increase in peripapillary total retinal thickness [Delta TRT]); 2) chorioretinal folds; 3) globe flattening; and 4) refractive error shift (≥+0.75D). Each presents risk to a crewmember's vision and mission effectiveness; however, it is not yet known what severity and/or duration might lead to acute or permanent impacts to ocular anatomy or visual performance. Brain anatomical changes also occur during LDSF and are being monitored; however, these changes have not yet been associated with functional decrements or with SANS. **METHODS:** Data were obtained from clinical records and subject matter experts. Areas of interest include: 1) prevalence of SANS, 2) ongoing SANS clinical efforts, and 3) SANS clinical thresholds. **RESULTS:** Prevalence of SANS findings in USOS LDSF crewmembers is: 64% for ODE, 15% for chorioretinal folds, 26% for globe flattening, and 14% for hyperopic shifts (≥+0.75D). **DISCUSSION:** All SANS diagnostic hardware are performing nominally onboard the International Space Station (ISS). The Goggle-Based Visual Field (GBVF) device has completed clinical validation testing at Ohio State University and is planned for parabolic flight testing (2022-23) and an ISS technology demo (2024). Four SANS Clinical Thresholds are now established: 1) "Earliest Indication of SANS" – Introduced in 2020, see definition, above; 2) "Clinically Concerning SANS" – Development of any of the following during or immediately following SF: a) ODE (≥55-micron Delta TRT and/or Frisèn grade ≥1), b) sharp chorioretinal folds in/near the macula, or c) moderate globe flattening; 3) "Pathological SANS with Acute Functional Impact" – Development of any of the following during or immediately following SF: a) visual field (VF) loss, b) distorted central vision, or c) shift in refractive error beyond power of available optical correction; 4) "Pathological SANS affecting Long-Term Health" – Development of any of the following during or following SF: a) permanent VF loss, b) reduced retinal nerve fiber layer thickness, c) permanently distorted central vision, d) atrophy of retinal pigment epithelium or photoreceptors, or e) choroidal neovascularization.

Learning Objectives

1. Understand the new and previously established clinical thresholds of Spaceflight Associated Neuro-ocular Syndrome (SANS), their rationale.
2. Understand the risk of SANS to the eyes, vision, and mission of astronauts during long- and extended-duration spaceflight missions.

[136] INTRAOCULAR PRESSURE DYNAMICS IN MICROGRAVITY AND TERRESTRIAL ANALOGUES: A SYSTEMATIC REVIEW AND QUALITATIVE ANALYSIS

Wiaam Elkhatib[1], Kristen Shafer[2], Sara Mason[3], Tyson Brunstetter[4]
[1]*Mayo Clinic Florida, Jacksonville, FL, United States;* [2]*Naval Medical Center, Portsmouth, VA, United States;* [3]*MEI Technologies, Houston, TX, United States;* [4]*NASA JSC, Houston, TX, United States*

(Original Research)

INTRODUCTION: Spaceflight-Associated Neuro-ocular Syndrome (SANS) presents risk to expeditionary spaceflight. Related ocular findings carry poorly understood pathophysiology, including relationship to intraocular pressure (IOP) dynamics in microgravity. The study objectives were to conduct a systematic literature review and pool available IOP data from terrestrial microgravity analogs plus published spaceflight measures for comparison and qualitative analysis. **METHODS:** Manuscripts were retrieved through October 2, 2022, from the Scopus, PubMed, Google Scholar, Web of Science electronic databases and NASA document repository. References were citation-mined. Search terms limited to English language included IOP, microgravity, spaceflight, head down tilt, and bedrest. Inclusion criteria required the presence of original quantitative IOP data, human subjects aged 18 to 65 years, and subjects ≥ 3 for analogues. Exclusion criteria were pre-existing intraocular pathology, non-peer-reviewed sources, use of IOP-altering medications, recent ocular surgery, and head down tilt angles beyond -15°. Two individuals independently reviewed literature with a third-party resolving any conflicts. Retrieved manuscripts underwent CEBM clinical appraisal with PRISMA 2020 checklist application. Literature summaries and IOP data were qualitatively synthesized tabularly and graphically. Bias risk assessment and statistical analysis were limited by study heterogeneity and cohort sizes. **RESULTS:** After duplicates removal, 796 studies were screened, and 35 eligible studies identified with their characteristics summarized. Cohorts varied from one to 65 subjects with a total number of 520 participants, age range of 18 to 65 years, and male sex majority. IOP changes between baseline and microgravity/analogues were found to generally trend from an initial, significant increase followed by stabilization at a value above baseline with gradual return to baseline (or slightly below) mostly maintained within nominal IOP ranges (8mmHg - 21mmHg). **DISCUSSION:** IOP microgravity dynamics suggest physiologic adaptation rather than ocular pathology with analogue data correlating to spaceflight. Margins of instrument and operator error often confounded statistical significance within studies, and variable experimental protocols impeded complex statistical analysis for comparison. This assessment factors evidence from thousands of IOP measurements to help elucidate the theoretical mechanisms in SANS.

Learning Objectives

1. Understand the current status of literature regarding IOP dynamics in microgravity.
2. Discuss the potential role of IOP in SANS, and the limitations of IOP measuring devices on-orbit with implications towards future research.

[137] THE PRECISION STUDY: A ONE-YEAR LONGITUDINAL QUANTITATIVE MRI STUDY OF HEALTHY CONTROLS NOT EXPOSED TO MICROGRAVITY

Larry Kramer[1], Khader Hasan[1], Xu Zhang[1], Brandon Macias[2], Steven Laurie[3]
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(Original Research)

INTRODUCTION: Quantitative MRI has been utilized to study the intracranial effects of long-duration spaceflight using serial longitudinal measurements for up to one year postflight. There is however lack of control data on how reproducible these quantitative MRI measurements are over a one-year period. **METHODS:** 10 healthy control subjects (5 men, 5 women, Age = 38.3 years (SD=7.80)) volunteered for this study. Subjects were scanned using a subset of sequences obtained from the current astronaut-based MedB MRI protocol on the same dedicated 3-T MRI system using a 32-channel head coil. Each subject underwent a baseline study at 0 months, followed by repeated imaging at 2, 6, and 12 months. Pulse-gated MRI phase-contrast flow imaging was used to quantify peak-to-peak cerebral spinal fluid (CSF) velocity (CSF_{Vp-p}) within the cerebral aqueduct. A 3D T1-MPRAGE sequence was used to quantify total intracranial volume (ICV= brain and intracranial cerebral spinal fluid (CSF) spaces) and lateral ventricular volume using MRI Cloud software and pituitary height measurements. A mixed model was built for each parameter measured over time which included nominal time as the fixed effect factor and subject as the random effect factor. Based on each mixed model, the intraclass correlation coefficient (ICC) was calculated to assess consistency over time. **RESULTS:** All results shown hereby are mean ± standard deviation obtained at 0, 2, 6, and 12 months respectively. CSF_{Vp-p} was 12.2±.3.2, 12.9±4.5, 12.2±3.1, 11.0±4.0 cm/s (ICC = 0.82, 95% CI 0.61-0.94); ICV was 1466±133, 1481±141, 1465±131, 1482±141 mL (ICC = 0.97, 95% CI 0.93-0.99); lateral ventricular volume was 17.8±4.5, 17.9±4.5, 17.7±4.3, 17.8±4.6 mL (ICC = 0.99, 95% CI 0.98-1.00); and pituitary height was 6.6 ±.1.3, 6.7±1.4, 6.8±1.4, 6.6±1.6 mm (ICC = 0.98, 95% CI 0.95-0.99). The heart rate obtained at the time of the CSF flow measurements was 62.6±5.8, 61.5±6.1, 61.3±7.4, 59.3±11.3 bpm (ICC = 0.65, 95% CI 0.36-0.88). **DISCUSSION:** Mean longitudinal quantitative MRI measurements of intracranial anatomy and physiology showed excellent reproducibility over the one-year observation period. Further work is underway to identify thresholds representing normal change over this period of time to aid in the interpretation of spaceflight effects.

Learning Objectives

1. The participant will understand how quantitative MRI is used to study intracranial changes in anatomy and physiology relative to long-duration spaceflight and how the parameters are altered over a one-year period.
2. The participant will learn how intracranial anatomy and physiology using quantitative MRI is altered over a one-year period in healthy controls not exposed to spaceflight.

[138] LONGTERM VISUAL OUTCOMES IN A TERRESTRIAL MODEL OF SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME

Susan Mollan[1], Mark Thaller[2], Victoria Homer[2], Yousef Hyder[2], Alex Sinclair[2]
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(Original Research)

INTRODUCTION: Only limited data can be gained from astronaut populations, and lifelong follow-up outcomes are not yet a reality for those who develop spaceflight associated neuro-ocular syndrome (SANS). Terrestrial analogues, such as Idiopathic Intracranial Hypertension (IIH), can help provide insights that may help guide flight surgeons and agencies. The aim was to evaluate long term visual outcomes in IIH in those with a normal body mass index (BMI) and those who are asymptomatic, which may best represent an astronaut population. **METHODS:** A longitudinal prospective cohort study (IIH:LIFE) was conducted between 2012 to 2021. The study was ethically approved by National Health Service National Research Ethics Committee (14/LO/1208). Data included demographics and disease status. Visual outcomes included acuity, visual field and optical coherence tomography (OCT) measurements including total retinal thickness (TRT). To assess longitudinal visual outcomes, the effects of body mass index (BMI), presence or absence of symptoms, and categorization of TRT informed models. LOESS (locally weighted scatterplot smoothing) graphs were constructed in order to ascertain the relationship between variables and emergent trends. **RESULTS:** The cohort contained 490 confirmed IIH patients. 98% were female with a mean body mass index (BMI) of 38kg/m^2. TRT did not alter with BMI at baseline. Those with the highest TRT had the worst visual outcomes. Those with a BMI <30kg/m^2 had a

more rapid improvement in papilledema over the first 6 months from baseline visit, with an additional improvement of the retinal nerve fibre layer of 10.79µm/month (95% CI: -26.51, +4.92) and TRT of 5.90µm/month (95% CI: -36.29, +24.48). Those who were asymptomatic had a lower BMI. Patients with a BMI <30kg/m^2 and those who were asymptomatic did not have a different long term trajectory for mean deviation of the visual field and OCT ganglion cell layer measures as compared to typical IIH patients when trends over time were demonstrated on LOESS graphs. **DISCUSSION:** The long-term visual outcomes were not significantly different between BMI groups nor were they determined by presence or absence of symptoms. Amount of papilledema as measured by TRT determines long term visual outcomes. These data enable potential cut-off levels of OCT measures, such as TRT, that could be used to inform clinical decision making in SANS.

Learning Objectives

1. The audience will understand the different measures that can be taken from an optical coherence tomography scan of the eye that can identify optic nerve head swelling.
2. The audience will be able to summarize the similarities and differences between idiopathic intracranial hypertension and Space Flight Associated Neuro-Ocular Syndrome.
3. The audience will be able to consider the challenges in making management decisions in Space Flight Associated Neuro-Ocular Syndrome and apply knowledge from terrestrial analogues based on well characterized clinical cohorts.

[139] UPDATED PERSPECTIVE ON INTRACRANIAL PRESSURE IN ASTRONAUTS DURING SPACEFLIGHT

Steve Laurie[1], Connor Ferguson[2], Patrick Sibony[3], Brandon Macias[4]

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(Original Research)

INTRODUCTION: Crewmembers flying ~6-month missions to the International Space Station (ISS) show signs of optic disc edema (ODE), chorioretinal folds, globe flattening, and/or hyperopic shifts in refractive error, along with increases in ventricular volume; collectively these findings are known as spaceflight associated neuro-ocular syndrome (SANS). No direct measures of intracranial pressure (ICP) have been collected during long-duration spaceflight. Mild elevations in ICP have been recorded after spaceflight in some, but not all astronauts with signs of ODE, but preflight measures of ICP are lacking. No ICP measurements have been obtained in astronauts without optic disc edema. This presentation will provide an update on our understanding of SANS in astronauts during spaceflight. **METHODS:** Noninvasive indicators of ICP (nICP) were collected in 13 ISS crewmembers before and after long-duration spaceflight in multiple postures, and during spaceflight. Optical coherence tomography (OCT) images collected before and during spaceflight were assessed to quantify morphological changes at the optic nerve head and the development of SANS findings in 21 crewmembers. **RESULTS:** Early signs of optic disc edema were observed in 69% of crewmembers. During long-duration spaceflight mean nICP measures were similar to the seated upright posture and did not exceed the supine posture. OCT images revealed a 24% incidence of choroidal folds and 10% incidence of retinal folds in crew with early signs of ODE. Choroidal fold progression worsened with flight duration. **DISCUSSION:** The lack of elevated nICP indicators during spaceflight, along with different presentation of optic nerve head changes and chorioretinal fold incidence than occurs in patients with pathologically elevated ICP, argue against pathologically elevated ICP developing during spaceflight. Further research is needed to better understand the chronic, unremitting headward fluid shift that occurs during spaceflight and whether it contributes to pathologic ocular findings in some, but not all astronauts. The long-term health of astronauts may depend on identifying who is most at risk for developing SANS findings and tracking the severity and duration of optic disc edema, especially since future missions to Mars will be longer than current ~6-month mission duration.

Learning Objectives

1. The audience will understand the limitations to our understanding of ICP during spaceflight.
2. The audience will learn about differences between the presentation of SANS findings in astronauts and signs and symptoms in individuals with pathologically elevated ICP.

Tuesday, 05/23/2023 ***10:30 AM***
Grand Ballroom D-E

[S-26]: PANEL: EVOLVING SCIENCE SURROUNDING PILOT HEALTHCARE SEEKING BEHAVIOR, DISCLOSURE AND AVOIDANCE IN THE US AND ABROAD

Chair: William Hoffman
Co-Chair: Quay Snyder

PANEL OVERVIEW: *Aircraft pilots are required to meet certain medical standards in order to maintain an active flying status. If a pilot develops a new symptom or condition and discloses during aeromedical screening, the pilot runs the risk of temporary or sometimes permanent loss of their aeromedical certificate. For this reason, it has been proposed that some aircraft pilots participate in healthcare avoidance behavior due to fear for aeromedical certificate loss. Several recent studies have demonstrated that a proportion of aircraft pilots participate in healthcare avoidance behavior due to fear for certificate loss both in the US and abroad. These findings have been hypothesized to have broad implications to (1) aeromedical screening, (2) pilot health, and potentially (3) aviation safety. Importantly, pilot healthcare seeking behavior and avoidance is anticipated to become more complicated as aerospace science advances and the pilot population becomes more diverse. The current panel aims to present the evolving data surrounding pilot healthcare seeking and avoidance behavior in the US and abroad. The panel will begin with a patient case followed by five abstracts addressing pilot healthcare seeking behavior and avoidance over the course of a pilot's career. Topics include: (1) a cross sectional descriptive study of pilot healthcare avoidance in US and Canadian pilots due to fear for aeromedical certificate loss, (2) cross sectional descriptive study of underreporting during aeromedical screening in Norwegian pilots, (3) qualitative study of factors that influence healthcare seeking behavior, information disclosure, and wellness in a sample of USAF undergraduate pilot training students and civilian university student pilots, (4) pilot mentality (the "Right Stuff"), peer support programs and mental healthcare seeking, and (5) pilot medical certification and healthcare avoidance from a safety management system framework.*

[140] HIDING IN PLAIN SIGHT: HEALTHCARE AVOIDANCE DUE TO FEAR FOR AEROMEDICAL CERTIFICATE LOSS IN US AND CANADIAN PILOTS

William Hoffman

Brooke Army Medical Center, San Antonio, TX, United States

(Original Research)

BACKGROUND: Aircraft pilots are required to meet certain medical standards in order to maintain an active flying status. If a pilot develops a new symptom or condition and discloses during aeromedical screening, the pilot runs the risk of temporary or sometimes permanent loss of their aeromedical certificate. For this reason, it has been proposed that some aircraft pilots participate in healthcare avoidance behavior due to fear for aeromedical certificate loss, but the degree of healthcare avoidance in US and Canadian pilots and subgroups remains uncertain. **METHODS:** We conducted a cross sectional population-based anonymous survey of pilots in the United States and Canada.

RESULTS: There were 3,763 U.S. pilots and 1,405 Canadian pilots (72.8% v. 26.7%) included in the analysis. The respondents included 491 female pilots (9.5%), 1,679 paid civilian pilots (34.2%) and 280 military pilots (5.7%). There were 55.9% of respondents admitted to at least one type of healthcare avoidance behavior due to fear of medical certificate loss (56.1% of US pilots v. 55.2% Canadian pilots, p=0.58). There were 67.9% of Canadian pilots who reported ever seeking informal medical advice due to fear of medical certificate loss compared to 52.7% of US pilots ($p \leq 0.01$). When asked if they had ever withheld information during an aeromedical examination, there were 39.9% of Canadian pilots and 28.7% of US pilots who affirmed ($p<0.001$). Pilot types associated with compensation were more likely to report a history of healthcare avoidance than pilot types not associated with compensation. Statistical significance was found between select pilot subgroups. **DISCUSSION:** Pilot healthcare avoidance due to fear of medical certificate loss may be present in US and Canadian pilots and select behaviors may have higher prevalence in certain jurisdictions due to factors unique to the local aeromedical system. Open questions center around the impact of pilot healthcare avoidance to aviation safety and pilot health.

Learning Objectives

1. The learner will define pilot healthcare avoidance and factors that might influence healthcare avoidance behavior.
2. The learner will describe the rate of self reported healthcare avoidance due to fear for aeromedical certificate loss in US and Canadian aircraft pilots.
3. The learner will describe demographic factors associated with higher rates of self reported healthcare avoidance due to fear for aeromedical certificate loss.

[141] UNDER-REPORTING OF SELF-REPORTED MEDICAL CONDITIONS IN AVIATION: A CROSS-SECTIONAL SURVEY

Trond-Eirik Strand
Own, Oslo, Norway

(Original Research)

INTRODUCTION: The applicants' self-declaration of aeromedical history (during aeromedical certification) and healthcare avoidance is crucial for flight safety. In a civil aircrew population (Norway) 12% admitted having ever under-reported any medical conditions. **METHODS:** We conducted a survey among all civilian aircrew in Norway and 1 616 responded the electronic questionnaire about the aeromedical certification process. Main results have been published in AMHP, April 2022 (doi: 10.3357/AMHP.5823.2022). A total of 726 of the respondents were commercial pilots and further analyses were performed to investigate this subgroup more in depth. **RESULTS:** Among commercial pilots 5.6% had (ever) underreported /withheld information for an aeromedical examiner (AME) about his or her physical health. And for same questions regarding mental health, use of medications and drug use including alcohol the proportion of pilots confirming underreporting was 4.7%, 2,2% and 7,0% respectively. The corresponding numbers for other classes combined were 2,9%, 2,2%, 1,2% and 5,4 respectively. A total of 70,6% pilots believed medical certification to a large extent contribute to increased flight safety. The corresponding number for non-pilots was 58,0%. **DISCUSSION:** Pilots in general believe aeromedical certification to a higher degree contribute to increased flight safety compared to non-pilots. On the contrary, pilots have increased drive to underreport in all four categories questioned (physical and mental health, use of medication and drug use including alcohol) compared to non-pilots. Strategies for underreporting should be implemented and we might assume this could contribute to reduce health care avoidance among air crew as well.

Learning Objectives

1. The audience will learn about the frequency of self-reported underreporting among different aircrew classes in civil aviation.
2. The audience will learn that pilots have different reported proportion of undererreporting compared to other aircrew classes.

[142] PILOT MENTALITY (THE "RIGHT STUFF"), PEER SUPPORT PROGRAMS AND MENTAL HEALTHCARE SEEKING

Dave Fielding
BALPA and British Airways, London, United Kingdom

(Education - Program/Process Review)

TITLE: Pilot mentality (the "Right Stuff"), peer support programs and mental healthcare seeking. **OVERVIEW:** Other speakers have identified under-reporting of aeromedical issues by pilots. Reasons behind this are necessarily complex and inter-related. Whilst the *prima facie* reason is fear of loss of the Class 1 medical, the 'typical' pilot mentality of setting high personal standards, independently solving problems, and demonstrating resilience in unexpected circumstances often leads to pilots attempting to solve their own issues rather than seek professional help. The speaker will argue that these personality characteristics frequently amplify the stigma that is associated with declaration of mental health issues in particular. It is not uncommon for pilots to attempt to use cockpit stress coping mechanisms and problem-solving structures to solve longer-term mental health issues. These are unlikely to be successful, exacerbating the feelings of failure and sinking a small percentage of pilots deeper into depression and further healthcare avoidance. The role of Pilot Peer Support Programs (PPSPs) is critical in addressing this problem. A suitably trained Peer is in a position to assure the pilot that their problems are not uncommon (normalization), to work with them to facilitate those pilot problem-solving skills in a more productive way (roughly 85% of pilot issues are resolved at this stage), and finally to act as a reassuring bridge to professional aeromedical assistance if required. **DISCUSSION:** Many pilots are mistrustful of AMEs. The perception that sometimes-lifelong dreams and ambitions of a flying career could be destroyed by one test or declaration is powerful. For a highly risk-averse population, a surprising number of pilots prefer to risk the consequences of concealing a medical issue from the Regulator rather than declaring it. The challenge facing Regulators and AMEs is to persuade pilots that permanent removal of medical certification for mental health issues is statistically extremely rare. However, direct communication with pilots by the aeromedical community of this fact has had limited effect, hence this Panel. The recent advent of PPSPs into mainstream aviation offers the opportunity for a trained colleague to persuade pilots that they are safe to declare their mental health / aeromedical issues. Partnership with the aeromedical community in this training is paramount.

Learning Objectives

1. To give the audience an understanding of typical pilot psychological characteristics which are relevant to the under-reporting of medical issues.
2. To discuss the importance of Pilot Peer Support Programs in persuading pilots to disclose medical issues.

[143] PILOT MEDICAL CERTIFICATION AND HEALTHCARE AVOIDANCE FROM A SAFETY MANAGEMENT SYSTEM FRAMEWORK

Anthony Tvaryanas
FAA, Oklahoma City, OK, United States

(Education - Program/Process Review)

BACKGROUND: Safety management systems are the product of a continuing evolution in aviation safety, where safety is viewed from a systemic perspective, encompassing organizational factors in addition to human and technical factors. The Federal Aviation Administration (FAA) chose to implement a SMS as it integrates the management of safety risk into business planning, operations, and decision-making. This presentation reviews pilot medical certification, and the issue of pilot healthcare avoidance, from the perspective of the SMS framework. **OVERVIEW:** Within the SMS framework, the FAA establishes the acceptable level of risk. It then falls to pilots, operators, and manufactures to assess and manage their risk with the goal of compliance and shared interests of

safety. The FAA provides oversight and independent validation of their risk management. This process aligns with the code of federal regulations on pilot medical readiness (14 CFR 61.53) and qualification standards (14 CFR 67). The pilot is responsible for determining their fitness to fly given a medical condition and any associated medications and treatments on any given day between periodic examinations. The FAA conducts independent validations of pilot medical risk management through the periodic medical examination conducted by its designated examiners. When the designee identifies a pilot who does not meet medical standards, the designee refers the case to a FAA medical officer for a safety risk assessment. This safety risk assessment involves a determination of the probability of an aeromedical event during the certification period given pilot health-related hazards and any available mitigations. The goal for these risk assessments is data driven, risk based decision-making, however, when sufficient data is unavailable expert opinion on a case-by-case basis is employed. **DISCUSSION:** The SMS framework emphasizes the primary role of the pilot in managing their medical risk and supporting FAA oversight and validation activities. Given civil pilot medical care occurs in the community healthcare setting, often mediated through health insurance and the workplace, pilot healthcare avoidance is best considered in the context of a safety risk model that incorporates broader organizational and societal factors. Such a model is presented, which incorporates the levels of prevention and health policy factors.

Learning Objectives

1. The audience will learn how pilot medical certification is accomplished with the FAA's safety management system framework.
2. The audience will learn how organizational and societal factors influence pilot healthcare avoidance in the civil aviation setting.

Tuesday, 05/23/2023 ***10:30 AM***
Grand Chenier

[S-27]: PANEL: SAFETY CONSIDERATIONS OF REDUCED CREW OPERATIONS ON LONG-HAUL FLIGHTS

Sponsored by Air Transport Medicine Committee (ATM - AsMA)

Chair: Ries Simons
Co-Chair: Roland Vermeiren

PANEL OVERVIEW: *Safety Considerations of Reduced Crew Operations on long-haul flights Introduction: Several stakeholders in the aviation industry are exploring the possibilities of Reduced Crew Operations of commercial airliners. Concrete developments concern Extended Minimum Crew Operations (eMCO: on long haul flights one Pilot Flying + one Pilot Resting - no augmentation of crew) and Single Pilot Operations (SIPO: one Pilot in cockpit + one supporting Pilot at a ground station). The eMCO concept is supposed to be implemented in the coming years and the SIPO concept is to be rolled out in 2030. The present panel session is geared to discuss safety risks of eMCO and SIPO. Operational, aeromedical, and human factors consequences of these operations will be discussed and main points for risk assessment will be proposed.*

[144] REDUCED CREW OPERATIONS – ADDRESSING THE HUMAN CENTRIC DESIGN OF THE SYSTEM – PILOTS' PERSPECTIVE

Juan Carlos Lozano
IFALPA and European Cockpit Association, Brussels, Belgium

(Original Research)

INTRODUCTION: Airline pilots have a proven track record of maintaining industry's safety record in the day-to-day operations. Despite that, the safety role of a pilot physically present in the flight deck is being questioned by certain parts of the industry. Numerous projects are ongoing to introduce single-pilot or remote-controlled operations to the air transportation system. Some aircraft manufacturers consider the technology aimed at implementing reduced crew configurations "as ready to go". But is it ready to go for all types of real-life scenarios? **CONSIDERATIONS:** Before considering any crew reduction issue, it is necessary to understand today's airline pilots working methods and philosophy. During the last 30 years, pilot training has substantially evolved to tackle the complexities that flight deck automation has brought as well as the increase in air operations. The development and implementation of Cockpit Resource Management (CRM) have proven to be an undeniable factor of the improved global flight safety. In the last 10 to 15 years, we have seen many cases where technology has seriously compromised flight safety and only the coordinated work of two (or more) well-rested, well-trained pilots saved the day. **DISCUSSION AND CONCLUSION:** There are numerous risks associated with the reduction of the number of pilots in the flight deck. Most prominently, these risks stem from the increased workload for the remaining pilot and the elimination of a critical layer of monitoring, cross-checking and operating redundancy provided by a second pilot in the flight deck. This could compromise the safety and security beyond acceptable levels of risk given the many variable emergency situations that may occur during a flight. It has not been demonstrated that automation has matured to the point of enabling operations with only one pilot in the flight deck without compromising safety. Currently, there is a complex interplay of two crewmembers, physically located next to each other on the flight deck, openly communicating with each other. We need to study the probabilities and impact should the pilot 'fail', how loneliness for long periods of time or in critical situations would affect pilot's performance. What are the consequences of pilot incapacitation in a reduced crew operations scenario and how can it be recognized and dealt with?

Learning Objectives

1. Understand the complimentary role of automation to the human in aviation safety.
2. Human limitations (physical and psychological) need to be fully understood before eliminating humans from the flight deck of an aircraft.

[145] WHAT ARE THE AEROMEDICAL CONSIDERATIONS NECESSARY TO FACILITATE REDUCED CREW OPERATIONS WHILST MAINTAINING OR IMPROVING FLIGHT SAFETY?

Declan Maher
European Society of Aerospace Medicine, Dublin, Ireland

(Education - Tutorial/Review)

INTRODUCTION: Reduced Crew Operations (RCO) call for a root and branch analysis of the fundamental aspects of what we take for granted as the fundamentals of Flight Safety. Movement away from the current model will require evidence and expert opinion for the development of a medical standard that applies to those that wish to fly in Extended Minimal Crew Operations (eMCO) or in Single Pilot Operation (SPO). **DISCUSSION:** We have developed Medical Standards that reflect best aviation medicine practice requiring two persons on the Flight Deck at all times. This was reinforced by events in 2015. The mitigation of risk to flight safety through sudden or subtle incapacitation are based on the same concept of two on the flight deck. Our current Medical Standards are based on evidence and expert opinion born from research and experience in Aviation Medicine. This new Medical Standard will need to mitigate against the risk imposed by the absence of the second person on the Flight Deck. How much of the Multi-Crew Operation mitigates risk? What is the impact of Crew Resource Management and does it still have a role? Do we have sufficient evidence that it does, and by how much? Is there evidence to support that it has little or no impact? What are the areas of Commercial Air Transport that are impacted by the concepts of RCO? Do we need to identify and, where possible, quantify the elements that need to be studied when considering the use of RCO?

The Aim of this Presentation is to highlight the elements for research and consideration.

Learning Objectives

1. Explore the changes in Aeromedical Standards required to allow reduced crew operations.
2. Consideration of the risk mitigation achieved by the multi-crew flight deck environment.

[146] REDUCED CREW OPERATIONS ON LONG-HAUL FLIGHTS: SOME FATIGUE CONSIDERATIONS

David Powell
International Air Transport Association, Auckland, New Zealand

(Education - Program/Process Review)

BACKGROUND: Reduced crew operations have been proposed as a possible mechanism to address pilot shortages, operating costs, and other operational challenges in long-haul commercial airline operations. **OVERVIEW:** There are many factors to be considered among the implications of reduced crew operations. For this presentation the focus is the question of pilot fatigue, and the optimal management of on-board rest. How might reduced crew operations impact the rest achieved on board? How might this impact be considered amongst the other factors also addressed in the panel? **DISCUSSION:** To look at this specific question, the presentation will review some research from many studies undertaken as a part of the fatigue risk management system within a long-haul airline. Possible application of the lessons learned will be discussed in the context of airline crew operations.

Learning Objectives

1. Understand the relationship of crew complement to on-board rest in long-haul airline operations.
2. State the typical findings of studies into long-haul fatigue of airline pilots with a range of crew complements, sector durations, and rest patterns.
3. State the possible effect of reduced crew operations on the on-board rest achieved.

[147] REDUCED CREW CONCEPTS (RCC) FOR CIVIL TRANSPORT AIRPLANES – THE FAA PERSPECTIVE

Melchor Antunano
FAA, Oklahoma City, OK, United States

(Education - Program/Process Review)

There is an Increasing interest from airlines and airframers in Reduced Crew Operations (RCC). This is due in part to compensate for existing/expected pilot shortages and to potentially reduce expenses related to crew costs. RCC includes 1) Single Pilot Operations (SPO), 2) Enhanced Minimum Crew Operations (eMCO), 3) Single Pilot – Second Pilot Optional (SPPO), 4) Pilot Optional Operations, and 5) Fully Autonomous Operations. RCC include operating with a single pilot in the flight deck for at least some portion of flight. Single pilot may be supported by additional flight crew for some flight segments, advanced automation on the aircraft flight deck, or ground station operator (remote pilot). Advanced automation implementation would require the retrofit an existing flight deck or to develop a clean-sheet design. This is a paradigm shift in the traditional flight crew design toward reliance on automation to mitigate and manage risk. Applicants for RCC will need to address many issues to establish this. There are a number of significant challenges to implement RCC including: 1) Pilot Incapacitation/Confusion Detection & Mitigation, 2) Pilot Workload & Performance, 3) Control Authority, Priority and Transfer, 4) Flight Deck Design, 5) System Design Philosophy, 6) Flightcrew Roles & Responsibilities, 7) System Safety/Risk Assessment and Contingency Management, 8) Concept of Operations, 9) Ground Station Communication/Signal Integrity and Security, 10) Ground Station Responsibilities/Authority, and 11) Pilot Type Ratings/Qualifications. The FAA Roadmap for RCC for Transport Airplanes mut identify the unique challenges and risks for the eMCO and SPO, assess current rules, guidance and standards and identify gaps and focus areas, develop a plan to fill gaps near-term and long-term, and ensure an equivalent (or higher) level of operational safety to today's transport airplane operations. Such a roadmap must involve Aircraft Certification, Flight Standards, Air Traffic Control, Airports Operations, and Aerospace Medicine.

Learning Objectives

1. The audience will understand the medical and human factors implications of Reduced Crew Concepts (RCC).
2. The audience will understand the challenges and complexity of reducing crew members to operate commercial transports.

Tuesday, 05/23/2023 ***10:30 AM***
Napoleon Ballroom C1-C2

[S-28]: PANEL: PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: A NATO WORKING GROUP

Chair: Ryan Mayes

PANEL OVERVIEW: *Tactical aviation has a long history of physiologic events (PEs) associated with flight in challenging environments. However, in the last decade, pilots of multiple high-performance aircraft (fighter/attack jets and trainers) have experienced a higher-than-expected rate of these episodes in multiple services. In order to facilitate dialogue across nations regarding PEs, a North American Treaty Organization (NATO) working group was formed in 2018. With over 20 members from 10 NATO and partner nations, this group seeks to develop a better understanding of the potential causes of PEs, compare PE presentation and experience across nations and airframes, and create international consensus on causes, mitigations, and response where appropriate. This panel will present the NATO working group's progress to date, with particular emphasis on the challenge and group approach, proposing case definition and categorization principles, a presentation of the parameters of interest for physiologic monitoring, a discussion on the best practices for physiologic monitoring in the tactical aviation environment, and an analysis of the knowledge gaps in the current literature.*

[148] PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: THE CHALLENGE AND NATO WORKING GROUP APPROACH

Ryan Mayes[1], Adrian Smith[2], Ted Meeuwsen[3], Nicholas Green[4], R. Allen Hoffman[1,9], Erik Frijters[3], Vivienne Lee[5], Oliver Erley[6], Roope Souvelius[7], Laetitia Bertrand[8], Michael Decker[9]
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(Education - Program/Process Review)

BACKGROUND: in-flight physiologic events (PEs) among high-performance aircraft pilots have been attributed hypoxia or g-induced loss of consciousness (GLOC). Accordingly, training, pilot selection, and incident response investigations have been centered around this paradigm. However, as jet life support systems and aircrew flight equipment have improved, it stands to reason that these traditionally-attributed causes of PEs may be incomplete. In the last decade, multiple PEs have been noted among 4th- and 5th-generation fighter pilots in multiple services that do not appear to be connected to hypoxia or GLOC. **OVERVIEW:** In order to facilitate international information

sharing and create a consensus understanding of PEs, a North American Treaty Organization (NATO) working group was formed in 2018. This group has 20+ members representing 10 NATO and partner nations. The group has multiple objectives, but the four primary goals are (1) creating PE classification criteria, (2) generation of a PE case definition, (3) conducting a study of aircrew PE experience across NATO nations and airframes, and (4) creating a matrix of the relevant exposures present in the tactical aviation environment along with the potential outcomes of those exposures. **DISCUSSION:** PE symptom presentation can vary widely, and the cause of PEs are multifactorial and variable. An understanding of the multiple exposures that may lead to symptoms and of the potential outcomes of those exposures, is critical to understanding PEs. PEs require a comprehensive, systematic, and methodical assessment by a specialist. However, not all relevant exposures and outcomes are well-understood, and the multifactorial nature of PEs requires an understanding of the interactions between exposures and physiologic responses. A current understanding of the rapidly evolving state of PE science is critical to assessment of PEs.

Learning Objectives

1. Understand the potential sources of, and challenges posed by, in-flight physiologic events.
2. Understand the objectives of the NATO working group focused on physiologic events.

[149] PRINCIPLES FOR THE EVALUATION, GRADING, AND CLASSIFICATION OF PHYSIOLOGICAL EPISODES.

Adrian Smith[1], Roy Allen Hoffman[2]
[1]*RAAF Institute of Aviation Medicine, Adelaide, Australia;* [2]*Naval Aeromedical Research Lab, Dayton, OH, United States*

(Education - Program/Process Review)

BACKGROUND: Physiological episodes (PHYSEP) remain a significant safety concern for military aircrew, especially those operating high-performance aircraft. Lack of standardized definitions and reporting have made it difficult to compare PHYSEP across platforms and between military forces. NATO RTG HFM 312 has developed a standardized approach to facilitate communication and analyses. **OVERVIEW:** Evaluation is based on establishing a symptoms-based probabilistic cause for PHYSEP through accurate symptom reporting. Classification is performed based on symptom clusters, their association with an anomaly in an aircraft system, standardized severity rating of symptoms, and physiological explanations with high degrees of confidence. Classification by systematically grouped aircraft system factors and presenting symptoms can be compared across different platforms and between military. The evidence underpinning different potential causes is weighted based on three questions: Is the symptomology consistent with the proposed mechanism? Is the timeline, evolution, and response to treatment or mitigation consistent with the proposed mechanism? Are the environmental conditions necessary for the proposed mechanism present? Grading is performed according to severity of the symptomatic event and adequacy of defenses. The severity of PHYSEP can be described in terms of the extent to which the symptoms degrade physiological margin and human performance or jeopardize flight safety. Reporting will have host nation variation but include the evaluation, classification and grading, of PHYSEP by aviation medicine specialists' consensus panel review, with timely release of preliminary information to support the engineering and safety investigations following a PHYSEP. **DISCUSSION:** The principles outlined in this presentation provide a structured approach to evaluating and assessing the most-credible explanations for the associated symptoms experienced in PHYSEP flights and serve as the basis to communicate relevant evidence-based information to assist the safety investigators and engineering-support team in developing their response and construct solutions. The standardized framework will allow PHYSEP experience to be shared between platforms and military forces.

Learning Objectives

1. The audience will learn about the framework proposed by NATO RTG HFM 312 for the assessment and classification of PHYSEPs.
2. The audience will learn about the benefits of adopting a standardized approach to PHYSEPs when comparing trends across different systems.

[150] PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: A NATO WORKING GROUP

Erik Frijters[1], Ryan Mayes[2], Ted Meeuwsen[1]
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(Original Research)

INTRODUCTION: Military flying is very demanding on the human operator, especially in high performance jet aircraft. High Gz forces, onboard oxygen systems, fluctuating cabin pressures and pilot flight equipment can all impact pilot physiology. Physiological events are sometimes reported by pilots who "just don't feel right". Physiological symptoms may be vague, non-specific, or ambiguous, and may not clearly be attributed to a single root cause. There is currently no objective measure that a pilot can use to assess signs and symptoms in-flight. **METHODS:** For effective application of a physiological monitoring system, the design principles to be considered include: fit for purpose in the flight test environment; a passive datalogger for forensic use post-event; active monitoring and display of relevant information in a format for aircrew to use to assess wellbeing in flight, including in the presence of symptoms; an alerting system to warn aircrew of degrading physiological conditions requiring action. Because physiologic events are multifactorial with wide-ranging symptoms and presentations, generalized parameters are the most useful to study. **RESULTS:** Cardiopulmonary measures (ECG, heart rate, minute ventilation, respiratory rate) are relevant and achievable. The "smart flight suit" has such capabilities. It is a cooperation effort between the Royal Netherlands Air Force and U.S. Air Force Research Laboratory and is an example of a product that is specifically designed for the cockpit environment. An overview of parameters of potential interest for the future will be discussed in the presentation. **DISCUSSION:** Parameters that are specific to a particular exposure or casual pathway (such as blood oxygen level) are of more limited utility. Looking to the future, electroencephalograpy (EEG) and eye tracking may provide valuable insight into aircrew state, but are more complex to measure. As technology progresses more ways to measure physiological responses may become available. Application in the cockpit environment depends on usability and robustness and requires thorough testing and certification. **BACKGROUND:** In 2021 a 3 year collaborative working group called 'Unexplained Physiological Events' (HFM RTG-312) was formed. The team consists of experts from 20 different NATO countries and is working on creating an exposure matrix to identify which factors are most relevant to the operator and ways to mitigate their effects.

Learning Objectives

1. The audience will learn about how measuring in-flight physiological parameters can be relevant to increase operator effectiveness and mission succes. Current and future potential will be discussed.
2. The audience will learn about the challenges that come with designing a reliable and robust way of measuring physiological parameters in the cockpit environment.

[151] MONITORING: BEST PRACTICES FOR MEASUREMENT IN THE TACTICAL AVIATION ENVIRONMENT

Nicholas Green[1], Erik Frijters[2], Oliver Erley[3], Roy Hoffman[4], Vivienne Lee[5], Ted Meeuwsen[2], Adrian Smith[6], Roope Sovelius[7], Michael Decker[8], Ryan Mayes[9]
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[4]U.S. Navy Air Systems Command, Patuxent River, MD, United States; [5]QinetiQ PLC, Farnborough, United Kingdom; [6]Institute of Aviation Medicine, RAAF, Adelaide, Australia; [7]Center of Military Medicine, Satakunta, Finland; [8]U.S. Naval Medical Research Lab, Dayton, OH, United States; [9]USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: The aerospace environment presents significant challenges to the acquisition of accurate biomedical data, even in the controlled environment of a hypobaric chamber or centrifuge. The presence of environmentally generated artefacts or other confounding variables has an important influence on the interpretation of any changes observed. This presentation outlines some guiding principles to optimize biomedical measurements in the tactical aviation environment. **DESCRIPTION:** At the outset, target variables should have been previously demonstrated to show meaningful changes in the flight setting. We need to be confident that data collected can be used to prompt changes in pilot behavior or equipment operation during flight, so that aircrew performance is increased or risk is reduced in a timely manner. If no meaningful intervention can be made, there is no value in monitoring (except sometimes for post-flight investigation). It is essential to monitor the most reliable and reproducible data source. For many variables, this source may not be directly from the human. For example, breathing rate and depth can be more readily measured in the gas supply to the pilot rather than by detecting movement of the pilot's chest. Measures must have appropriate sensitivity and specificity in the flight environment, and caution should be exercised when reading across the performance of proprietary algorithms to flight. If real-time data analysis is being conducted, data must be artefact free or must be amenable to real-time artefact stripping. Artefacts may be reduced by careful location of sensors, but these must be compatible with flight gear. Ideally, the variable chosen for monitoring should have clear threshold values for action, but often meaningful changes in flight physiology data are trend-based, which makes reliable real-time analysis more challenging. **DISCUSSION:** The occurrence of Physiological Events is rare per flight hour. Therefore, when considering monitoring in the tactical flight environment, it is important to consider Bayes' theorem. Without measures that have high specificity, there is a risk that monitoring in tactical aviation will generate an unacceptable number of false positive reports. Appropriate choice of target variable, measurement site and data handling may optimise utility.

Learning Objectives

1. Understand the challenge of physiological monitoring in the flight environment.
2. Understand the principles that may improve the chance of success when monitoring in the flight environment.

[152] PHYSIOLOGIC EVENTS IN HIGH-PERFORMANCE AVIATION: WHAT DON'T WE KNOW AND WHAT DO WE NEED TO KNOW?

Vivienne Lee[1], Roope Sovelius[2], Michael Decker[3], Nicholas Green[4], Adrian Smith[5], Erik Frijters[6], Ted Meeuwsen[6], Oliver Erley[7], Ryan Mayes[8]

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(Education - Tutorial/Review)

INTRODUCTION: Pilots of high-performance aircraft from a number of nations have reported in-flight physiologic events (PEs) over recent years. As part of its remit, the NATO HFM RTG-312 group has identified areas where knowledge is lacking and where effort is required to promote an international understanding of the factors influencing PEs, their mitigations and to inform aircrew education. **TOPIC:** The HFM RTG-312 has developed a matrix of exposures containing factors relevant to PE occurrence. As part of the process, knowledge gaps associated with these factors are being identified and key areas for research are being considered. The process has already highlighted knowledge gaps including: the implications of the operational environment on inflammatory processes and the significance of these with respect to aircrew performance and PEs; the implications of delivered gas mixture, dehydration, nutrition, smoking and external stressors on PEs; the effect of exercise and sleep quality prior to flight; the effects of circadian disruption and fatigue on flight performance and susceptibility to PEs. Additionally, a review of current knowledge has highlighted the need for further research into breathing system resistance to improve standards; with increasing capability to undertake long duration missions, cockpit ergonomics and other factors associated with extended periods of flight need consideration with respect to susceptibility to PEs, and their effect on cognitive performance. In many areas, research has been undertaken on individual stressors associated with the flight environment but knowledge is lacking on the potential synergistic effects of combined stressors. Importantly, there is a need to understand implications of age, anthropometry and sex; going forward, there is a need for research to include female participants as these data are currently lacking. **APPLICATION:** Research into the knowledge gaps identified will inform international understanding of the factors influencing the development of a PE, which in turn can underpin development of robust mitigations. A broad, robust knowledge base should support best practice for aircrew education, leading to optimal management of PEs by operators and aircrew.

Learning Objectives

1. The audience will learn what NATO RTG 312 consider the key knowledge gaps relevant to physiologic events.
2. The audience will learn what NATO RTG 312 consider to be research priorities relevant to physiologic events.

Tuesday, 05/23/2023 ***10:30 AM***
Napoleon Ballroom D1-D2

[S-29]: SLIDES: COVID AND HEALTHCARE INTEGRATION

Chair: Benisse Lester
Co-Chair: Tamara Averett-Brauer

[153] EATC CROSS-NATIONAL STRAT AE FLIGHTS DURING COVID-19 AND UKRAINIAN CRISIS

Alessandro Fiorini, Martin Gascon Hove, Erwan Dulaurent, Ralph Vermeltfoort, Henning von Perbandt, Mathias Borsch
European Air Transport Command, Eindhoven, Netherlands

(Education - Program/Process Review)

INTRODUCTION: European Air Transport Command (EATC) is integrated command of 7 nations and among its core capabilities is that of Strategic Aeromedical Evacuation (Strat AE). During the global COVID-19 pandemic and Ukrainian crisis, EATC has proven that only acting in concert leads to success. This is achieved by pooling and sharing aircraft and personnel, thus having privileged access to a diverse fleet and pool of experts. It is based on a common set of rules and regulations. This ensures that EATC is able to address any problem with innovation and expertise. **MATERIAL AND METHODS:** Impact of novel coronavirus and the recent Ukrainian crisis were analyzed based on numbers and characteristics of patients and executed missions within EATC during the biennium 2020-2022. **RESULTS:** 1060 COVID-19 patients were transported in 186 missions. Neither death nor disease contagion were reported during those Strat AE flights. Military cases transferred were 986, mostly routine priority (91,4 %). The other 74 cases were civilians, who were transported in 17 missions, 81,1 % of which

were categorized as urgent. 251 patients were transported during the Ukrainian crisis, 112 of which were military and 139 were civilians, including 30 children. Among the recorded injuries were cerebrocranial, abdominal and chest injuries, as well fractures of extremities (180) and amputations (48). **CONCLUSIONS:** EATC is recognized as a centre of expertise in the aeromedical evacuation domain, where interoperability and harmonization of concepts are keys for success and safety. Cross-national missions, where a patient is evacuated by an aircraft and medical crew provided by another nation, offer a maximum of flexibility. Complex situations, such as the COVID-19 pandemic and the Ukrainian crisis, have shown that multinational cooperation is the best way forward.

Learning Objectives

1. The audience will learn about the nature and participants of EATC and its core task of Strat AE.
2. The audience will learn about the challenges and advantages of cross-national Strat AE flights during the COVID-19 pandemic and Ukrainian Crisis.

[154] ENROUTE CARE PROVIDER POSTURE STUDY

Amy Lloyd[1], Rachel Kinsler[2], Kerri Caruso[1], Laura Kroening[1], Joshua Dupuy[1], Jeffery Molles[1]
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(Original Research)

INTRODUCTION: The confined space of common medical evacuation (MEDEVAC) platforms requires strenuous positions and painful postures of Critical Care Flight Paramedics (CCFPs) during patient loading and unloading. The goal of this study was to characterize the postures used to load and unload patients and compare them to known acceptable limits for preventing musculosketal disorders (MSD). **METHODS:** Subjects performed patient loading and unloading on a simulated MEDEVAC interior while motion data was collected through a reflective marker-based motion capture system. A total of ten trials were taken for each subject (five loading and five unloading). Six trials were completed on the Basic Medical Interior (BMI), and the other four trials were completed on the Interim MEDEVAC Mission Support System (IMMSS). The subject's postures were investigated to identify potentially dangerous postures that are known to lead to injury or MSD. A questionnaire was given following each loading and unloading pairing, allowing subjects to describe which factors caused the most difficult postures and document their general experience. **RESULTS:** The data from the litter pan position evaluations document was examined to identify movements or postures that cause pain or discomfort. The lower back was consistently mentioned as negatively affected by the lifting for each litter pan position; 77% of subjects reported lower back discomfort. From the motion tracking software average joint angles were found for the back, hip, and knee. Using these average angles, the compressive force was estimated for the vertebral disk between the fifth lumbar and first sacrum vertebrae for two subject load scenarios: half the manikin weight and one quarter of the manikin weight. All the values for both cases were over the safe lifting limit of 770 pounds force. **DISCUSSION:** En route care providers are reporting injuries from the painful postures resulting from loading and unloading patients in the MEDEVAC environment. All subjects mentioned at least one posture and one area of the body negatively affected. If it was assumed the subject only lifted a quarter of the manikin weight versus half, there was a reduction in the compressive force on the back by an average of 40%.

Learning Objectives

1. Understand the postures and positions that cause discomfort or pain when loading or unloading patients.
2. Understand the MEDEVAC features that can negatively affect loading and unloading of the patient.
3. Understand the areas of the medic's body that are negatively affected by loading and unloading patients.

[155] GLOBAL HEALTH INNOVATION GAP ANALYSIS: AVOIDING THE NEXT PANDEMIC

Diego M. Garcia[1], Charles A. DeJohn[2], Kris Belland[3]
[1]*Independent Researcher, Space Coast, FL, United States;* [2]*Independent Researcher, Oklahoma City, OK, United States;* [3]*Independent Researcher, Dallas, TX, United States*

(Education - Program/Process Review)

BACKGROUND: The Public Health Public Health Emergency of International Concern (PHEIC) triggered by COVID-19 posed a heavy burden on the aerospace industry. International passenger transport played a key role in rapid virus translocation, raising questions about the effectiveness of global health security countermeasures implemented by authorities and stakeholders. A systematic review of the policies, strategies, and technology developed for the COVID-19 crisis, reflecting on the opportunities for improvement, paradigm shifts, and new technological advancements for the prevention of transmissible diseases in commercial air transport is in need. **OVERVIEW:** Although travel restrictions and border closures were enacted early in the COVID-19 crisis, a rather quick international spread of the disease was observed, followed by uncoordinated efforts by mostly unprepared states that delayed the full onset of the initial waves of the outbreak, but were insufficient for stopping its eventual global dissemination and ubiquitous presence. Unfruitful travel restrictions remained in place even after full-scale local transmission was ongoing in almost every country of the world. Then, when further improvement in diagnosis, disease treatment and immunizations concurred with the predominance of virus variants with enhanced morbidity potential (Delta and Omicron), air travel was back close to pre-pandemic numbers with record occupancy in the summer of 2022, right before a new PHEIC made appearance: Monkeypox. At risk of repeating this dystopian scenario, the policies, strategies, tools, and procedures related to global health security must be reassessed in the wake of persistent, debutant or re-emerging infectious diseases with pandemic potential. **DISCUSSION:** Observational and some scarce experimental data on the transmission dynamics of pathogens with high-reproduction number will inform a gap analysis on how to enhance existing capacities and how to bond key stakeholders around new collaborative platforms and leading-edge technology with the aim of innovating in our defense strategy against the next pandemic.

Learning Objectives

1. The audience will review the lessons learnt related to COVID-9 travel restrictions and aerospace industry policies in order to identify room for improvement and the need for collaborative and innovative approaches.
2. Attendants will learn about new technology and collaborative platforms for intersectoral participation in Public Health Emergencies of international Concern (PHEIC).

[156] INTEGRATING CIVILIAN AND MILITARY MEDICAL RESOURCES – COST-EFFECTIVE HEALTHCARE IMPROVEMENT

Russell Andrews
World Federation of Neurosurgical Societies, Los Gatos, CA, United States

(Education - Program/Process Review)

BACKGROUND: Improving global healthcare – both routine day-to-day care and mass-casualty disaster response – depends upon cost-effective programs. One-third of deaths worldwide are due to conditions requiring surgery; nearly one-half of deaths in the USA among those less than 50 years old are due to trauma, a condition requiring surgical resources. Cost-effective programs to expand surgical care are essential to improve global healthcare. In many countries military medical resources are better developed than the public civilian resources – yet the military resources are frequently underutilized. Over the past several decades in the USA there have been efforts to integrate civilian and military medical resources – primarily to improve trauma care nationwide. **OVERVIEW:** The trauma center

model addresses the need not only for surgical resources 24/7/365 but also for ancillary services such as radiology, blood bank, and laboratory that are necessary for non-surgical conditions. A trauma center closely resembles the most extensive emergency medical team facility (Type 3 Specialized Care) specified by the World Health Organization (WHO). WHO has also noted that effective response to both natural disasters and man-made mass casualty situations requires a robust and resilient local medical infrastructure: external resources (e.g. the Red Cross) that arrive days to a week or more after the event are not effective for acute surgical conditions. A prime example of civilian-military integration comes from Israel. The Israeli Defense Forces Field Hospital, combined with civilian sector healthcare resources, optimizes injury prevention, prehospital transport and care, acute care, and rehabilitation. Other examples of integration of civilian and military medical resources in Australia and Chile are considered. Civilian-military integration of technology — e.g. electronic records, telemedicine, drones — is another cost-effective way to expand healthcare. **DISCUSSION:** By combining the advanced resilient resources of the military for emergency response with the breadth and depth of the civilian healthcare system for day-to-day care, the trauma center model can be expanded into the mass casualty center model that cost-effectively augments both emergency mass casualty care and routine day-to-day care for large segments of the population.

Learning Objectives

1. The audience will learn the primary role of surgical resources for improvement in global healthcare.
2. The audience will learn the advantages of integrating civilian and military medical/surgical resources for optimizing both day-to-day and emergency mass casualty healthcare capabilities.
3. The audience will learn about technological advances that improve healthcare from both effectiveness and cost aspects.

[157] THE ROLE OF NURSE PRACTITIONERS AND PHYSICIAN ASSISTANTS IN AEROSPACE MEDICINE

Jessica Knizel[1], William Gressier[2], Scott Rhodes[3]
[1]*U.S. Air Force, Eglin AFB, FL, United States;* [2]*U.S. Air Force, March AFB, CA, United States;* [3]*Center for Aerospace Nursing Excellence, Dayton, OH, United States*

(Education - Program/Process Review)

BACKGROUND: Since 2014, the AF has experienced its steepest manpower cuts in two decades resulting in marked vacancies, yet mission demands and requirements have continued to expand. This has increased and stretched the Flight Surgeon's (FS) role beyond the historical scope. Many FS vacancies are being filled by Aeromedical Physician Assistants (APA) and Aeromedical Nurse Practitioners (ANP) whose scope of practice is being limited by the Federal Aviation Administration (FAA) and AF. These limitations decrease aviator access to care for readiness and suitability examinations. **OVERVIEW:** Preparing for future conflict and facing ever-changing readiness demands require a second look at our approach to aerospace medicine. **DISCUSSION:** We will outline several peer reviewed articles with a focus on innovative remolding of the primary care team by utilizing autonomous Nurse Practitioners (NPs) and Physician Assistants (PAs). Following a True Care Team Model, with multiple providers functioning independently, improves access to care, care coordination, and enhanced communication (Chaney et al., 2022). A study of state regulations and outcomes found that restricting scope of practice did not improve quality of care (Perloff et al., 2019). Less restrictive states had 40% increased access to care for its beneficiaries (Graves et al., 2016). Over three decades of research have shown that NPs are equally as safe and effective as their physician counterparts (Geller & Swann, 2021). NPs have consistently demonstrated quality, safe, and cost effect health care in many settings (Lowery et al., 2016; RAND, 2009). The utilization of full scope NPs increases access to cost effective care (Liu et al., 2020; RAND, 2009). NP and PA visits are often 35% less expensive than their physician counterparts (RAND, 2009). The current FAA aeromedical certification process has positively shown a reduction in odds of death while holding a medical certificate. Aviators with a waiver have lower odds of an accident compared to aviators with a regular issuance (Mills & Greenhaw, 2019). Modification to the current FAA regulations and updating the AF Medical Standards Directory will allow aeromedical-trained NPs and PAs to work at their full scope of practice within the multidisciplinary team. Facilitating a change and allowing a collaborative co-sign agreement has the potential to increase access to care, improve readiness, and yield cost savings for the DoD.

Learning Objectives

1. The learner will be able to provide two examples of benefits to increasing ANP and APA autonomy in Team Aerospace.
2. The learner will be able to name the three regulating bodies discussed in the presentation.
3. The learner will be able to list three of the AF Aeromedical Provider training requirements.

[158] FACIAL BAROPARESIS MIMICS A STROKE IN A COMMERCIAL AIRLINE PASSENGER: A CASE REPORT

Azeem Ali
Emirates Group, Dubai, United Arab Emirates

(Education - Case Study)

INTRODUCTION: This case report describes a previously healthy 31-year-old male passenger on a commercial aircraft that experienced an acute unilateral facial muscle paralysis at cruising altitude with a complete resolution of symptoms shortly after the descent. **BACKGROUND:** Neurological symptoms account for up to 30% of all in-flight medical events that require ground-based medical support (GMS) services. Strokes and other suspected neurological emergencies are time-sensitive with a limited window for potential reperfusion therapies; hence they account for approximately 10-30% of all medical diversions in commercial aviation. Non-specific neurological symptoms in a previously healthy passenger require a detailed review by a GMS service before making impactful recommendations like an aircraft diversion. **CASE PRESENTATION:** The passenger was a 31-year-old male travelling from the Maldives to Dubai with no recent diving but had a sinus problem during the vacation. Our in-house GMS service managed this case with an acute and evolving right facial numbness that also involved his tongue and buccal area. This started approximately 2 hours before landing at a cruising altitude of 39,000 feet. A physician medical volunteer on board assisted and found that he had non-specific neurological symptoms with a suspected stroke or bell's palsy. With continuous observation and no medication, he had a complete resolution of symptoms with a decrease in altitude during landing. Further medical evaluation at the airport medical services found no signs/symptoms of a neurological emergency, with a likely diagnosis of facial baroparesis. No follow-up was required. **DISCUSSION:** Facial baroparesis is a seventh cranial nerve palsy caused by transient hypoxemia of the facial nerve due to increased pressure in the middle ear cavity. Symptoms mimic a stroke, Bell's palsy, air embolism, or Type II decompression sickness. It is under-reported because of its transient nature and single episodes despite recurrent exposure to similar flight or diving conditions. This case highlights the awareness of the physicians involved that resulted in no unnecessary recommendations to divert the aircraft or the requirement for inappropriate investigations by the medical services on the ground. Eliciting an accurate history together with symptoms that resolved shortly after equalization of the middle ear and ambient pressure will lend itself to an accurate diagnosis.

Learning Objectives

1. Participants will be more aware of facial baroparesis as a differential diagnosis for transient unilateral facial numbness. This awareness may prevent unnecessary aircraft diversion recommendations, inappropriate investigations at hospitals or revocation of diving/aviation medical certification.
2. The audience will learn that facial baroparesis is an under-recognised condition that can mimic a stroke, Bell's palsy and other neurological medical conditions.

Tuesday, 05/23/2023 ***10:30 AM***
Napoleon C3

[S-30]: PANEL: DOES AEROMEDICAL SCIENCE SUPPORTS THE USE OF UV-C LIGHTING TO REDUCE DISEASE TRANSMISSION / TRANSLOCATION ABOARD AIRCRAFT

Chair: Charles DeJohn

PANEL OVERVIEW: *Ultraviolet Germicidal Irradiation (UVGI) air disinfection is nearly 100 years old. UVGI was widely uised in hospitals and public places to reduce infections by inactivating airborne pathenogens in the 1930's through the 1950's. The SARS-Cov-2 pandemic has led to a resurgence of interest in the research and development of UVGI air disinfection, leading to the development of practical Light Emitting Diode (LED) systems showing promise for use in aircraft. Although questions of efficacy and safety of UVGI as a control measure have been raised, the use of far-UV-C wavelength has led to a reexamination of UV technology and Threshold Limit Values (TLV's) have been revised. Innovative designs and improved procedures have been implemented to improve the safety and efficacy of today's UVGI systems. This panel will examine the safey and efficacy of using direct, continuous UV-C irradiation of occupied cabins of commercial aircraft cabins inflight.*

[159] EMERGING AVIATION MULTI-LAYERED DISEASE DEFENSE STRATEGY (AMLDDS), ULTRAVIOLET (UV-C)

Kris Belland
Aerospace Medical Association, Alexandria, VA, United States

(Education - Program/Process Review)

BACKGROUND: Worldwide aviation has been greatly and negatively impacted by the COVID-19 pandemic. Right from the outset, organizations, businesses, and individuals within the aviation industries have faced unique and complex challenges. As the pandemic evolved, so did knowledge, attitudes, and expectations. Controversy has not been rare, especially around the relative weight of preventive measures, creating unique opportunities for learning. In this presentation, the author will provide an Systematic Review / Meta analysis overview and update to the Aviation Multi-Layered Disease Defense Strategy (AMLDDS) and discuss Emerging risk-mitigations (application of Reason Swiss Cheese Theory to inflight disease transmission / translocation). Strategies will include current and emerging technologies to include use of airborne Ultraviolet (UV-C) irradiation. **OVERVIEW:** The author served as the AsMA representative to the International Civil Aviation Organization (ICAO) and Collaborative Arrangement for the Prevention and Management of Public Health Events in Civil Aviation (CAPSCA) during the last three years of the COVID-19 pandemic and has formed a unique perspective and best business practices. Contingency planning has had to adapt constantly. Procedures have been assessed, reassessed, implemented and made more robust, which may serve the aviation community well in years to come. Emerging layers of disease risk mitigation protection including the use of UV-C at safe levels and how they can reduce translocation and transmission of disease in flight will be discussed. **DISCUSSION:** After a thorough systematic review of subject publications and in anticipation of publishing a systematic review / meta analysis in the AsMA Blue Journal, the author will discuss existing and emerging infectious diseases risk mitigation strategies critical to aviation - COVID-19 and beyond, and will provide an overview and update to the AMLDDS and discuss Emerging risk-mitigation (evolutionary application of James Reason, Swiss Cheese Model / Theory which was successfully adapted to international COVID-19 pandemic response by ICAO and CAPSCA. Lessons learned and emerging technologies will continue reduce inflight disease transmission / translocation of disease and enhance future pandemic responses. New advanced technology strategies including airborne use of Ultraviolet (UV-C) will be discussed.

Learning Objectives

1. Understand Reason Swiss Cheese Model of risk mitigation and risk reduction in order to mitigate disease transmission and translocation in flight.
2. Ultraviolet - "C" utilization in flight, commercial, military and space to reduce disease burden, translocation and transmission.

[160] SAFETY ASPECTS OF GERMICIDAL ULTRAVIOLET RADIATION

David Sliney
Johns Hopkins University Bloomberg School of Public Health, Fallston, MD, United States

(Education - Program/Process Review)

Germicidal UV (GUV) – or ultraviolet germicidal irradiation (UVGI) – dates back more than a century and was widely used in hospitals and public places to reduce infections by inactivating airborne parthenogens in the 1930s – 1950s. With the outbreak of COVID-19, questions of efficacy and safety of UVGI as a control measure appeared and optical safety experts were questioned on this. At that time, most experience with UVGI had largely been limited to TB clinics – particularly in some developing countries where some expertise on this technology had been retained. Sadly, misconceptions about GUV, such as a perceived skin cancer risks remained and a lack of understanding of proper safety precautions continue to slow the wide acceptance of UVGI in North America and Europe. The COVID-19 pandemic greatly accelerated development of traditional UV-C lamps and new lamp types such as UV LEDs the krypton-chloride (222-nm) lamp to augment the traditional use of low-pressure mercury (254 nm) lamps. Accidental exposure of skin and eyes if GUV is poorly installed GUV had resulted in transient effects of the skin and eyes leading to real safety concern. The cornea is the most sensitive tissue to UV-C irritation: this is a transient injury – photokeratitis ("welder's flash," or "snow-blindness") – with symptoms of "sand in the eyes." Erythema – reddening of the skin– is mild from the very superficially penetrating UV-C. The delayed effects, such as skin cancer raise the greatest concern, but it is the UV-B in sunlight that penetrates to the basal (germinative) layer of the epidermis and is the recognized cause of most skin cancer. The "far UV-C" wavelengths (e.g., 222 nm) are even more heavily absorbed in the superficial epidermis & stratum corneum than longer UV-C wavelengths greater than ~ 230 nm, with the result that guidelines for human exposure can be much less restrictive below 230-240 nm. For this reason, whole-room, far-UV-C GUV became practicable. The use of the new, far-UV-C wavelengths led to a reexamination of UV TLVs and these have now been revised. Instead of shifting wavelength, manipulation of the geometry of exposure has been shown particularly effective with UV LEDs.

Learning Objectives

1. The audience will learn about the potential for acute-injury hazards to the eye (photokeratitis) and skin (erythema) from inappropriately installed germicidal ultraviolet UV-C lamps.
2. The audience will learn that not all ultraviolet exposures pose a real risk of skin cancer, the actual spectral band is critically important. Because UV-C (100 - 280 nm) has very shallow penetration the photocarcinogenic risk is less than 1 % of that from UV-B (280-315 nm) wavelengths in sunlight.
3. The participants will learn to distinguish between the levels of safety afforded by newer germicidal lamp systems that emit at shorter UV-C wavelengths compared to the traditional mercury-lamp systems when requested to provide judgements on the choice of differing germicidal ultraviolet systems.

[162] THE SAFE AND EFFECTIVE APPLICATION OF GERMICIDAL UV AIR DISINFECTION – A 40 YEAR EXPERIENCE

Edward Nardell
Harvard Medical School and Harvard TH Chan School of Public Health, Boston, MA, United States

(Education - Tutorial/Review)

Germicidal UV (GUV) air disinfection technology is nearly 100 years old. In the 1930s It was proven to reduce measles transmission in schools in suburban Philadelphia. Early public health practitioners envisioned making indoor free from seasonal airborne infections just as water treatment virtually eliminated water-borne infections. But indoor air cannot be centrally disinfected like water, and the advent of antibiotics and vaccines promised to eradicate respiratory infections, eliminating the need to further develop the technology. Until a resurgence of TB in the US from 1985-1992 upper room UV was uncommonly used, but TB transmission in homeless shelters, hospitals, AIDS treatment facilities resulted in a resurgence of interest and research. In 2009, NIOSH published guidelines for safe and effective upper room UV air disinfection. As the TB officer for Boston and Massachusetts, I was instrumental in an installation of upper room UV to prevent TB transmission in homeless shelters, jails, prisons, hospitals, and other congregate setting around the US. A controlled nationwide study in homeless shelters demonstrated no more eye or skin complaints when active fixtures were in use than in the same shelters under placebo conditions. A published personal UV dose monitoring study showed that room occupants receive a fraction of threshold limit value dose. An experimental hospital in South Africa demonstrated that 80% less airborne infection was transmitted from infectious TB patients to highly susceptible Guinea Pigs breathing ward air on days when upper room UV fixtures were on in their rooms. The dose specifications used in those experiments is the basis for upper room UV air disinfection dosing recommendations about to be issued by ASHRAE. Numerous published bioaerosol chamber studies using a variety of surrogate test organisms have further refined the scientific basis for the safety and efficacy of upper room GUV. The SARS-CoV-2 pandemic has again led to a resurgence of interest, development, and research on GUV air disinfection, leading to the development of practical LED and 222 nm excimer lamps, with advantages and disadvantages compared to conventional mercury based 254 nm GUV sources.

Learning Objectives

1. The participant will understand the history and current safe and effective use of germicidal ultraviolet (GUV) air disinfection, and recent technical developments such as LED-UV and FAR-UV in its application against SARS-CoV-2 and future airborne pathogens.
2. The participant will understand why germicidal UV is the most effective and cost-effective method of air disinfection for many applications compared to mechanical ventilation and air filtration.
3. Participants will understand that GUV efficacy and safety are based on the ability of UVC to penetrate airborne microbes whereas penetration of the exposed human cornea and skin is limited by confining energy to the upper room in the case of upper room GUV, and by the use of low-penetration 222 nm UV in the case of FAR-UV.

[163] CONTINUOUS DISINFECTION OF CABIN AIR USING SAFE AND CONTROLLED LEVELS OF ULTRAVIOLET LIGHT

Gary Allen

Princeton University, Euclid, OH, United States

(Education - Program/Process Review)

BACKGROUND: Ventilation in commercial aircraft is very good, but not good enough to prevent airborne transmission of disease in a cabin densely packed with passengers. Additional risk mitigation is required, such as wearing masks, which is not popular. Disinfection of the air with safe levels of ultraviolet (UV) light augments, or may surpass, the air disinfection efficacy of aircraft ventilation. **DESCRIPTION:** Using safe levels of UV can contribute significantly to a multi-layered risk mitigation strategy to reduce transmission of airborne diseases in aircraft. Transmission of SARS-CoV-2, Influenza, and other airborne pathogens appears to be primarily via aerosols, not droplets or surface contamination. Air disinfection can be accomplished either by replacing contaminated air with fresh air (ventilation) or by inactivating airborne pathogens in the air without replacing the air (e.g., UV). The air disinfection rate is quantified in Air Changes per Hour (ACH). Typical ventilation rates in aircraft are 10-35 ACH, compared to 1-10 ACH in terrestrial settings. UV disinfection rates in aircraft are expected to be 20-50 ACH_{eq}. The risk of infection is proportional to the density of passengers (pax/m^3) divided by ACH. The extremely high pax density in aircraft cabins drives the risk of infection to exceed that in most other settings, so that aircraft ventilation should be augmented by other risk mitigants, e.g., UV. UV levels safe for human occupancy inactivate 90% of SARS-CoV-2, Influenza, Colds, pneumonia, etc., in 10-30 minutes. Rapid improvements in UV technology will soon provide 100-200 ACH_{eq} at safe levels, and inactivation times of 2-6 minutes. We will explain the allowed Exposure Limit vs. wavelength of light for skin and eyes, demonstrating that UV exposure to pax on an 8-hour flight is equivalent to less than 5 minutes of sunshine. **DISCUSSION:** UV disinfection of air in the cabin of military and civilian aircraft may increase the confidence and wellness of passengers, may reduce crew absences due to illness, and may help to mitigate outbreaks of coronavirus, Influenza, colds, TB, and other airborne diseases in military and general populations.

Learning Objectives

1. The audience will be introduced to a new technology for disinfection of air in an aircraft cabin using levels of ultraviolet light that are safe in occupied spaces, and several reasons why existing aircraft ventilation systems are insufficient and should be augmented by UV disinfection.
2. The participant will learn how to quantify the efficacy of ventilation and UV systems for mitigating the risk of infection by airborne pathogens such as SARS-CoV-2, Influenza, colds, pneumonia, and how ventilation and UV additively contribute to a multi-layer disease defense strategy in aircraft.
3. The participant will learn how the rapidly emerging technology of UV-C LEDs promises to enhance the efficacy of UV air disinfection by about 10x over the next few years, such that UV disinfection may soon become the dominant risk mitigant for airborne disease transmission in aircraft.

[161] OPTIMIZING DESTRUCTION OF AEROSOLIZED-PATHOGENS USING MODERN ELECTRONIC TECHNIQUES

Stephen Glaudel

Syracuse University, Syracuse NY, United States; St. Joseph's University, Philadelphia, PA, United States

(Education - Program/Process Review)

BACKGROUND: The recent Covid-19 pandemic (more prior, will be more to come) impacted virtually all aspects of our lives. We have seen over 1m lives lost (just in USA), many more hospitalized, and countless more impacted more subtly. Fear and Restrictions have severely impacted many livelihoods, especially in places where people aggregate. Businesses have suffered in many ways: customers & employees lost, sick-time, resignations, work-patterns permanently changed (e.g. telecommuting), etc. When we look more closely, epidemics have been here all along: E.g. Influenza typically kills 'only' 40k people annually in USA alone (we become 'numb' to this); Young children with RSV hit the news; Measles rebounds; ad-nauseum. We in USA, and around the world, need to deal with disease-prevention more diligently, utilizing ALL Tools provided by modern Science & Technology. **OVERVIEW:** The author has educational background in Engineering, Biology, and Business, with 48+ years experience in development & applications of Electronic Control-Systems in multiple Industries (Semiconductor-Fabs/Tools, BioTech/Pharma, Power-Gen, Water-Treatment, Metals, Oil&Gas, ...) and has managed teams globally (traveling to over 100 countries). Air travel has been sorely impacted by the above Epidemiological / Societal issues. We herein discuss emerging layers of disease risk mitigation in aircraft, including use of Ultraviolet-light at safe Irradiance levels, with 'Intelligent' dosing & direction, and how that can reduce transmission of disease in flight. **DISCUSSION:** Aerosolized Pathogens pose a large & growing risk: Epidemics have become Pandemics. Difficulties in prevention arise from the simple fact that infected Humans exhale those aerosols in close proximity to Humans inhaling those aerosols. Thus, episodic-cleaning is ineffective; preventive treatments must be provided continually & safely, where & while Humans are present for hours.

"Swiss-Cheese" models (multiple protection layers) include: Vaccines, Masks, HVAC, and now Ultraviolet Irradiance. Advanced technology & control-strategies are available (versus large/older ?fluorescent tubes?), to provide broad-spectrum disinfection (viricidal/bactericidal), including rapidly growing availability of UV-C LEDs (Light-Emitting Diodes: low-power, small-size, low-cost) controlled by simple Electronics that deal with adjusting & directing that Irradiance to where these pathogens can best be eliminated: the Air in-between the passengers.

Learning Objectives

1. The audience will learn more of the practical applications of Ultraviolet light to Disinfection: its benefits, limitations, and the selection of auxiliary componentry to ensure Safety and Efficacy in an Aircraft application.
2. The audience will learn about Safety & Efficacy different wavelengths of light.
3. The audience will learn about selection of different sources of Ultraviolet light.

Tuesday, 05/23/2023 ***10:30 AM***
Nottoway & Oak Alley

[S-31]: PANEL: GERMANY'S HOT TOPICS IN AEROSPACE MEDICINE

Sponsored by German Society of Aerospace Medicine (DGLRM)

Chair: Jens Jordan
Co-Chair: Torsten Pippig

PANEL OVERVIEW*: This session provides different hot topics of the last year in Aerospace Medicine. The session language is Germa; slides are presented in English.*

[164] CARDIOVASCULAR TOLERANCE TO GRAVITATIONAL STRESS FOM ASTRONAUTS TO PATIENTS WITH ORTHOSTATIC INTOLERANCE

Jens Jordan
German Aerospace Center (DLR) and University of Cologne, Cologne, Germany

(Education - Program/Process Review)

The ability of the cardiovascular system to cope with gravitational stress is crucial for astronauts returning to Earth or setting foot on another celestial body, for fighter pilots, and for patients with orthostatic intolerance. Ultimately, tolerance to gravitational stress is determined by the magnitude of the hemodynamic stress and counterregulatory mechanisms, particularly baroreflex-mediated changes in autonomic nervous system activity. I will introduce novel methodologies to assess these mechanisms in human beings. Combining lower body negative pressure with physiological monitoring and cardiac real-time magnetic resonance imaging provides unobtrusive insight in hemodynamic responses to simulated standing. High-resolution functional resonance imaging combined with physiological or pharmacological challenges can be applied to elucidate baroreflex mechanisms at the level of the brainstem. Previously, brainstem mechanisms have only been accessible in animal studies. Finally, I will present findings from recent head-down bedrest studies testing artificial gravity through short-arm centrifugation and prolonged daily lower body negative pressure as potential countermeasures for spaceflight. In addition to enabling human spaceflight, such studies may have applications for patients prone to orthostatic intolerance on Earth.

Learning Objectives

1. Novel technologies to assess mechanisms affecting cardiovascular tolerance to gravitational stress.
2. The talk introduces currently tested countermeasures for astronauts, such as artificial gravity.

[165] PREDICTION OF FATAL OUTCOMES IN GERMAN GA ACCIDENTS BY USING A SCORING SYSTEM TO FACILITATE ADEQUATE RESPONSE OF EMERGENCY CONTROL CENTRES

Felix Liebold, Katharina Hippler, Jochen Hinkelbein, Jan Schmitz, Volker Schick, Markus Rothschild
University Hospital-Cologne, Cologne, Germany

(Original Research)

BACKGROUND: Whereas only few accidents are documented for large aircrafts, numerous accidents occur with small aircrafts every year. However, prediction of survival or death is impossible so far. The current study aims to identify significant factors elementary to predict survival or death of occupants after General Aviation aircraft accidents using a scoring system which can then be implemented in emergency control centres for improving future aviation safety. **MATERIAL AND METHODS:** Data of flight accidents over a 20-year period (extracted from the German Federal Bureau of Aircraft Accident Investigation [BFU] webpage) was analysed for fixed-wing motorized small aircrafts. Various factors of interest were analysed. Correlation tests were performed using Chi^2- and Mann-Whitney-U-Tests. Logistic regression was used to create a score to calculate the probability of a fatal outcome after an aircraft accident. **RESULTS:** The BFU lists 1,595 aircraft accidents between 2000 and 2019. The influencing factors "Last quarter of the year" ($p=0.002$), "fire" ($p<0.0001$), "distance away from airport > 10 km" ($p<0.0001$), "landing" ($p<0.0001$) and "cruise" ($p<0.0001$), significantly correlated with a fatal outcome. "Take-off", "approach", "month", "day of the week", "persons on bord above three", "night-time" and "icing conditions" showed no significant correlation. Using logistic regression "cruise" was excluded when using the B-STEP Method. Including the four significant parameters, the score showed a strong effect with $f^2=0.709$. **DISCUSSION:** The implementation of a score in the rescue coordination centre in the context of digital development and artificial intelligence can contribute to provide the best possible emergency aid in the event of a small aircraft crash.

Learning Objectives

1. The audience will learn about how the development of a scoring system to predict the outcome of aircraft accidents can improve the EMS response chain and thus ensure better emergency management for aviation accident victims.
2. The participant will be able to understand the distribution of severity and outcome of small aircraft accidents in Germany.

[166] UNFIT TO FLY. WHAT'S NEXT? AEROMEDICAL WAIVER.

Torsten Pippig
Zentrum Luft- und Raumfahrtmedizin der Luftwaffe, Koeln, Germany

(Original Research)

INTRODUCTION: Military pilots and crew, as well as the entire Air Force personnel involved in flight operations, are exposed to high physical stress. Therefore, for all personnel an initial aeromedical examination is performed, and regular follow-up examinations of the musculo-skeletal system are conducted. Any congenital or acquired changes to the musculo-skeletal system that limit operability and mission capability, preclude service as a pilot, crew member or air traffic controller. As a consequence, it may happen that highly experienced personnel are rejected from service due to minor physical conditions. Within the framework of an aeromedical waiver, it can be evaluated and decided on a case-by-case basis whether service can be permitted with or without restriction. **METHODS:** Between 1.1.2012 and 31.12.2021, approx 3,000 per anum people were examined and assessed annually in the Dept of Orthopaedics and Anthropometry. During this period, 369 applicants and active military personnel applied for an aeromedical waiver. At a young age, congenital changes in the musculoskeletal system (scoliosis, spondylolysis/spondylolisthesis, Scheuermann's disease, transition vertebrae) are the most common reasons, in middle age (up to the age of 50), trauma and consequences, rheumatic diseases, soft

disc diseases, and in old age osteoarthritis, spinal stenosis, spondylodesis, artificial joints, and gout. The medical reasons, gender, age, use, waiver, and potential restrictions are evaluated. Important, are the function and load capacity of the joint and the spine, the prognosis of the disease, the requirements and hazards in the aircraft, the flight order. The decision-making process is explained with several examples (jet pilot after hip endoprosthesis, helicopter pilot after cervical spondylodesis, helicopter pilot with psoriasis arthropathy). **RESULTS:** A total 369 cases that applied for an aeromedical waiver were included. These consisted of 227 aircrew (138 recruit applicants, 30 pilots, 47 crew members) and 142 ground staff. The average age was 29.3 years. In 28 cases, an aeromedical waiver was refused. Of the 227 air crews examined, 162 were subject to service restrictions. **SUMMARY:** An aeromedical waiver is valuable to maintain operational capability. It is always a case-by-case decision considering arguments in favor an against it. In many cases, a restriction in the waiver allows personnel to stay mission capable, despite minor physical limitations.

Learning Objectives

1. The audience will learn about aeromedical waiver decision in case of disorders of musculoskeletal system.
2. The audience will learn about significant musculo-skeletal disorders and military flying fitness.
3. Waiver and aeromedical limitations.

[167] WAIVER RESULTS (REFERRALS) FOR CLASS 3 MEDICALS IN GERMANY 2017 - 2021

Ulrich Werner
German Military Aviation Authority, Cologne, Germany

(Education - Program/Process Review)

BACKGROUND: Within the European Union (EU) aviation has a single regulatory framework. Aviation Medicine is documented in Commission Regulation (EU) No 1178/2011. Additionally, specifics for Class 3 Medicals (Air Traffic Controllers) are documented in Commission Regulation (EU) 2015/340. If an applicant does not fulfill the medical requirements, the Aeromedical Examiner (AME) must forward the case for referral (Class 1 and 3) or consultation (Class 2) to the Competent Authority of the EU member state. The technical term waiver is not used in EU legislation, but referral. The Competent Authority (CA) has a medical department and employs Medical Assessors (MA). With regard to air traffic controllers, the German competent authority is the Federal Supervisory Authority for Air Navigation Services (BAF). The CA and it´s MA are the waiver authority for aeromedical decision making. This presentation depicts the German competent authority's experience and results of referrals for Class 3 medicals over the 5-year period from 2017 to 2021. **OVERVIEW:** There are about 1700 Class 3 medical examinations in Germany every year. On average 30 referrals were forwarded to the CA by the AMEs annually, which correlates to 1.8% of each year's examinations. 88% of all referrals ended with a positive aeromedical decision. The 3 most affected medical domains for referrals were visual system incl. colour vision (29%), cardiovascular (17%) and, with equal magnitude, psychiatry and neurology (10% each). The 3 most affected medical domains with negative decisions were neurology (28%), visual system (22%) and otorhinolaryngology (17%). Of those negative decisions, no case was disputed by the applicant. **DISCUSSION:** Waiver decisions or referrals represent a high-level discipline in aviation medicine decision making. With regard to the low number of cases, it requires a relatively high amount of working capacity. Medical Assessors themselves take specialist advice for sound decisions. Notwithstanding the required responsibility and difficulties for those decisions, it represents an interesting focal point of aeromedical work.

Learning Objectives

1. The audience will learn about the waiver results of Class 3 aeromedical examinations.
2. The participant will be able to assess the impact of the waiver process to the workload of a medical department of an aviation authority.

Tuesday, 05/23/2023 ***2:00 PM***
Grand Ballroom A-B-C

[S-32]: PANEL: NASA EXPLORATION ATMOSPHERE - THE PATH TO THE MOON AND MARS

Chair: Alejandro Garbino

PANEL OVERVIEW: NASA's Moon to Mars exploration architecture, as well as the emerging commercial LEO market that NASA is helping foster, will involve multiple different crew capsules, orbital habitats, transit habitats, landers, surface habitats, pressurized rovers, IVA spacesuits and EVA spacesuits. The selection of atmospheres (i.e., operating pressures and constituent gases) for each of these elements is a complex trade between hypoxia, flammability, crew time, crew workload/fatigue, consumables, ECLSS efficiency, vehicle inter-operability, and decompression sickness risk. NASA has been trading various 'Exploration Atmospheres' - pressure/O2 combinations that maximize EVA operations. In 2022, NASA performed a series of chamber tests at 56.kPa (8.2psi) and 34% O2 atmosphere, culminating in an 8-crew, 11-day chamber run testing the effectiveness in controlling DCS, as well as characterizing the hypoxic stress of living in a low-pressure environment.

[168] HABITABILITY ASSESSMENTS AND LESSONS-LEARNED FROM 3-DAY AND 11-DAY ENRICHED OXYGEN HYPOBARIC CHAMBER TESTS AT NASA JOHNSON SPACE CENTER

Andrew Abercromby[1], Lichar Dillon[2], Monica Hew[3], Patrick Estep[4], Karina Marshall-Goebel[5], Alejandro Garbino[4]
[1]*NASA Ames Research Center, Houston, TX, United States;* [2]*NASA and UTMB, Houston, TX, United States;* [3]*NASA and KBR, Houston, TX, United States;* [4]*NASA/GeoControl Systems, Houston, TX, United States;* [5]*NASA JSC, Houston, TX, United States*

(Original Research)

INTRODUCTION: Decompression sickness (DCS) is a risk to the health and performance of astronauts and high-altitude aircrew. Tolerance to flammability, hypoxia, prebreathe duration, and DCS risk varies across different organizations, vehicles, suits, and destinations, necessitating a variety of DCS risk mitigation approaches. Existing models of altitude DCS risk are often insufficient to enable accurate risk-informed decisions during hardware development, mission planning, and flight operations. **METHODS:** NASA completed outfitting of a dedicated facility at Johnson Space Center to support testing of up to eight human subjects for multiple days in hypobaric and enriched oxygen atmospheres. The primary purpose of the testing capability is validation of DCS risk mitigation protocols for Artemis missions to the Moon; however, it will also support development and validation of a generalizable altitude DCS risk estimation tool. A 3-day and an 11-day prebreathe validation test were completed in 2022, each with 8 human subjects living at 56.5 kPa (8.2 psia), 34% O2, 66% N2, with 6 simulated EVAs performed on masks at 29.6 kPa (4.3 psi), 85% O2, 15% N2. Facility and organizational lessons-learned and process improvements were recorded during and following the tests, and subjective habitability ratings were recorded daily during the 11-day test. Hypoxia and DCS-related physiological and cognitive outcome measures were recorded during both tests and are reported in companion presentations.

RESULTS & DISCUSSION: All subjects completed each of the tests. Primary habitability issues related to mask discomfort during simulated EVAs and poor sleep quality due to thin mattresses. Polybenzimidazole (PBI) clothing was worn by all subjects due to the increased fire risk and may be required for Artemis missions; clothing was found to be acceptable overall with the worst ratings being due to poor fit and inelasticity. Chamber O2 and CO2 sensor inconsistency was observed that did not result in test termination but required post-test follow-up. Forward

plans include additional hypobaric testing and integration of existing and future physiological outcome data into an open-source Aerospace Estimation Tool for Hypobaric Exposure Risk (AETHER). NASA is also working to make the testing capability available to commercial companies.

Learning Objectives

1. The audience will learn about NASA's recent altitude chamber testing operations, including multi-day high altitude chamber tests.
2. The audience will learn about NASA's plans to develop and operationalize DCS and hypoxia models to support spaceflight and high-altitude operations.

[169] EVALUATION OF PLANETARY EXTRAVEHICULAR ACTIVITY PREBREATHE PROTOCOLS USING A 56.5 KPA/34% O2 CABIN ATMOSPHERE IN AN 11-DAY HYPOBARIC HYPOXIA STUDY

Alejandro Garbino[1], Lichar Dillon[2], Patrick Estep[1], Monica Hew[3], Karina Marshall-Goebel[4], Jason Norcross[3], Kadambari Suri[3], Andrew Abercromby[5]

[1]*NASA and GeoControl Systems, Houston, TX, United States;* [2]*NASA and UTMB, Houston, TX, United States;* [3]*NASA and KBR, Houston, TX, United States;* [4]*NASA JSC, Houston, TX, United States;* [5]*NASA Ames Research Center, Houston, TX, United States*

(Original Research)

INTRODUCTION: Apollo missions used 100% O2 cabin atmospheres which effectively eliminated the risk of decompression sickness (DCS) during Lunar extravehicular activities (EVAs, 'spacewalks'); however, this atmosphere presented a flammability risk that is no longer acceptable to NASA. Denitrogenation prebreathe protocols used to mitigate DCS risk for Space Shuttle and International Space Station EVAs are validated for the microgravity environment, but the significantly increased risk of DCS during equivalent ambulatory surface EVAs make these protocols inapplicable to planetary/Lunar missions. A cabin/vehicle "Exploration Atmosphere" of 56.5 kPa (8.2 psia), 34% O2, 66% N2 has been recommended by NASA for future Moon and Mars missions as a compromise that balances subsequent pre-EVA prebreathe duration, hypoxia, and flammability risk, assuming a 29.6 kPa (4.3 psi) spacesuit. Prebreathe validation studies were initiated utilizing a three-story 6m diameter hypobaric chamber at NASA's Johnson Space Center. Here, we report the results of a 11-day human-in-the-loop system checkout. **METHODS:** Six volunteers lived in a hyboparic chamber for 11 days with an 'exploration atmosphere' of 56.6kPa/34% O2 66% N2. Subjects acclimated to the exploration atmosphere for 48 hrs and thereafter participated in five 6-hour simulated EVAs at 34kPa/85% O2 / 15% N2 over the course of 11 days. Prior to each simulated EVA, subjects underwent a 20-minute prebreathe at 85% O2. The EVA simulation was designed to include tasks that are physically and ergonomically representative of future planetary EVAs, proportionate to the subject's VO2max. Decompression stress was evaluated during the simulated EVA by serial doppler and echocardiographs alternating every 15 min, as well as clinical monitoring for DCS signs/symptoms. **RESULTS AND DISCUSSION:** Venous gas emboli (VGE) were present in 3 of 6 subjects during EVAs, with peak Grade II VGE as evaluated by Doppler and a peak Eftedal-Brubakk score of 5 by cardiac ultrasonography. Two cases of DCS were diagnosed during the 11-day test chamber. No acute hypoxic symptoms were noted. Musculoskeletal and gastrointestinal complaints were noted, likely associated with the exercise load and the food system. Two cases of DCS (8%) does not cross either accept or reject pre-test criterion, so an additional study is planned for 2023 to meet our pre-test thresholds.

Learning Objectives

1. The audience will learn about the NASA Decompression algorithms and their applicability to EVA operations on Artemis/Moon
2. The audience will learn about decompression diagnosis and treatment methods available for crew and for ground testing operations.

[170] IMPACTS OF A NOVEL EVA PREBREATHE PROTOCOL ON BEHAVIORAL HEALTH AND PERFORMANCE OUTCOMES AMONG ASTRONAUT SURROGATES

Steven Anderson[1], Alexa Doerr[1], Sheena Dev[1], Bruce Keller[2], Alaa Khader[2], Jennifer Miller[2], Suzanne Bell[3]

[1]*KBR Inc., Houston, TX, United States;* [2]*JES Tech, Houston, TX, United States;* [3]*NASA, Houston, TX, United States*

(Original Research)

INTRODUCTION: Decompression Sickness (DCS) is a risk during spaceflight extravehicular activities (EVAs). The current study aimed to validate modeling efforts for a short (15-20 minute) prebreathe protocol while adequately mitigating risk of DCS. We examined effects of exposure to the hypobaric hypoxic environment on behavioral health and performance. **METHODS:** 8 astronaut surrogates (mean age: 35.70, SD = 4.27, 50% female) spent 11 days in a chamber at NASA Johnson Space Center (JSC) where they were exposed to an atmosphere consisting of lower pressure (8.2 psia) and higher O2 (34%), controlling physiologic levels of N2. Data were collected on participants' cognitive performance, operational performance, and self-reported behavioral health. Cognitive performance was collected via a computerized battery of 10 cognitive tasks. Operational performance was measured by ROBoT-r (robotics onboard trainer for research), a task that simulates capture and grappling maneuvers required for astronauts operating the Canadarm2 robotic arm on the ISS. Demographics, fatigue, energy, and mood were collected via self-report surveys. **RESULTS:** Cognition results were consistent with data collected in previous analog studies without the exposure to the hypobaric hypoxic environment. There were small improvements or stabilization in speed and accuracy over time for most subtests. Performance on many Cognition subtests showed greater consistency during the 11-day test compared to pre- or post-test phases. Similar to findings in previous analog studies, ROBoT-r results suggested improved performance across the 11-day test for accuracy and overall performance. However, unlike previous analog studies, ROBoT-r response times remained stable (i.e, no improvement). Survey results indicated that participants reported less energy on the days that they conducted EVAs. Fluctuations in mood were reported by some participants early in the 11-day test, possibly due to a conflict between crew members. **DISCUSSION:** Results were consistent with trends observed from data in other NASA spaceflight analog environments (e.g., HERA) except for response times on the ROBoT-r task. Limitations include the small sample size and no control group. However, initial findings suggest that the tested short-term prebreathe protocol and hypobaric hypoxic environment is unlikely to negatively affect behavioral health and performance.

Learning Objectives

1. [The audience will learn about...] the effects of a prebreathe protocol and hypobaric hypoxic environment on behavioral health and performance.
2. [The participant will be able to…] understand how the effects of a hypobaric and hypoxic environment impact cognitive and operational performance in astronaut surrogates.

[171] APPETITE AND FOOD INTAKE DURING 11 DAYS OF MILD HYPOBARIC HYPOXIA

Lichar Dillon[1,4], Grace Douglas[2], Holly Dlouhy[1], Patrick Estep[3], Patti Gillman[1], Monica Hew[1], Robert Howard[2], Thomas Oswald[1], Susan Rapley[1], Sara Zwart[4], Alex Garbino[3]

[1]*KBR, Houston, TX, United States;* [2]*NASA, Houston, TX, United States;* [3]*GeoControl Systems, Houston, TX, United States;* [4]*UTMB, Galveston, TX, United States*

(Original Research)

INTRODUCTION: Reduced food consumption and loss of body mass have been observed during spaceflight. Hypoxic conditions that

astronauts may encounter on exploration missions may further implicate satiety signals and dietary intake. Appetite, food intake, and satiety hormones were investigated under conditions of mild hypoxia and simulated extravehicular activity (EVA). **METHODS:** Artemis-like food was packed for each subject based on estimated energy requirements for the 11-day test. Only room temperature water was available to rehydrate food and beverages in-mission. Measures included food records; fasted body weight; Dual-energy X-ray absorptiometry (DXA); crew feedback; and fasted blood levels of ghrelin and leptin. **RESULTS:** On average, subjects consumed 341 calories less on EVA days compared to non-EVA days in-mission (p=0.0511). Total weight loss from weight measurements (-1.1 kg, p=0.0028) is consistent with underconsumption and supported by DXA measurements (-1.3 kg total body mass, p=0.0123 and -1.6 kg fat mass, p=0.0016). Most foods that were consumed were given acceptable scores. Comments indicated that the most acceptable foods were those not intended to be heated. Comments also indicated that subjects found their favorite foods early in the mission and avoided the foods that they did not like throughout the mission. Habitability scores indicated that overall aspects of the food system were considered borderline or unacceptable over the length of this mission. Foods that caused gas were avoided pre-EVA to prevent discomfort during pressure changes. Average fruit and vegetable intake decreased from 4.8 servings/d pre-mission to 3.4 servings/d on non-EVA days (p=0.0872) and 2.3 servings on EVA days (p=0.0020). Fasting ghrelin was lower pre-EVA and on non-EVA days when exposed to mild hypoxia compared to normoxic conditions pre-mission and post-EVA (p=0.0136). Fasting levels of leptin did not change. **DISCUSSION:** Food intake declined in-mission, resulting in a caloric deficit and weight loss for most subjects. Appetite ratings and crew comments indicated this was due to a combination of limitations in food choices, preparation capability, time, and physiological challenges with the changing pressure. The regulation of appetite stimulating hormone ghrelin, but not the appetite suppressor leptin, appeared to be sensitive to hypoxic conditions. Results demonstrate the importance of scheduling ample recovery time between EVA days.

Learning Objectives

1. The audience will learn about the effects of mild hypoxia on appetite and food intake.
2. The audience will learn about the effects of mild hypoxia on hormonal regulators of appetite.

[172] MEDICAL LESSONS LEARNED FROM THE EXPLORATION ATMOSPHERES STUDY

Robert Sanders[1], Kristi Ray[2], Jennifer Law[2]
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(Education - Program/Process Review)

BACKGROUND: The National Aeronautics and Space Administration's (NASA) Exploration Atmospheres study (EA) was done to evaluate alternative cabin atmospheres for future spacecraft designs and planetary surface exploration of the Moon, Mars, and beyond. Deep space exploration involves creating habitats and environments safe for human occupancy and the means to explore the outside environment (extravehicular activities, EVA). In order to validate alternative atmospheres and pre-spacewalk procedures, the EA study was conducted to evaluate factors such as hypoxia risks, denitrogenation protocols, food limitations, medications, and the impact of other factors on human performance. **OVERVIEW:** Space travel is constrained by mass, volume, power, and the cost of vehicle development, which creates tradeoffs in various capabilities, including breathing gasses. Higher atmospheric pressure in a vehicle means more gas and a stronger containment vessel/habitat; while lower pressure requires higher oxygen partial pressure, which may increase fire risk. NASA's EA study evaluated a proposed alternative cabin environment (8.2 psia, 34% Oxygen), for future spacecraft habitat and planetary EVAs. EA included both a 3-day and a 11-day trial. These trials included a depressurization and saturation to 8.2psi at 34% O2 with additional depresses to 4.3 psia at 85% O2 for simulated EVAs (1 EVA during the 3-day and 5 during the 11-day trials). **DISCUSSION:** Planning for and executing the medical monitoring and response plan for a trial of this scope was a huge undertaking with no prior practice to fall back on. Food obstacles, sleeping issues, medications, joint injury, equipment limitations, medical privacy, multiple cases of decompression sickness, and even a COVID outbreak among the support team proved challenging. Testing of this nature is an essential part NASA's preparation for the upcoming Lunar Artemis missions. As spaceflight transitions beyond low earth orbit, to planetary, even more trials of this nature will be required to learn what are the optimal atmospheric and associated operational constraints to maintain the optimal health of the crew and achieve mission objectives.

Learning Objectives

1. The audience will learn about the lessons learned from NASA's Exploration Atmosphere.
2. The audience will learn about medical monitoring and response of NASA's Exploration Atmosphere.

Tuesday, 05/23/2023 ***2:00 PM***
Grand Ballroom D-E

[S-33]: PANEL: AEROSPACE TOXICOLOGY

Chair: David Mattie
Co-Chair: Richard Pleus

PANEL OVERVIEW: *Aerospace Toxicology is the multi-disciplinary approach to understanding and managing the effects and impacts of chemical and biological agent exposures, while in flight or on the ground preparing and servicing vehicles for flight, to keep humans healthy and safe. Exposures to chemicals associated with all aspects of flight need to be understood and managed to ensure everyone associated with aerospace operations are protected. The Aerospace Toxicology Association is a new organization that is in the process of becoming an AsMA affiliate. The abstracts in the session while having diverse topics all address issues related to toxicology associated with flight or maintenance operations.*

[173] THE STATE-OF-THE-SCIENCE REGARDING HEALTH IMPACTS OF CHEMICALS IN THE CABIN AIR OF COMMERCIAL AIRCRAFT

Richard Pleus, Gretchen Bruce, Lisa Corey, Kelli Hackney, Cameron Bellamoroso
Intertox, Seattle, WA, United States

(Original Research)

Studies demonstrate that small amounts of jet engine oil or hydraulic fluid can enter the environmental systems of commercial aircraft and the aircraft cabin air. These occurrences are called fume air events. Often during a fume event, only an odor is detected; even more rarely, a haze is present. The chemical class that has gained the most interest is organophosphates, a broad class that includes tricresyl phosphate and its isomers (TCP). Some aviation community members single out TCP as a causative agent of neurotoxicity in crew members. We review the neurotoxicology of chemicals in jet engine oil and hydrolytic fluid. We evaluate the byproducts of jet oil and hydraulic fluid combustion. The toxicology literature for many chemical agents is sufficient to evaluate toxicity, and doses of detected chemicals can be estimated. For example, TCP produces distinctive delayed neurotoxicity known as organophosphate-induced delayed peripheral neuropathy (OPIDN). After exposure of sufficient magnitude, OPIDN develops after a period of from ten days to a few weeks. Except for instances where the doses of TCP are very high (e.g., Ginger Jake syndrome during Prohibition), the effects of OPIDN are reversible. TCP has not been demonstrated to cause cognitive effects, whole-body injury, loss of smell and taste, coughing, or breathing problems. Most

organophosphates affect the enzyme acetylcholinesterase (AChE) and cause a distinct collection of associated symptoms, including constriction of the pupils, sweating, urination, defecation, salivation, nausea, vomiting, and diarrhea immediately after exposure. TCP is a weak inhibitor of AChE. We summarize the literature on the health effects of exposure to jet engine oils, hydraulic fluids, by-products of combustion, and mixtures. We conclude that chemicals are detected in commercial aircraft cabins at different phases of operation and, in some cases, may cause temporary or reversible irritation of mucus membranes but that the exposure levels, duration of exposure, and subsequent doses are not sufficient to cause neurotoxicity.

Learning Objectives

1. How toxicologists conduct a chemical toxicity assessment in aerospace toxicology.
2. The method toxicologists use to determine acceptable levels of human chemical exposure in aerospace toxicology.

[174] TOXICOLOGICAL ASSESSMENT OF PHYSIOLOGIC EPISODES IN F/A-18A-F AND ES-18G AIRCREW

Michael Kosnett[1], Richard Pleus[2]

[1]*Colorado School of Public Health, Aurora, CO, United States;* [2]*Intertox, Seattle, WA, United States*

(Original Research)

In 2010 the number of F/A-18A-F and EA-18G hazard reports (HAZREP) related to unexpected aviator(s)/operator(s) physiologic episodes (PEs) began to increase. A Root Cause Corrective Action (RCCA) started on March 10, 2017. A team of Aeromedicine, Physiology, and Toxicology experts investigated these PEs. The Aerospace Medical Team consisted of a multidisciplinary group of clinicians and scientists. We focus on the toxicological work conducted in this effort through 2018. In some PEs, pilots reported neurological and constitutional symptoms that included dizziness, cognitive impairment, tingling in extremities, headache, nausea, vision disturbances, and fatigue. Collectively these symptoms suggested potential impairment of the central nervous system via direct or indirect modes of action. The question posed to toxicologists was whether chemical contaminants in breathing air caused or contributed to these symptoms. The toxicology team assessed over 400 chemicals that were measured and evaluated. Air samples were taken in various locations, including on the tarmac, flight deck, cabin, and inlet and outlet of the On-Board Oxygen Generating System (OBOGS). Measurements were compared to toxicological reference values, and hazard quotients and indices were calculated. The overall toxicological assessment, based on maximum measured concentrations, potential sustained doses, and the nature and temporal pattern of the episodes was that direct or indirect neurotoxic effects of chemical contaminants in breathing air were unlikely to account for almost all reported PEs, although their possible role in a handful of isolated events could not be excluded. As part of its work, the team independently developed a comprehensive list of chemical agents considered capable of causing overt neurotoxic or irritant effects after low-dose, short-duration exposure. To the extent that industrial hygiene, chemistry, or engineering assessments indicated that any of these compounds could conceivably be present in the aircraft environmental control system by their presence in native aircraft fluids or components or their thermal degradation or reaction products, expansion of future analytical techniques to measure those agents not detectable using current investigative regimes was recommended. Revised approaches for augmenting the collection and recording of clinical toxicology findings in future incident investigations were also presented.

Learning Objectives

1. Understand the approach toxicologist use to assess possible chemical exposures.
2. Understand the type of data that is needed to conduct a toxicological assessment.

[175] COMPARISON OF OPERATIONAL JET FUEL AND NOISE EXPOSURES

David Mattie[1], Satoshi Maruyama[2], Nobuhiro Ohrui[2], Takahiro Imamura[2], Kunio Takada[2], Asao Kobayashi[3], Kerrine LeGuin LeGuin[4], Dirk Yamamoto[1]

[1]*U.S. Air Force Research Lab, 711th Human Performance Wing, Airmen Systems Directorate, Wright-Patterson AFB, OH, United States;* [2]*Aeromedical Lab, Japan Air Self-Defense Force, Sayama, Japan;* [3]*HQ Air Development Test Command, Japanese Air Self Defense Force, Fuchu AB, Japan;* [4]*U.S. Air Force Research Lab, 711th Human Performance Wing, USAFSAM, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Personnel who work around aircraft on the flight line are potentially at risk for developing hearing loss. A study that is part of an international agreement with Japan was designed to address gaps in data for flight line personnel with combined exposure to jet fuel and noise. **METHODS:** Subjects from JASDF and USAF air bases in Japan (Hyakuri, Matsushima, Hamamatsu, Kadena, and Misawa, ABs) were sampled during a single shift on the flight line. Control subjects from Hyakuri, Yokota, Kadena, Misawa and Iruma ABs were sampled during a single shift in an administrative area or at a base hospital or clinic. All subjects were recruited under approved Japanese and AFRL human subject research (IRB) protocols. A previous study showed the importance of sampling control subjects to obtain data for comparison between working on an air base versus working on a flight line. During their work shift, subjects wore a personal vapor pump to sample for jet fuel components and a noise dosimeter to assess their personal noise exposures. After their shift, each subject was asked questions concerning exposures during the shift and audiological history. In addition, blood was drawn, urine was collected, and a complete audiometric test battery was conducted. **RESULTS:** The noise dosimetry data showed an average actual TWA for time of sampling was 94.5 dB for flight line personnel versus 68.2 dB for controls in clinics or offices. Audiological histories showed a trend for tinnitus in flight line personnel but was also identified in some controls. The post-shift questions confirmed exposure to jet fuel and exhaust as well as engine oils and hydraulic fluids. **DISCUSSION:** The chemicals in air, blood and urine will be in another presentation in the Aerospace Toxicology Panel. Exposure to higher noise and jet fuel supports a potential for jet fuel as an ototoxicant although studies suggest it may be a synergist effect. Audiometric test results are not available yet. (Disclaimer: No DoD endorsement implied.)

Learning Objectives

1. Attendees will learn about the combined exposure of jet fuel and noise on USAF and JASDF flight lines in Japan.
2. Attendees will learn about the audiological history of subjects and the potential for Jet fuel to be an ototoxicant.

[176] COMPARISON OF OPERATIONAL JET FUEL AND NOISE EXPOSURES: FUEL EXPOSURE RESULTS

Nobuhiro Ohrui[1], Satoshi Maruyam[1], Chisato Takazawa[1], Atsushi Torihata[1], Yasutami Otsuka[1], Takahiro Imamura[1], Asao Kobayashi[2], David Mattie[3], Dirk Yamamoto[3], Kunio Takada[1], Tetsuya Tsujimoto[1]

[1]*Aeromedical Lab, Japan Air Self-Defense Force, Sayama, Japan;* [2]*Air Development and Test Command, Japan Air Self-Defense Force, Fuchu, Japan;* [3]*U.S. Air Force Research Lab, 711th Human Performance Wing, Airmen Systems Directorate, Wright-Patterson AFB, Dayton, OH, United States*

(Original Research)

INTRODUCTION: Noise is pervasive in the living environment and can cause hearing loss. The noise and chemical exposures have long been crucial issues in flight or maintenance operations. Recent studies suggested jet fuel in combination with noise are more associated with hearing

loss than with noise exposure alone. Flight line personnel working in and around aircraft, who are constantly exposed to noise and exhaust fumes, may be more likely to developing hearing loss. This study was a collaborative research effort between the Japan Air Self-Defense Force (JASDF) and the US Air Force (USAF) to examine the effects on hearing in flight line personnel with combined exposure to jet fuel and noise. The JASDF measured jet fuel components as personal exposure of 15 volatile organic compounds (VOCs) in blood, urine and within flight line air environment (personal air samples) at air bases in Japan. **METHODS:** There were 152 subjects. The subjects were divided into eight groups: CJ, Non-exposed control subjects in JASDF; CK, Non-exposed control subjects in Kadena; CM, Non-exposed control subjects in Misawa; T-4, JetA1 (T-4) exposed subjects in Matsushima and Hamamatsu; F-2, JetA1 (F-2) exposed subjects in Matsushima; F-4, JP-4 (F-4) exposed subjects in Hyakuri; F-15, JP-8 (F-15) exposed subjects in Kadena; F-16, JP-8 (F-16) exposed subjects in Misawa. Personal air samples were collected during a work shift. The subjects also had their blood drawn post shift and their urine collected prior to shift (early morning urine) and post shift. **RESULTS:** Total VOCs concentrations in personal air sample, blood and urine in each group were extremely low. Total VOCs concentrations in personal air samples were higher in the jet fuel exposure groups, except for F-2, than in CJ and CK. The total VOCs concentrations in blood sample was significantly higher in F-4 compared to in CJ, CK and CM. Total VOCs concentration in urine sample was significantly higher post shift than prior to shift in T-4. **DISCUSSION:** There were no significant correlation between total VOCs concentrations in personal air sample and in blood sample. The effects of jet fuel exposure on auditory function will be analyzed in along with results of noise dosimetry and audiometric test conducted by the USAF.

Learning Objectives

1. The participant will learn about exposure levels of volatile organic compounds in air, blood and urine under flight line environment.
2. The participant will learn about the differences of jet fuel exposure effects by jet fuel type or aircraft type.

[177] NON-INVASIVE BIOMARKERS FOR AEROSPACE TOXICOLOGY ASSESSMENTS

Nesrine Ramadan
University of Oxford, Oxford, United Kingdom

(Education - Program/Process Review)

BACKGROUND: Various non-invasive biomarkers such as microRNAs (miRNAs), proteins, and antibodies can serve as informative markers to examine physiological alterations or toxic effects on tissues and organs. Their presence in biological fluids (e.g. saliva, urine, sweat, plasma) provides the opportunity to utilize them as potential novel monitoring tools to investigate how spaceflight stressors affect human health. This presentation will be part of the Aerospace Toxicology Panel and will review how biomarkers used in terrestrial risk assessments, clinical studies, diagnosis, and therapeutic monitoring can be envisaged as novel toxicological and monitoring biomarkers in aerospace fields. This is relevant for biomedical, scientific, educational, and regulatory audiences. **OVERVIEW:** This work focuses on the growing potential of miRNAs and deciphers 2 overarching strands: 1) Space: this section provides an explanation of how established studies investigating the impact of environmental and occupational toxicants on miRNAs can be exploited for aircraft toxicology studies and risk assessments. 2) Outer space: this segment highlights miRNA's roles in a plethora of terrestrial physiological, biological, and psychiatric phenomena which are also identified as responses to microgravity and spaceflights such as muscle wasting, osteoporosis, depression, and PTSD (post-traumatic stress disorder) in civilians and veterans. Overall, understanding the wide potential of miRNAs in aerospace allows to propose novel solutions and pipelines. This will be discussed through 3 primary recommendations also aimed at developing consensus for the use of these molecules: 1) generating repertoires to evaluate the significance of miRNAs signatures in combination with other proteins, metabolic or biochemical biomarkers; 2) integrating non-invasive biomarkers in systems monitoring stress, fatigue, and depression in spaceflights; 3) generating inclusive data for the development of both universal and personalized solutions. **DISCUSSION:** Non-invasive biomarkers will emerge as tools for health and mental health surveillance. They can facilitate the development of promising medical and technological innovations and solutions aimed at maximizing human performance and operational health capability in both civilians and military spheres. MiRNAs specifically hold promising potential in the aerospace toxicology arena and open new perspectives for aerospace precision and personalised medicine.

Learning Objectives

1. Understanding the potential of non-invasive biomarkers with emphasis on the roles of microRNAs in the aerospace toxicology sector and beyond.
2. Learning how terrestrial biomedicine advances can support aerospace precision and personalized medicine.

Tuesday, 05/23/2023 ***2:00 PM***
Grand Chenier

[S-34]: SLIDES: SAFETY & SURVIVABILITY: WHAT CAUSED THAT

Chair: Albert Lee
Co-Chair: Erik Johnson

[178] IN-FLIGHT INCAPACITATION/IMPAIRMENT IN AIRCREW- AN ANALYSIS OF UK CAA MANDATORY OCCURRENCE REPORTS

Ryan Anderton, Jonathon Walter
UK Civil Aviation Authority, Gatwick, United Kingdom

(Original Research)

INTRODUCTION: The incapacitation of aircrew presents a clear flight safety risk. Mandatory Occurrence Reports (MORs) have been a part of UK aviation operations since 1976, with regulation mandating the reporting of safety related occurrences, including aircrew medical incapacitation/impairment. Understanding trends in the causes may lead to an improvement in flight safety through review of medical policy, guidance material and approach to aeromedical fitness decisions. An analysis of the data from 2006 to 2021 was undertaken to identify MORs with medical causes of incapacitation. **METHODS:** The UK Civil Aviation Authority database of MORs was analyzed for incapacitation/impairment events with a suspected medical cause. Categorization of the events into type of condition was undertaken through a review of free-text entries. Data on whether crewmembers recovered for landing, the flight origin, flight distance (short, medium and long haul) and the affected crew members position was also collected. Collection and use of data was retrospective, anonymized and considered exempt from research ethic committee approval. **RESULTS:** Between 2006 and 2021, there were 659 MORs reports with a suspected medical cause for aircrew incapacitation/impairment. The reports in order of most frequent were gastrointestinal, 'unknown/unwell', hypoxia/fume events, injuries/pain, syncope/LOC, disorientation/dizziness, sinus/ear pain, vision impairment, cold/flu symptoms, epistaxis, fatigue, seizure, allergy, choking, renal colic, migraine/headache, psychological, myocardial infarction/chest pain and death. 36.2% of reports involved the First Officer, 24.1% the Captain and 6.6% involved both members of aircrew. 39% of events occurred on short haul flights, 39% on long haul and 21% on medium haul. In 42.3% of cases the crewmember recovered for landing, 37.1% did not, and in 19.4% of events they were replaced by additional crew. 41.4% of flights in the reports departed from the UK and 58.5% departed from overseas. **DISCUSSION:** Gastrointestinal illness is the leading cause of incapacitation. Whilst difficult to predict and prevent, improved crew education/training may have a significant impact on total incapacitations. This data provides an opportunity for

regulators and airlines to review medical policy and guidance material to target reductions in incapacitation risk where possible. Future research may identify impacts of any policy/guidance material development on incapciation numbers.

Learning Objectives

1. The audience will gain an understanding of the leading causes of in-flight incapacitation in aircrew.
2. The audience will gain an understanding of how data collected about in-flight incapacitations might influence medical policy and guidance material to improve flight safety.

[179] THE MORE THINGS CHANGE, THE MORE THEY REMAIN THE SAME: WEATHER-RELATED ACCIDENTS IN HELICOPTER EMERGENCY MEDICAL SERVICES

Paige Lawton, Gabriela Rosado, McKenna Tooker, Albert Boquet
Embry Riddle Aeronautical University, Daytona Beach, FL, United States

(Original Research)

INTRODUCTION: Historically, investigations of accidents within aviation have placed attention primarily on errors committed by the pilot. This analysis aims to examine the theater of operation within which Helicopter Emergency Medical Services (HEMS) pilots fly and the factors associated with accidents in HEMS operations. **METHODS:** Researchers collected FAR Part 91 and Part 135 HEMS accident and incident reports occurring between [blank to blank] from the National Transportation and Safety Board (NTSB) database. In total, sixty accidents were analyzed using the HFACS and consensus coded by a three-person panel trained in the Human Factors Analysis and Classification System. Coding was further validated through collaboration with an HFACS expert. **RESULTS:** Analysis of 60 accident reports yielded a total of 211 causal factors, primarily within the Unsafe Acts (77) and Preconditions for Unsafe Acts (123) tiers. Within the Preconditions for Unsafe Acts tier, 57% of contributing factors were attributed to physical environment, in particular instrument meteorological conditions (IMC) (30%) and dark night conditions (40%). Accidents that occurred in dark night conditions contributed 87% of all fatalities. Additionally, 78% of accidents involving flight into IMC resulted in fatalities while only 27% of non-IMC accidents resulted in fatalities. **DISCUSSION:** An HFACS analysis of HEMS accidents demonstrates the extent to which factors within HEMS pilots' operational environment contribute to safety outcomes. As no pilot operates within a vacuum, taking a closer look at personal and environmental factors that lead to unsafe acts lends itself to the development of data-driven interventions. Despite improvements in on-board weather identification technologies and reporting, preliminary findings suggest that causal factors associated with inadvertent flight into instrument meteorological conditions and dark night remain a persistent threat to helicopter emergency medical services (HEMS) crews and their patients. These results present a monumental safety concern in HEMS with little to no policy change to support safe operations. Thus, future researchers should focus on identifying system components including behaviors, technologies, and policies and procedures that serve to arrest failures and prevent accidents and behaviors associated with these factors.

Learning Objectives

1. The audience will learn more about the theater of operation within which HEMS pilots perform to mitigate the factors that contribute to pilot error and develop data-driven interventions.
2. The audience will be able to better understand the preconditions that contribute to the occurrence of unsafe acts that result in HEMS accidents characterized by flight into IMC and dark night conditions.

[180] MENTAL HEALTH IN AVIATION: A REVIEW OF ACCIDENT REPORTS

Clare McNerlin[1], Riley Ferguson[2], Matthew Wilson[1]
[1]*Georgetown University School of Medicine, Washington, DC, United States;* [2]*University of Cincinnati College of Medicine, Cincinnati, OH, United States*

(Education - Program/Process Review)

BACKGROUND: The Federal Aviation Administration (FAA) requires a certified Aviation Medical Examiner (AME) to issue at least a third-class medical certificate to all civilian pilots currently flying. This certification requires full disclosure of all medical history and prescription records of the pilot. According to FAA standards, pilots with psychiatric diagnoses must seek a special issuance of this medical certificate, and are often grounded for at least six months, incurring significant healthcare costs and an inability to work. Depression is one of the most commonly diagnosed mental health disorders, and despite its high prevalence in the general population, it is often not discussed among aviators due to the fear of no longer being able to fly. **OVERVIEW:** The National Transportation Safety Board (NTSB) compiled and provided a database of all aviation accidents from 1/1/2002-12/31/2021 which resulted in 29,904 accident reports, of which 5,527 were fatal. Each fatal report was analyzed and the prevalence of mental health diagnoses and use of psychoactive pharmaceutical medication determined by toxicology reports, autopsy reports, and witness and family statements were assessed. On review of fatal accident reports, intentional suicides were identified as a specific subsection of fatal accidents. Additionally, some of these reports documented that the pilot had a history of a mental health disorder that was not disclosed to their AME and the FAA during their initial or subsequent medical evaluations. Toxicology reports showed multiple fatal accidents where psychotropic medication was considered to be a factor. Of significance, there is evidence of selective serotonin reuptake inhibitor (SSRI) use both before and after FAA approved their use in 2010. Pilot mental health needs to be adequately addressed and treated to ensure safety. **DISCUSSION:** In this presentation, the prevalence of psychiatric diagnoses in relation to fatal aircraft crashes is discussed, as well as current avenues of treatment accessible to the aviation community. Ultimately, pilot reluctance to seek mental healthcare and the current FAA regulations around psychiatric treatment must be considered as these mental health associated intentional suicides continue to take place.

Learning Objectives

1. Discuss the current state of mental health care and barriers to access for pilots.
2. Understand the impact of the Federal Aviation Administration's changes to selective serotonin reuptake inhibitor use among pilots.

[181] CHANGING MISHAP REPORTING SYSTEMS CHANGED HUMAN FACTORS TRENDS IN U.S. NAVAL AVIATION MISHAPS

Jefferson Grubb
U.S. Naval Safety Command, Norfolk, VA, United States

(Original Research)

INTRODUCTION: A 2005 memorandum of agreement mandates that all branches of the U.S. military use the Department of Defense Human Factors Analysis and Classification System (DoD HFACS) to record human factors contribution to mishaps. In principle, this commonality permits comparison of human factors trends both longitudinally and between services. Although the DoD specifies the use of DoD HFACS, it does not mandate a common overarching mishap reporting system. How the reporting system handles HFACS data entry may influence which codes investigators assign for a given mishap. If so, HFACS codes recorded under different reporting systems may not be comparable. In 2020, the Department of the Navy switched reporting systems from the Web Enabled Safety System (WESS) to Risk Management Information (RMI). This study compared HFACS coding trends in U.S Naval Aviation mishap reports entered using WESS with those entered using RMI. **METHOD:** The author examined 878 Class A-D Naval Aviation mishaps entered under WESS between FY17 and FY20 and 584 such mishaps entered under RMI between FY20 and FY22. Empirical Bayes estimation was used to compare the percentage of mishaps in which each DoD HFACS 7.0 code was cited in the two mishap data sets. **RESULTS:** Of 109 possible codes,

29 showed significant changes in citation rate after the reporting system change. Investigators cited more codes for unsafe acts, environmental preconditions, teamwork preconditions, and supervisory planning issues. In contrast, investigators cited fewer codes for mental awareness preconditions, state of mind preconditions, and supervisory violations. **DISCUSSION:** Policy makers and researchers must use caution when interpreting DoD HFACS data. In particular, these results indicate that HFACS codes entered using different reporting systems are not directly comparable. HFACS data are subjective. A change in an HFACS code's reporting rate may reflect a real safety trend, a change of investigator perception of existing safety conditions, or simply a change in the mechanics of how investigators assign HFACS codes.

Learning Objectives

1. Examine factors that limit the interpretability of DoD HFACS data.
2. Explore factors influencing investigators' classification of human factors contributions to mishaps.
3. U.S. Department of Defense reporting requirements for human factors contributions to mishaps.

[182] GENERAL AVIATION ACCIDENTS RELATED TO DEFICIENT AERONAUTICAL DECISION-MAKING (1991-2019)

Douglas Boyd, Mark Scharf
Embry-Riddle Aeronautical University, Daytona Beach, Florida, United States

(Original Research)

INTRODUCTION: The ~60X higher general aviation (GA) accident rate (c.f. air carriers) partly reflects less rigorous operational regulations for the former (14CFR 91 vs. 121). Accordingly, since 1991, aeronautical decision-making (ADM), in context of go/no-go, has been emphasized in *ab initio* and recurrent GA training. However, no research has address whether ADM-related mishaps have declined thereafter or identified the most frequent subcategories. Herein, we determined the (i) temporal change in ADM-related fatal accidents (1991-2019) involving private pilots (PPLs) operating single piston engine airplanes and (ii) the most prevalent categories of such ADM-related mishaps per the Pilot-Aircraft-enVironment-External Pressure (PAVE) model. **METHODS:** Fatal mishaps were per the National Transportation Safety Board database. GA fleet time was used to determine accident rates. Statistical testing employed Poisson Distribution, Fisher Exact and Mann Whitney U-tests. **RESULTS:** Of 1,437 fatal accidents, 846 were ADM-related. Although the ADM-related accident rate declined ($p<0.001$) from 6.6 to 3.6/million flight hours (1991-2005), no further decrease was evident thereafter ($p=0.446$). Using the PAVE model, half of mishaps involving poor go/no-go decision-making were environment-related with adverse weather representing the largest sub-category. Regarding the latter, non-instrument-rated PPLs were over-represented for accidents involving departures into forecasted/known enroute degraded visibility (IMC). Conversely, a disproportionate count of mishaps was observed for IFR-PPLs electing to depart with forecasted thunderstorms ($p=0.012$) or icing enroute ($p<0.001$). Interestingly, external pressure to undertake a flight was evident only for 10% of ADM-related accidents. No difference ($p=0.444$) in PPL total flight experience was evident for ADM-related and un-related accidents. **DISCUSSION:** Notwithstanding substantial gains made over 3 decades in educating pilots as to the importance of pre-flight ADM, new educational approaches are needed to further decrease a stagnated rate. Finally, for the IFR-rated and non-rated PPL, selective emphasis needs to be placed on go/no-go decision-making for flights with forecasted thunderstorm/icing and IMC respectfully.

Learning Objectives

1. Audience will learn that approximately half of general aviation accidents are due poor decision-making prior to the flight being undertaken.
2. Audience will learn about the widely-used PAVE model for aeronautical decision-making introduced to general aviation in 1991.
3. The audience will learn that the type of adverse weather leading to deficient aeronautical decision-making varies between the IFR-rated and non-IFR rated pilot.

[183] FOLLOW UP OF THE BOEING 737 MAX MISHAPS, WHO WENT WRONG, AND THE FIXES AND REMARKS ABOUT THEM

Carlos Salicrup
Colegio Mexicano de Medicina Aeroespacial, Mexico City, Mexico

(Education - Case Study)

INTRODUCTION: There is nothing more thrilling than trying to take manual control of the airplane during a critical situation and an erratic computer overtaking your commands. Along with manual skills getting blurred by automation and the startle and surprise effect. **BACKGROUND:** For those already flying the Boeing 737 NG, the training for the 737 MAX consisted of a few hours watching videos and reading material online. It was not required to fly, at least for the first flight, with a flight instructor. The Flight Crew Operation Manual only stated in a single paragraph the existence of an MCAS, the Maneuver Characteristics Augmentation System. Nowadays we take a full Return to Service (RTS) Training, consisting of several hours on computer-based training, ground school and a full simulator session that involves training in the MAX systems, containing full scenarios involving new automation, how it works and how to recover or manage its failures. **CASE PRESENTATION:** Automation means a machine that partially or fully covers the task of a human being, when a new automation is introduced, the user (pilot) along with being aware of the new "system" capability, and functions, should be trained about the failure modes and how to overcome them. The Boeing 737-MAX mishaps lead to an investigation that resulted in pointing out interesting factors like human-systems integration, automation training, and the economic-administrative factors. These days, due to the past events and the RTS obligations, the B737MAX may be the most surveilled and safe airliner, pilots feel more comfortable with the specific training and automation was limited so the pilot may overtake control at any time, not letting systems like the MCAS put the airplane in an upset situation. On the other side, we are not only training pilots to be proficient, but also to develop and maintain their competencies, some compromised by automation. **DISCUSSION:** A hard lesson was learned, indeed automation has lowered the rate of mishaps, but when one occurs it is disastrous. We must be careful introducing new automation and to train pilots in its functions, failure modes and recovery, along with continuously train and develop pilot competencies that are identified to be blurred by automation, like manual flying skills, upset recovery and situational awareness.

Learning Objectives

1. The attendee will learn about the overcome of the 737MAX investigations.
2. The attendee will learn about levels of automation and pilot competencies.

Tuesday, 05/23/2023 ***2:00 PM***
Napoleon Ballroom C1-C2

[S-35]: SLIDES: HOW TO TRAIN FOR FLIGHT

Chair: Jeffrey Harris
Co-Chair: David Gregory

[184] EFFICACY OF ADAPTIVE ALGORITHMS FOR TRAINING IN VIRTUAL REALITY

Alessandro Verniani, Esther Putman, Abhishektha Boppana, Benjamin Peterson, Ellery Galvin, Sandra Tredinnick, Eric Vance, Torin Clark, Allison Anderson
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Virtual reality (VR) has been increasingly used for training over the last three decades for its immersiveness and practicality.

However, training is often facilitated by an operator or automated rather than personalized to individual needs. This research investigates the effect of training algorithm adaptivity, which alters task difficulty as a function of subject performance across a range of disparate but interconnected subtasks, and its effect on skill acquisition and performance. We hypothesize that more adaptive training algorithms lead to improved outcomes in learning retention between trials, increased skill transfer between the virtual and physical environments, and improved performance in a physical cockpit mock-up. **METHODS:** A virtual training simulator was developed to emulate landing a spacecraft on Mars, with VR immersion being conducted through a head-mounted display for three subtasks. Given IRB approval, we used human subjects to study three degrees of adaptivity in algorithms, including fixed linear response, dynamic linear response, and non-linear response. Difficulty was modulated linearly to a set paradigm, modulated dynamically to consecutive increases in performance, or modulated proportionately to performance, respectively. These were compared to non-individualized fixed progression, which coarsely mimics the adaptive paradigm, and non-adaptive algorithms which fix difficulty. Subjects (n=8 per algorithm, 4M/4F) aged 18-60 were screened for colorblindness and motion sickness susceptibility, grouped randomly, and baseline information was taken by means of a demographic survey, Affect Grid questionnaire, and reaction time test. Data was collected on joystick and keyboard inputs and associated performance grades across subtasks and sessions were analyzed using non-parametric regression and both paired and non-paired tests. **RESULTS AND DISCUSSION:** We analyzed the effect of training personalization on learning outcomes across several algorithms compared to a control and determined the extent to which different algorithms had similar outcomes. We evaluated learning retention between trials and skill transfer between the virtual and physical environments. Our results inform the required algorithmic complexity to attain optimal training results. Future research should explore the use of Bayesian estimation and machine learning models to scale difficulty by predicting performance for more optimally individualized training.

Learning Objectives

1. The audience will learn about the effect of training algorithm adaptivity on skill acquisition, learning retention, and performance.
2. The audience will learn about the required algorithmic complexity to attain optimal training results.

[185] GALVANIC VESTIBULAR STIMULATION AS AN ANALOGUE DEVICE FOR SPATIAL DISORIENTATION TRAINING IN MILITARY AVIATION

Amanda Lippert[1], Aaron Allred[2], Scott Wood[3]
[1]*U.S. Navy, Patuxent River, MD, United States;* [2]*University of Colorado-Boulder, Boulder, CO, United States;* [3]*NASA, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: The number one cause of fatalities in military aviation continues to be Spatial Disorientation (SD). For decades, there has been a multifaceted approach to lowering this statistic, including developing automated systems within aircraft and training aircrew to recognize and recover from a disorienting scenario in flight. Current SD training for military aircrew consists of regularly occurring didactic training on topics such as human sensory systems (capabilities and limitations), environmental conditions that may induce SD, and widely accepted theory on the types of SD. This lecture-style training is sometimes coupled with using devices such as flight simulators (both motion-based and static), the Multi-Station Disorientation Device (MSDD), Underwater Egress Training Devices, and Barany Chairs. However, the experiential training that the various devices offer is infrequent, with the most common device being a static flight simulator. Static flight simulators offer no vestibular stimulation to the brain of the crew, often relying solely on visual and audible inputs when simulating a disorienting scenario. **OVERVIEW:** Galvanic Vestibular Stimulation (GVS) offers an opportunity to create a perception of disorientation by providing supra-threshold bilateral bipolar electrical current to the vestibular system in a safe and reliable manner. GVS has been used on humans for decades in the laboratory environment, to research topics such as balance, neurological functions of healthy and diseased populations, detrained vestibular systems in spaceflight crew, and recently in virtual reality scenarios to simulate a variety of commonly experienced somatogravic and somatogyral illusions in flight. **DISCUSSION:** The ability to disorient aircrew in the safe training environment of a static flight simulator would allow for aircrew to experience the sensations of sensory mismatch while demonstrating typical flight-related tasks. Additionally, this would serve as an opportunity to practice the life-saving checklist items to recover from Spatial Disorientation while actually experiencing a disorienting event. In this presentation, the authors discuss using targeted waveforms of GVS that will elicit the sensations felt during common sensory illusions in flight, creating a training profile that could be worn by military aircrew in a static flight simulator, offering a low-cost training solution to the number one cause of fatalities in military aviation.

Learning Objectives

1. Explain the basic workings of a typical Galvanic Vestibular Stimulation (GVS) device.
2. Describe how GVS will function as a training analogue for Spatial Disorientation (SD).

[186] PRELIMINARY EVALUATION OF AN OSTEOPATHIC MANIPULATIVE TREATMENT (OMT) TO PREVENT MOTION SICKNESS SYMPTOMS

Virginia Thomas[1], Amanda Kelley[2], Albert Lee[3], Thomas Fotopoulos[1], Jason Boggs[2], John Campbell[2]
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(Original Research)

INTRODUCTION: Unmanaged motion sickness can lead to pilot or aircrew impairment during flight, and if severe enough, disqualification from flight duty. Advancements in the next fleet of rotary-wing aircraft anticipate increased maneuverability and speeds which may lend towards increased incidence of motion sickness. While many medications currently exist in the marketplace, they vary dramatically in reported effectiveness and side effects, and are allowed only on a limited basis for military flight teams. This study aimed to demonstrate the use of osteopathic manipulative treatment (OMT) to alleviate the neuromuscular components of the impacted systems related to motion sickness. **METHODS:** A novel OMT protocol for the reduction of motion sickness symptoms and severity was evaluated using a sham-controlled, counter-balanced, between-subjects study design. The independent variable was OMT treatment administered prior to the motion sickness inducing procedure (target treatment vs. sham treatment). The primary dependent measures were total and sub-scale scores from the Motion Sickness Assessment Questionnaire (MSAQ) and heart rate. **RESULTS:** The findings suggest the novel treatment shows promise for this purpose. Specifically, the results suggest that the treatment may reduce gastrointestinal (nausea) and sopite-related symptoms (sleepiness). The OMT target treatment group experienced significantly less gastrointestinal symptoms than the sham group whilst controlling for motion sickness susceptibility. Heart rate data patterns were consistent across groups supporting the validity of the manipulation (procedure) for inducing motion sickness. **DISCUSSION:** While our findings did not result in specific, implementable recommendations, they did provide a more-focused direction for future investigations. A more precise evaluation of the mechanism of action is needed. In terms of practicality and applicability, the treatment needs to be tested with a variety of providers, using a variety of motion sickness inducing stimuli. Also, the duration of the effect needs to be established. Further investigation will be invaluable in determining the validity of OMT to alleviate motion sickness symptoms.

Learning Objectives
1. Participants will learn about a non-pharmaceutical approach to motion sickness symptom prevention.
2. We will consider the mechanisms of action which resulted in greater reduction of some symptoms over others.

[187] CERVICAL RANGE OF MOTION ASSESSMENT- A NOVEL APPROACH USING VIRTUAL REALITY

Aya Ekshtein[1], Yuval Kozlov[2], Miriam Peri[1], Shachar Shapira[1], Oded Ben-Ari[1]
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(Original Research)

INTRODUCTION: Neck pain (NP) in military aviators is a significant problem associated with cervical injury and impaired flight safety and operational performance. There is evidence of a link between decreased cervical range of motion (CROM) and NP in aviators and the general population. Our goal was to evaluate whether CROM assessment in aviators using a Virtual Reality (VR) device can predict NP. **METHODS:** The study was a cross-sectional study. Clinical, demographic, and military data was collected from the electronic medical records system. **RESULTS:** A total of 1,187 active Israeli Air Force (IAF) aviators underwent CROM assessment by the unit's physical therapist using the XRHealth™ Oculus Quest VIVE HTC VR™ system between January 2020 and July 2021. Of 1,187 IAF aviators, 30% reported neck pain. NP was significantly correlated ($p<0.001$) with reduced neck flexion. A significant decrease in CROM was found in subjects 50 and over years of age ($p<0.0001$). **DISCUSSION:** Our findings suggest that the VR system may be a valuable tool for assessing aviators CROM and their risk of developing NP. The most significant factor associated with a decline in CROM was increased age. Reduced flexion was associated with NP.

Learning Objectives
1. Implementation of a virtual reality device to assess cervical range of motion.
2. Cervical range of motion as a mandatory examination during yearly routine checkup.
3. Adding the possibility of grounding aircrew due to neck pain.

[188] MILLER FISHER SYNDROME IN A JORDANIAN FIGHTER PILOT

Rafat Rahayfeh[1], Vasileios Pastamentzas[2]
[1]*Royal Jordanian Air Force Medical Facility, Amman, Jordan;* [2]*Hellenic Air Force, Athens, Greece*

(Education - Case Study)

Introduction: In this case report we will describe a military F16 pilot who was infected with mild acute respiratory syndrome coronavirus 2 (SARS- CoV-2) and develop Miller Fisher syndrome (MFS). **Background:** MFS is a rare variant of Guillain-Barré syndrome (GBS), It is an autoimmune response that typically follows an upper respiratory or diarrheal illness. It is characterized by the acute development of ataxia, weakness, ophthalmoparesis and areflexia. The muscle weakness can progress to cause respiratory failure. MFS occurs in approximately 5-10% in the US and 20% in Asia of GBS cases. Serum anti-GQ1b IgG antibody is indicative of syndrome. Treatment could include supportive respiratory care, intravenous immunoglobulin therapy (IVIG), or plasmapheresis. **Case Presentation:** The pilot is a 25-year-old fighter pilot, who was infected with SARS-CoV-2. He was previously vaccinated, but still experienced mild to moderate viral symptoms. After 3 days of symptoms, he started to have severe headache, unsteady gait, dysarthria and blurry vision. He was seen by his flight surgeon and transferred to King Hussein Medical Center for inpatient neurology evaluation and ophthalmology consultation. MRI and lab work were normal despite his persistent symptoms. He was diagnosed with Miller Fisher Syndrome. Treatment included a course of IVIG over his 5-day hospital stay. Symptoms resolved day by day but complete recovery took six months. He was evaluated 1 year after recovery and recommended to have training flights to evaluate his ability in the jet and G-tolerance. He had no problems and was returned to full duty. **Discussion:** Even though Miller Fisher syndrome is a rare form GBS, it should be included in the differential diagnosis of a patient with neurologic and ophthalmologic symptoms and a recent illness. With the large number of SARS-CoV-2 infections flight surgeons should be aware of this potential complication. This report highlights the importance of early diagnosis and treatment of the syndrome especially on a pilot whose vision, balance and situation awareness are crucial to safe operation of an aircraft. The decision to return to flying duties should consider the low likelihood of recurrence and include a sufficient time interval to assure full resolution of symptoms.

Learning Objectives:
1. Recognize and understand how to diagnose Miller Fisher syndrome and identify treatment options.
2. Review the aeromedical policies of the US Department of Defense, Federal Aviation Authority, and international aviation standards for Guillain Barre and Miller Fisher syndrome.

[189] AAMIMO GRAND ROUNDS PRESENTATIONS

AAMIMO Physician
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

The Advanced Aerospace Medicine for International Medical Officers (AAMIMO) program is a 6-month workshop hosted by the US Air Force School of Aerospace Medicine (USAFSAM). Experienced Aerospace Medicine physicians from militaries outside of the US complete rotations with each US Dept of Defense Agency, as well as with the FAA and NASA. The workshop is meant to increase understanding and interoperability between Aerospace Medicine practitioners from all over the world. Each participant will prepare and present a clinical case, either from their country or from their experiences at USAFSAM, that will highlight similarities and differences in clinical care between the US and their home country. The participants do not begin the program until Jan 2023, they will have their case abstracts completed for submission in mid-February.

Learning Objectives
1. The audience will learn about the clinical care of the condition chosen.
2. The audience will learn about care of the aviator in US and International military environments.

Tuesday, 05/23/2023 ***2:00 PM***
Napoleon Ballroom D1-D2

[S-36]: PANEL: NEUROTICISM IN AVIATORS: SHOULD WE BE WORRIED?

Chair: Joe Wood
Co-Chairs: Monica Malcein, Justin Bunn, John Heaton, Kevin Heacock

PANEL OVERVIEW: *This panel presents original research from clinicians at the Neuropsychiatry Branch of the Aeromedical Consultation Service (ACS). The first presentation describes the concept of personality in general and neuroticism in particular and provides an overview of the literature regarding neuroticism and aviators. The second presentation examines differences in personality characteristics across three generations of pilots (Generation X, Millennials, and Generation Z), focusing on similarities and differences in the domain of neuroticism for 33,074 pilots. Next will be a presentation describing changes in pilot personality over time comparing 98 baseline neuroticism scores with results obtained during subsequent psychological evaluations at the ACS. The fourth presentation discusses the use of the NEO-PI-3 personality measure as a clinical tool for evaluating aviators*

and compares neuroticism scores for 198 pilots evaluated at the ACS who did and did not receive a recommendation for a flying waiver. The final speaker will provide two case presentations and highlight the benefits of utilizing personality measures when conducting clinical assessments.

[190] NEUROTICISM IN AVIATORS: SHOULD WE BE WORRIED?

Joe Wood
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The ability to compartmentalize and perform under pressure is a hallmark attribute of the prototypical aviator. The personality characteristic of neuroticism provides a framework with which to examine these traits. **TOPIC:** As one of the domains from the Five-Factor model of personality, neuroticism assesses emotional stability, proneness to psychological distress, and use of maladaptive coping strategies. Persons low in neuroticism are often described as calm, resilient, and secure. High scorers on neuroticism are associated with increased likelihood of developing psychiatric disorders. Thus, selecting aviators with lower levels of neuroticism can be beneficial in multiple ways. First, they would be expected to perform more proficiently during high-stress periods. Second, they would be less susceptible to developing clinical distress or disorders that would degrade their performance or cause extended periods of non-flying while treated for psychiatric conditions. Though there are some special duty programs that specifically assess for neuroticism using psychological measures, such as the NEO-PI-3, most are not. An attempt is made to screen out highly neurotic applicants indirectly through review of their medical record, with a history of diagnosis and treatment for psychiatric conditions disqualifying for most aviation positions. For those with a psychiatric history requesting a waiver to pursue an aviation-related field, use of psychological measures to help determine neurotic tendencies can be helpful in determining relative risk of recurrence of psychological distress. Personality measures have been utilized fruitfully for many decades at the Aeromedical Consultation Service as part of the intensive evaluation process. **APPLICATION:** Assessing for neuroticism can provide career fields with individuals who are more resilient and better able to handle the stressors inherent in the aviation environment. Utilizing clinical personality measures is beneficial as part of a robust clinical evaluation of aviators.

Learning Objectives

1. The audience will learn about the importance of the personality domain of neuroticism in aviators.
2. The audience will learn how personality tests that measure neuroticism can provide useful when assessing aviators for flying duties.

[191] NEUROTICISM IN AVIATORS: A CROSS-GENERATIONAL STUDY OF USAF AVIATORS FROM GENERATIONS X, Y, AND Z

John Heaton, Joe Wood III, Kevin Heacock, Jared Haynes
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: Neuroticism is the tendency to experience negative emotions like anxiety, depression, and anger. Low scorers on this scale tend to have more self-confidence, are slow to become frustrated, worry little, and are able to calm themselves down effectively. People high in neuroticism are more emotionally reactive and easily stressed, thus making them more susceptible to anxiety and depressive disorders. Generational research shows that Generation Xers, Millennials, and Gen Zers view the world, work ethic, and priorities differently, and these differences can present different strengths and challenges for military service, occupational demands of aviation, and interpersonal relationships. The aim of this study is to examine similarities and differences in the domain of neuroticism of USAF aviators across three generations (X, Millennials, and Z). **METHODS:** The authors analyzed data of 33,074 pilot applicants who completed comprehensive computer-based personality (NEO-PI) testing prior to pilot selection. Those categorized as Generation X (n=2060) have birth years between 1964 and 1979 (mean age 27.53). Millennials (n=23,896) have birth years between 1980 and 1994 (mean age 23.56). Generation Z (n=7118) have birth years between 1995 and 2001 (mean age 21.26). Sample includes 29,477 (89.12%) male and 3,597 (10.88%) female. Commissioning sources include 63.71% (ROTC, OTS, AMS, other) and 36.29% (USAFA). **RESULTS:** Millennials and Gen Zers endorsed significant differences in anxiety (X: 11.47, Y: 11.50, Z: 12.53) and depression (X: 9.06, Y: 9.37, Z: 10.43) compared to their Generation X counterparts. Gen Zers endorsed significantly higher levels of vulnerability to stress (X: 6.17, Y: 6.64, Z: 7.09) compared to Gen X counterparts. Millennials showed significantly lower levels of anger hostility (X: 11.18, Y: 10.48, Z: 10.25) and impulsiveness (X: 14.29, Y: 13.57, Z: 13.11) compared to Generation X individuals. **DISCUSSION:** Differences in personality scores for pilots versus the general population illustrate the need for using pilot-specific norms and support the use of both sets of data for clinical evaluation. Personality differences found between generations are consistent with other literature based on intergenerational variability. Future research on the implications on training and retention should be of focus.

Learning Objectives

1. The audience will better understand generational differences in pilot applicants concerning susceptibility to psychological distress.
2. The audience will better understand how USAF pilots differ from the general population.

[192] THE PERSONALITY TRAIT OF NEUROTICISM IN A CLINICAL SAMPLE OF USAF PILOTS

Monica Malcein
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: The personality dimension of neuroticism, the tendency to experience negative emotions, has been shown to predict the development of anxiety and depression in the general population. Within the USAF, the assessment of personality traits on the NEO-PI has been studied in student pilots, with a consistent finding of lower neuroticism compared to the general population. Few studies have focused on NEO-PI in clinical evaluation of trained pilots and little is known about neuroticism scores in a population of pilots referred for clinical evaluation. **METHODS:** 98 USAF pilots with mental health diagnoses were evaluated at the ACS for waiver recommendation. All pilots underwent cognitive and psychological assessment, including the NEO-PI-R or NEO-PI-3. The neuroticism factor and facet scores were compared to the general population. Additionally, differences were explored on the neuroticism factor and facet scores for those that received recommendation for waiver versus those that were not. **RESULTS:** Compared to general population on the NEO-PI, trained pilots with a history of mental health diagnosis exhibited overall lower levels of neuroticism ($p < 0.5$). All neuroticism facet scores were lower than the general population, with the vulnerability to stress facet score producing the largest effect size (d=.89). Those recommended for waiver (n=156) exhibited lower levels of anxiety, anger/hostility, depression, and vulnerability to stress than those not recommended for waiver (n=33), although these findings were not significant. While there were differences between the two groups (waiver vs. disqualified), the average scores for both groups remained lower than the general population. **DISCUSSION:** The overall neuroticism score on the NEO-PI in the clinical population of trained USAF pilots referred for clinical evaluation with history of mental health diagnosis was significantly lower than those in the general population. This was observed across all facets of the N scale, with the clinical pilot population exhibiting lower anxiety, anger, depression, impulsivity, and vulnerability to stress than the general population. Pilots that were not recommended for a waiver due to ongoing clinical symptoms, slightly higher scores on neuroticism facets were seen, but remained considerably lower than the general population. These findings may assist with the interpretation of the neuroticism factor when evaluating trained pilots in a clinical setting.

Learning Objectives
1. The audience will develop a basic understanding of the personality trait of neuroticism in the pilot population.
2. Data related to levels of neuroticism in the clinical population will provide context for interpretation in the clinical context.

[193] COMPARING THE PERSONALITY TRAIT OF NEUROTICISM IN A CLINICAL SAMPLE OF USAF PILOTS FROM INITIAL FLIGHT SCREENING TO FLIGHT WAIVER

Justin Bunn
U.S. Air Force, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The five-factor model describes the structure of normal personality traits, dividing personality into five dimensions, including neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness (Costa & McCrae, 1992). Each dimension has identified personality traits or facets utilized to further describe the dimension. For example, the dimension of neuroticism is composed of the facets of anxiety, angry hostility, depression, self-consciousness, impulsiveness, and vulnerability. Individuals who experience these facets at higher levels often describe tendencies to experience more negative emotions, such as fear, sadness, anger, and guilt. Given the potential psychological impact of traits of neuroticism, the USAF administers the NEO-PI to pilot applicants as a baseline measure to assess for the five dimensions of personality. If a trained pilot then develops a mental health diagnosis that requires a flying waiver, the measure can be repeated and compared with the baseline administration. With personality dimensions and traits considered to be fairly stable across the lifespan, changes in dimensions, particularly neuroticism, could aid in providing important information in the clinical evaluation and diagnosis of Air Force pilots. **TOPIC:** 198 USAF pilots with mental health diagnoses were evaluated at the ACS for waiver recommendation. During the medical flight screening (MFS) process, the pilots had completed the NEO-PI-R or NEO-PI-3 and the assessment was re-administered as a part of their evaluation for waiver. This presentation discusses the comparison of baseline MFS scores with those attained during the mental health waiver evaluation, with a particular focus on the neuroticism factor and facet scores. Additional discussion will focus on the differences on the neuroticism factor and facets scores for those who received a waiver recommendation vs. those who did not. **APPLICATION:** This presentation will explore differences in the factor and facet scores of neuroticisms on the NEO-PI for pilot applicants who are then evaluated following the development of a mental health diagnosis. Scores of those who received a waiver recommendation vs. those who did not will also be explored. These comparisons will invite discussion on the potential clinical utility of assessing for changes in the trait of neuroticism and its facets.

Learning Objectives
1. The audience will learn about the potential clinical utility of assessing for changes in the trait of neuroticism and its facets in the pilot population.
2. The participant will be able to identify the specific facets of neuroticism and how they impact the psychological experience of the individual.

[194] EXAMINING THE PERSONALITY TRAIT OF NEUROTICISM IN THE CLINICAL EVALUATIONS OF PILOTS: CASE ILLUSTRATIONS

Kevin Heacock
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The personality dimension of neuroticism, the tendency to experience negative emotions, has been shown to predict the development of anxiety and depression. Within the USAF, baseline assessment of personality traits is accomplished with the NEO-PI and studies have consistently documented lower neuroticism scores in this population compared to the general population. When trained pilots are seen for clinical evaluation following the diagnosis and treatment of a mental health condition, these baseline scores are available for comparison to current scores in the clinical setting. Changes in these scores over time can represent changes in mental health status that would prompt further examination. **TOPIC:** Case presentations incorporating amalgamated information related to pilots' current level of neuroticism, compared to the pilot population, the general population, and the pilots'baseline data will be presented to highlight the usefulness of assessing this trait in the clinical evaluation. Case #1 features a pilot presenting for evaluation with a history of depression and anxiety treated with an antidepressant. Comparison of NEO-PI scores obtained during clinical evaluation revealed significantly higher neuroticism scores than those seen at baseline, consistent with clinical symptomatology. Case #2 describes a pilot seen for several clinical evaluations with variability in symptoms of anxiety across time. NEO-PI obtained at baseline and atsubsequent evaluations mirrored the clinical anxiety symptoms he was experiencing at that time, suggesting the NEO-PI can be useful to track progression of symptoms. **APPLICATION:** The evaluation of the personality trait of neuroticism in the clinical population of trained pilots can be a useful adjunct for assessing current clinical symptomatology. When there is a deviation from baseline scores or from the pilot norm, further exploration of the facets of neuroticism can provide useful information in the clinical setting.

Learning Objectives
1. The participant will be able to see how useful the NEO-PI can be in tracking mental health symptom progression.
2. The audience will learn about the use of the NEO-PI to further explore facets of neuroticism in the clinical setting.

Tuesday, 05/23/2023 ***2:00 PM***
Napoleon C3

[S-37]: PANEL: PILOT SPATIAL DISORIENTATION RESEARCH, MODELING, AND MITIGATION

Chair: Richard Arnold
Co-Chair: Brennan Cox

PANEL OVERVIEW: *Pilot spatial disorientation (SD) remains a leading contributory and causal factor in flight mishaps. Efforts to reduce the incidence of SD-related flight mishaps, for example through SD familiarization training, appear to have had negligible measurable effects on SD mishap rates, which have remained high and relatively stable for decades. Emerging knowledge, technologies, and research tools are producing better understanding of SD phenomena and should ultimately lead to more effective SD mitigations. This panel will expand upon research featured in our 2022 AsMA panel by highlighting recent and current efforts to understand, characterize, and model sensory, perceptual, and cognitive factors involved in spatial orientation. The panel will discuss research and modeling of vestibular sensation and perception, visual perceptual illusions, sensory integration, and operational contributors to SD. The panelists will also discuss research gaps to inform future SD research, development, and modeling initiatives, in addition to how such efforts may ultimately inform safety mitigations.*

[195] RECOMMENDATIONS FOR SPATIAL ORIENTATION MODELING WITH REALISTIC COCKPIT ENVIRONMENTS AND MULTI PHYSIOLOGICAL AND NEUROLOGICAL VARIABLES

Fred Patterson, Richard Folga
Naval Medical Research Unit-Dayton and Leidos Contract Support, Dayton, OH, United States

(Education - Program/Process Review)

BACKGROUND: Historically, spatial disorientation (SD) and spatial orientation modeling (SOM) research has focused on vestibular sensory misperceptions as the primary cause of pilot SD. Most SOM investigations concentrated on fixed head vestibular accelerations in dark environments where subjects maintained a strict vertical head alignment with their body and the apparatus. **OVERVIEW:** Aircraft accident statistics and pilot surveys consistently indicate visual misperceptions cause SD episodes at a much higher rate than vestibular anomalies. Additionally, conflicting with the fixed head orientation concept is validated aeromedical research that documents pilots rarely maintain head alignment with the cockpit during VMC roll and pitch maneuvers; instead, during VMC maneuvers visually driven spatial reflexes, such as the opto-kinetic cervical reflex (OKCR) trigger continuous head movement away from the cockpit vertical axis, toward the horizon. Researchers investigating human cognition have also discovered there are at least three types of overlapping spatial cells in mammalian brains - head direction, boundary, and grid cells - which are thought to function similar to a compass rose for orientation in 3D environments. Since spatial cognition is, "understanding through thought, experience, and the senses", variables related to limbic spatial cells should be considered critical components for defining future pilot spatial orientation models. **DISCUSSION:** To improve on the accuracy of SOM to predict pilot SD, an expanded taxonomy of existing pilot human factor variables should be added to the SOM criteria. Recommended variables for inclusion are: sight picture dynamics of visual primary and secondary spatial cues, sensory processing bandwidths, pilot spatial strategies, sensory spatial reflex interactions, and interactions of brain spatial cells. Since pilot vestibular accelerations are directly related to continuous changes in head position relative to the aircraft, in order to create an accurate in-flight dynamic vestibular model, it will be necessary to include OKCR head movement variables. While some SOM research papers mention task saturation as a contributing SD factor, human cognitive processing bandwidth limits were not incorporated into SOM conventions. Since there exists validated information describing functional limits of human sensory, working, and long-term memories, these variables should be included with any pilot SOM taxonomy.

Learning Objectives

1. The participant will be able to recognize that the most prevalent causes of pilot spatial disorientation are visual cognitive processing problems.
2. The Participant will be able to understand pilot spatial awareness and spatial orientation are dependent upon spatial strategies derived from dynamic pilot sight pictures involving primary, secondary, and tertiary visual spatial cues.
3. The participant will be able to understand that accurate Spatial Orientation Modeling (SOM) should prioritize an expanded taxonomy of existing pilot human factor variables that include sight picture dynamics of visual primary and secondary spatial cues, sensory processing bandwidths, pilot spatial strategies, sensory spatial reflex interactions, and interactions of brain spatial cells.

[196] THREE CANDIDATE LAWS THAT GOVERN MUCH OF SENSORY INTEGRATION

Vincent Billock[1], Adam Preston[2]
[1]*Leidos, Inc. at Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States;* [2]*Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Sensory integration is a discipline that has an abundance of beautiful data and a modicum of theoretical principles, chief among them Stein and Meredith's three Principles of Spatiotemporal Coincidence and Inverse Enhancement. This is inadequate. We need to understand sensory combination and sensory interaction quantitatively, to feed into models of sensory performance and disorientation. **RESULTS:** We extensively mined neural and behavioral data for the simplest theoretically motivated quantitative rules that model sensory integration and other sensory interactions. We found three so far: (1) Gated Amplification: A simple power law beautifully models both modulated multisensory cell firing rates and behavioral data for multisensory perceptual magnitude. The power law has a compressive exponent that agrees with the Principle of Inverse Enhancement. Gated amplification also explains some aspects of color perception and binocular facilitation. (2) Nonlinear Summation: Minkowski's nonlinear summation formula is a good model for facilitatory bimodal neuron firing rates and the cortical neural model matches the psychophysical results. (3) Nonlinear Weighted Averaging: It has always been a mystery what suppressive bimodal neurons are for. We find that most multisensory suppressive neurons seem to compute weighted averages of sensory inputs and thus resemble Bayesian-like reliability-weighted models already used for some psychophysical data. Bayesian averaging is difficult to implement in wetware. Amusingly, the neural data for both multisensory and binocular neurons is better fit by Schrödinger's 1926 nonlinear magnitude-weighted equation, originally used to explain binocular averaging. These nonlinear means may have Bayesian ends. **METHODS:** Theoretical only – nonlinear models of neural and psychophysical data. **DISCUSSION:** Three simple mathematical rules account for virtually all of the neural and psychophysical data modeled so far in three domains: sensory integration, color vision and binocular vision. It is not always obvious in advance which of these three rules will apply. However, the applicability of these rules across sensory domains and the remarkable fits obtained suggest that these rules are generic neural mechanisms broadly available within and across sensory domains. These rules should be considered candidate laws of sensory integration and sensory interaction.

Learning Objectives

1. Understand the difference between faciliatory and suppressive/non-faciliatory interactions in sensory systems.
2. Understand the options that the brain has for combining information.

[197] MODELING VESTIBULAR ADAPTATION TO GRAVITY TRANSITIONS

Victoria Kravets, Aaron Allred, Torin Clark
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Following a gravity transition, astronauts experience sensorimotor impairment, including spatial orientation misperception, motion sickness, and ataxia. The Central Nervous System (CNS) eventually reinterprets altered sensory cues, but with only a conceptual understanding of this adaptation process, we cannot make the operational decisions (e.g., timing of extravehicular activities) necessary to ensure the safety and performance of the crew. Here, we present a computational model of vestibular adaptation to gravity transitions, enabling the modeling of this impairment mechanism. **METHODS:** The overarching model utilizes several Observers (a well validated model of spatial orientation perception) in parallel, each positing a different magnitude of gravity and generating a distinct sensory conflict signal. From these signals, a posterior probability distribution of the current magnitude of gravity is formulated and updated over time via Bayesian inference in conjunction with a particle filter algorithm. Notably, the model retains a "memory" of past states, allowing the model to consider previously experienced gravity levels (while also dynamically learning new states) when formulating new parallel alternative hypotheses of gravity. From the posterior probability distribution, an estimate (e.g., MMSE) of gravity is produced, driving a central Observer model of spatial orientation perception. **RESULTS:** The model dynamically adapts during gravity transitions without direct input of the true gravity level. Simulating the model with various gravity transitions and self-motions suggests different relative rates of adaptation. For example, more dynamic motion is predicted to increase the adaptation rate. Additionally, the stochastic nature of the gravity "learning" process

generates slightly different paths of adaptation for each simulation. **DISCUSSION:** We present the first computational model of the CNS's adaptation to transitions in the magnitude of gravity. Our model offers quantitative explanations for why astronauts experience different sensations while adapting to the same environment and why repeat flyers adapt to gravity transitions more quickly. Overall, this model generates quantitative predictions that can motivate future experimental work, and with experimental validation, it could also predict the severity and time-course of sensorimotor impairment associated with gravity transitions.

Learning Objectives

1. The audience will learn about sensorimotor impairment associated with space flight.
2. The audience will learn about potential computations involved in the Central Nervous System's adaptation to changing environments.

[198] MODELING ORIENTATION PERCEPTION DURING SUDDEN TRANSITIONS IN VISUAL CUE AVAILABILITY

Jamie Voros, Torin Clark
University of Colorado-Boulder, Boulder, Colorado, United States

(Original Research)

INTRODUCTION: Existing models of visual-vestibular integration for human orientation perception do not accurately predict perceived orientation during the transitionary period between visual cue states (e.g., when flying into a cloud, the presence of visual orientation cues suddenly disappears). We begin by collecting data on angular velocity perception about an Earth vertical axis. We present a modified model of orientation perception that is consistent with our collected data. **METHODS:** Eleven subjects (3 female) were asked to report their perception of rotation by pressing a left/right button every time they felt like they had rotated 90 degrees to the left/right. Subjects were instructed to hold down triggers when they felt they were not rotating. A head mounted display provided the visual rotation cues subjects had available to them. When present, visual cues were always congruent with inertial rotation. We used 4 different visual cue conditions: no visual cues, visual vection, visual vection transitioning to no visual cues, and no visual cues transitioning to visual vection. Based on the timing of subject reports of rotation, we inferred their perception of angular velocity. **RESULTS:** We found there was a delay on the order of ten seconds in which angular velocity perception transition based upon when visual cues suddenly became available. In the inverse scenario (visual cues suddenly lost), we saw a roughly 30 second period over which angular velocity perception adjusted. Based on the delay time following a visual cue availability transition, we hypothesize low pass filtering may be occurring along the sensory conflict channel of the existing class of observer models of perception. **DISCUSSION:** We present a model of orientation perception that is robust to sudden transitions in visual cue availability. Adding low pass filtering at key stages of the sensory conflict model of orientation perception has allowed model predictions to become more consistent with our human subject data and can help inform potentially disorienting scenarios experienced by pilots.

Learning Objectives

1. The participant will be able to understand how orientation perception changes during a sudden transition in the availably of visual cues.
2. The participant will understand the current state of orientation perception modeling and why the presented model is consistent with our data.
3. The participant will understand what scenarios the model has not been verified for and what open questions still exist.

[199] VESTIBULAR PERCEPTUAL THRESHOLDS ARE INCREASED BY HYPOXIA

Max Teaford[1], Anne Crecelius[2], Kyle Pettijohn[3], Daniel Merfeld[1]
[1]*Ohio State Wexner Medical Center, Columbus, OH, United States;* [2]*University of Dayton, Dayton, OH, United States;* [3]*Naval Aerospace Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Pilots are exposed to a variety of factors that may impact their ability to detect where they are relative to the environment including hypoxia. Despite the potential for hypoxia to impact our ability to detect where we are relative to the environment no prior studies have examined the impact of hypoxia on vestibular function in humans. Given this state of knowledge, we performed a study to begin to investigate how mild hypoxia impacts the vestibular system, specifically vestibular thresholds. **METHODS:** Using a MOOG movement platform in conjunction with a Reduced Oxygen Breathing Device (ROBD) we had 15 participants complete multiple sessions of z translation threshold tests while breathing gases with an oxygen content consistent with 0 feet and 8,000 feet. Thresholds were determined based upon participants responses on a 2 alternate forced choice recognition task which were used to adaptively select the next stimulus. **RESULTS:** We found that 86.7% of the participants' median z translation thresholds were higher when breathing gases with an oxygen content comparable to 8,000 feet than when breathing gases with an oxygen content comparable to 0 feet. The median z translation threshold was 24.1% higher in the hypoxia condition. In other words, larger movements up/down were needed for participants to reliably sense them. Additionally, 46.7% of participants exhibited acclimation effects. **DISCUSSION:** The results of the present study suggest that mild hypoxia (i.e. 8,000 feet; the altitude commercial air lines pressurize at) can impact our ability to reliably sense whether we moved up or down. Specifically, when hypoxic it takes larger movements for us to be able to sense them. Additional research is needed to determine the exact mechanism(s) of this effect and if this generalizes to other types of motions (e.g. roll-tilts). Regardless, the results of this study suggest that it may be beneficial to use supplemental oxygen at altitudes as low as 8,000 feet.

Learning Objectives

1. The participant will understand what vestibular thresholds are and how they relate to flight.
2. The participant will understand the effect of hypoxia on vestibular thresholds.

[200] THE IMPACT OF HYPOXIA AND WORKLOAD TYPE ON SPATIAL DISORIENTATION IN SIMULATED FLIGHT

Henry Williams, Mariateresa Sestito, Kyle Pettijohn, Daniel McHail
Naval Medical Research Unit-Dayton, Dayton, OH, United States

(Original Research)

INTRODUCTION: Spatial disorientation (SD) refers to a pilot's misperception of the attitude, position, or motion of the aircraft with respect to the Earth, gravitational vertical, and/or other objects. SD is a leading cause of fatal mishaps in military and civilian aviation. Another threat to aviation safety is hypoxia, and numerous studies have shown that hypoxia can impair sensory, cognitive, and motor performance. However, hypoxia's impact on the likelihood of SD is still not well understood; the present study was designed to fill that knowledge gap. **METHODS:** This study was approved by the NAMRU-D IRB. Twenty pilots flew simulated formation-flights requiring them to follow and maintain altitude/heading with a lead aircraft in both visual and instrument meteorological conditions (IMC). Participants also performed unusual attitude (UA) recoveries in IMC. Each pilot breathed a normoxic gas mixture in one flight session, and a hypoxic mixture in another session on another day (equivalent altitudes of 277 m [910 ft] MSL and 5334 m [17,500 ft] MSL, respectively). Two different workload conditions were presented on the formation flights: either a verbal Working Memory Task (WMT) or a spatial Variable-Following-Distance Task (VFDT). **RESULTS:** Subjective workload and SD ratings both increased significantly with hypoxia and in IMC. VFDT and altitude error also increased with hypoxia. For UA recoveries, the duration and severity of deviation from straight and level flight increased in the hypoxic condition, but WMT speed and accuracy and number of control reversal errors were not significantly affected. On formation flights, the VFDT, but not the WMT, led to more time spent banked past 60° in IMC.

DISCUSSION: Hypoxia had significant detrimental effects on four of the five dependent measures that were spatial in nature (SD ratings, VFDT error, altitude error, and UA recovery). The non-spatial WMT was not significantly impacted. This pattern of results suggests that hypoxia negatively affects spatial resources/processing and may increase a pilot's SD susceptibility. Regarding workload type, the VFDT (but not the WMT) led to more severe bank angles in IMC, suggesting spatial resource competition. Future work should further explore spatial/verbal cognitive resource allocation and any effects on likelihood of SD.

Learning Objectives

1. The audience will understand that spatial disorientation SD is one of the leading causes of fatal mishaps in military and civilian aviation.
2. The audience will understand that hypoxia can increase the likelihood of SD.
3. The audience will understand that it is usually advisable to employ more than one measure of SD to detect an SD event.

Tuesday, 05/23/2023 ***4:00 PM***
Grand Ballroom A-B-C

[S-38]: PANEL: IMPACT-ING EXPLORATION SPACEFLIGHT RISK PREDICTION AND MEDICAL SYSTEM DESIGN

Chair: Benjamin Easter
Co-Chairs: Kris Lehnhardt, Jay Lemery

PANEL OVERVIEW: *Human exploration spaceflight missions to the Moon and Mars present unprecedented challenges for in-mission medical care. Compared with the ISS, the greater distance from Earth will mean increased mission durations, communication delays, limited to no resupply opportunities, and significant limitations on the evacuation of ill or injured crew. Spacecraft mass, volume, and power will be curtailed while higher demands will be placed on the crew's knowledge, skills, and abilities. In this higher risk environment, it is important to: a) quantitatively estimate human system risk attributable to medical conditions, a process known as Probabilistic Risk Analysis, and b) use these estimates to inform medical system design. IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) is a PRA and medical trade space analysis tool developed by NASA to advance exploration mission medical system design. IMPACT improves upon and will soon replace NASA's existing tool, the Integrated Medical Model, with: a novel evidence base baselined to exploration environments; an expanded list of 120 medical conditions; a significant increase in the number of medical resources that can be utilized and in the flexibility of their use; and the modelling of time lost performing mission-specific tasks due to medical conditions. IMPACT provides evidence-based, mission-specific PRA estimates of in-flight medical risk and an initial list of clinical capabilities and medical resources/hardware to be considered. In addition, sophisticated trade space capabilities estimate how human system risk varies with changes to the mission architecture or medical capability set (e.g., if the system mass constraint decreases by 10% or ultrasound is removed). This panel will provide an overview of IMPACT, its intended use cases, and future development plans. The panel will be the first public presentation of IMPACT results, including medical risk estimates for extended duration Artemis missions, the medical conditions most influencing medical risk metrics, and the clinical capabilities that have the largest effect on medical risk.*

[201] INTRODUCTION TO THE IMPACT PROBABILISTIC RISK AND TRADESPACE ANALYSIS TOOL FOR MEDICAL SYSTEM DESIGN

Benjamin Easter[1], Jon Steller[2], Amy Kreykes[2], Jay Lemery[1], Arian Anderson[3], Emily Stratton[2], Ariana Nelson[2], Chris Zahner[2], Eric Kerstman[2], David Hilmers[4], Dana Levin[2]
[1]*NASA, Houston, TX, United States;* [2]*KBR, Houston, TX, United States;* [3]*University of Colorado-Aurora, Aurora, CO, United States;* [4]*Baylor College of Medicine, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Probabilistic risk analysis (PRA) is a method for estimating risk in complex engineered systems that, at a basic level, focuses on what can go wrong and the likelihood and consequences of those occurrences. NASA has used PRA as an integral component of medical system risk estimation and design for spaceflight. IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) is a novel tool to meet these goals for exploration missions. **OVERVIEW:** IMPACT performs hundreds of thousands of Monte Carlo simulations of missions to build aggregate pictures of medical risk. These simulations are based on 120 possible medical conditions (the IMPACT Condition List) selected in a consensus-based process because they are of highest likelihood and/or consequence for exploration spaceflight. The conditions are then tied to clinical capabilities which can be used for management (e.g., inserting an IV) and then to over 600 specific resources needed to deliver a capability (e.g., an angiocath or an ultrasound). Different mission profiles can be simulated with user-specified inputs such as mission duration, destination, number of crew and pre-existing medical conditions, and EVA frequency. While the IMPACT evidence base is designed for exploration environments, these user inputs allow the tool to be used across a broad range of missions. IMPACT's primary outcome metrics include loss of crew life (LOCL, a measure of in-flight mortality due to medical conditions), need for evacuation (RTDC, return to definitive care), and crew disability (TTL, task time lost based on how medical conditions impact the ability to perform over 1000 specific exploration mission crew tasks). In addition to modeling medical risk, IMPACT also accepts user-specified constraints, such as limitations of mass or volume, and will output a recommended clinical capability set and specific medical resources that meet the mission constraints. **DISCUSSION:** This abstract will provide an introduction to IMPACT and describe the nature of the underlying medical evidence. It will also detail potential use cases for how this tool can be utilized by NASA or commercial spaceflight providers.

Learning Objectives

1. The participant will be able to describe how the IMPACT tool models medical risk.
2. The participant will define the primary outcome metrics for IMPACT (loss of crew life, return to definitive care, and task time lost).

[202] IMPACT OUTPUTS FOR A REPRESENTATIVE EXTENDED DURATION ARTEMIS MISSION

Jonathan Steller[1], Dana Levin[1], Jay Lemery[2], Arian Anderson[3], Emily Stratton[1], Arian Nelson[1], Eric Kerstman[1], David Hilmers[4], Kris Lehnhardt[2]
[1]*KBR, Houston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*University of Colorado-Aurora, Aurora, CO, United States;* [4]*Translational Research Institute for Space Health, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: As NASA and private industry begin preparation for long-duration spaceflight, quantifying the impact that potential human health and performance capabilities have on crew health outcomes is imperative for medical risk mitigation. NASA's Informing Mission Planning via Analysis of Complex Tradespaces tool (IMPACT) applies Probabilistic Risk Assessment (PRA) methodology to estimate these outcomes. **OVERVIEW:** As NASA prepares to return to the Moon, medical system planning has already begun for extended Artemis missions, which will see humans spending months at a time in cis-lunar space and on the surface of the Moon. The Long Duration Lunar Orbital and Lunar Surface (LDLOLS) design reference mission (DRM) lasts 9 months, including 3 months on the lunar surface, and involves 2 male and 2 female crewmembers. LDLOLS assumes no extravehicular activities (EVAs) in orbit, but, while on the lunar surface, involves 2-4 EVAs/month in a pressurized rover and 2-4 EVAs/month in an unpressurized rover or on foot. This DRM assumes a physician level Crew Medical Officer with commensurate knowledge, skills, and abilities. The IMPACT tool was utilized to estimate in-flight medical risk for this mission. More specifically, 100,000 simulations of this DRM were modeled, and overall estimates for loss of

crew life (LOCL), need for evacuation (RTDC; return to definitive care), and crew task time lost (TTL; a measure of disability) were calculated. A recommended medical capability set, with appropriate mass and volume constraints, was also generated. **DISCUSSION:** This abstract reviews the IMPACT-derived risk of these mission outcomes with and without treatment, a macroscopic look at the total mass and volume necessary for full diagnostic and treatment capability, and how these change with input mission parameters.

Learning Objectives

1. The audience will learn about the Long Duration Lunar Orbital and Lunar Surface (LDLOLS) design reference mission (DRM).
2. The audience will learn about mission outcome predictions by IMPACT using the LDLOLS DRM.
3. The audience will have an overview for the medical resourcing predicted by IMPACT using the LDLOLS DRM.

[203] DERIVATION OF THE MOST INFLUENTIAL MEDICAL CONDITIONS FOR AN EXTENDED DURATION ARTEMIS MISSION

Ariana M. Nelson[1], Jon G Steller[1], Kamal Shair[1], Rosemarie Dizon[1], Dana Levin[1], Jay Lemery[2], Arian Anderson[3], Emily Stratton[1], Chris Zahner[1], David Hilmers[4], Kris Lehnhardt[2]

[1]*KBR, Houston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*University of Colorado-Aurora, Aurora, CO, United States;* [4]*Translational Research Institute for Space Health, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: The risk of loss of mission due to medical conditions may be influenced by loss of crew life (LOCL), need for evacuation (RTDC; return to definitive care), and crew task time lost. Predicting what medical conditions are most likely to lead to crew morbidity and mortality may influence medical system design, clinical capability prioritization, and research strategies. NASA's Informing Mission Planning via Analysis of Complex Tradespaces tool (IMPACT) applies Probabilistic Risk Assessment (PRA) methodology to assess these risks. **OVERVIEW:** A team of subject matter experts (SME) from a variety of medical disciplines developed a consensus-based process to determine 120 of the most clinically relevant medical conditions for long-duration exploration missions (LDEMs). This IMPACT Condition List (ICL) expanded upon previous work done for Integrated Medical Model (IMM). For each condition a best-case and worst-case definition were derived. These definitions were used to identify probability of occurrence, proportion of cases that are best case vs. worst case, clinical phase duration, and risk of outcomes (task time loss [TTL], RTDC, and LOCL) for both treated and untreated states. These data were sources from existing spaceflight databases (e.g. Longitudinal Survey of Astronaut Health), relevant models (e.g. the ISS fire model), and/or terrestrial literature. Each condition was then tied to diagnostic and therapeutic resources and capabilities. IMPACT was then run for the LDLOLS DRM (see Abstract #2 for this panel). **DISCUSSION:** This abstract will present the process for generating the IMPACT condition list, the relevant data for each clinical condition, and present results for the ten most influential conditions impacting LOCL, RTDC, and TTL for a representative extended duration Artemis mission.

Learning Objectives

1. Describe how the Informing Mission Planning via Analysis of Complex Tradespaces (IMPACT) Condition List (ICL) was formulated and its importance with respect to probabilistic risk assessment for long duration spaceflight missions.
2. Explain how the incidence, clinical phase duration, and probability outcomes were determined for each medical condition in the IMPACT tool.
3. List the ten most influential medical conditions impacting loss of crew life (LOCL), return to definitive care (RTDC), and task time lost (TTL) for the representative extended duration lunar Artemis mission.

[204] IMPACT IDENTIFIED MEDICAL CAPABILITIES WITH LARGEST EFFECT ON MEDICAL RISK FOR EXPLORATION SPACEFLIGHT

Arian Anderson[1], Steller Glenn[2], Dana Levin[2], Jay Lemery[3], Emily Stratton Emily[2], Ariana Nelson[2], Amy Kreykes[2], Chris Zahner[2], Eric Kerstman[2], David Hilmers[4], Kris Lehnhardt[3]

[1]*NASA Exploration Medical Capabilities, Boulder, CO, United States;* [2]*KBR, Houston, TX, United States;* [3]*NASA, Houston, TX, United States;* [4]*Translational Research Institute for Space Health, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Spaceflight medical system design will require a significant change as missions transition from low earth orbit to deep space missions. The risk of a medical event leading to mission failure has been projected to increase while the available resources, and support will decrease due to the constraints inherent to these missions. Thus far, identifying what to include in a medical system been based on prior experience which may be less accurate with changing mission goals. We aim to use the IMPACT software to model lunar missions and identify which capabilities have the largest effect on reducing medical risk to provide evidence-based guidance for medical system design. **OVERVIEW:** NASA previously identified 120 medical conditions with the largest contribution to medical system risk on a deep space mission. We developed an evidence library (EvLib) of medical condition incidence, likelihood of loss of crew life, and medical capabilities required to treat each condition based on best available data. EvLib used as inputs for IMPACT, a trade space analysis tool to perform probable risk assessment on these conditions and capabilities to identify those with the largest effect size. We identified the 10 medical conditions with the largest effect on medical system risk. Among these 10 conditions were respiratory infection, choking on foreign body, abnormal uterine bleeding, etc.… The medical capabilities that had the largest effect on reducing these risks included history taking, performing a physical exam, antibiotics, and pain medication. **DISCUSSION:** By utilizing IMPACT to model 100,000 simulated lunar missions, we were able to identify which conditions contributed to medical risk and which resources most significantly reduced this risk. The capabilities and resources with the largest effect involved a very basic approach to care included performing a history and physical, ultrasound, and treatment with antibiotics or pain medication. Larger and more technical equipment like an AED had a small effect on reducing mission risk. These model-based outputs can help provide an evidence-based approach to medical system design that can be then combined with prior experience in spaceflight to create the optimal medical system for exploration class missions.

Learning Objectives

1. Understand a specific example and application of trade space analysis tools.
2. The conditions with the largest effect on astronaut crew health in deep space long duration spaceflight.
3. The medical resources with the largest reduction in medical risk during deep space long duration spaceflight.

[205] FUTURE IMPROVEMENTS TO IMPACT FOR LONG DURATION EXPLORATION SPACEFLIGHT

Emily Stratton[1], John Steller[1], Dana Levin[1], Jay Lemery[2], Arian Anderson[3], Ariana Nelson[1], Amy Kreykes[1], Eric Kerstman[1], Kris Lehnhardt[2], Benjamin Easter[2]

[1]*KBR, Houston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*University of Colorado Department of Emergency Medicine, Aurora, CO, United States*

(Education - Program/Process Review)

BACKGROUND: While NASA currently uses the Integrated Medical Model (IMM) to model spaceflight medical risk for Low Earth Orbit missions, IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces) was created to improve the fidelity of medical risk analysis

for exploration missions involving the Lunar surface and beyond.
OVERVIEW: While completion work continues on the initial version of the IMPACT tool, work has already begun to investigate ways to further enhance the fidelity of the model and its utility to stakeholders.
DISCUSSION: Future additions leveraging the more robust and flexible IMPACT architecture include analyzing mission segments to account for segment-specific environments (ie. Lunar surface or microgravity), clinically tracible outcomes based on partial treatment of conditions, the ability to model mission outcomes based on provider Knowledge, Skills, and Abilities (KSAs), and the ability to affect the incidence of conditions based on the occurrence of related conditions (e.g. UTI progressing to sepsis). IMPACT also enables the addition of new conditions to its database as required to meet future risk assessment needs. Ultimately, the desire is to broaden IMPACT from a tool that models/trades medical risk to one that does so for all crew health and performance relevant systems (e.g., food, exercise, etc.).

Learning Objectives

1. The audience will review more about what IMPACT is and does.
2. The audience will learn about future proposed directions for IMPACT.

Tuesday, 05/23/2023 ***4:00 PM***
Grand Ballroom D-E

[S-39]: PANEL: ALPHA-1 ANTITRYPSIN DEFICIENCY: A HORSE AMONG ZEBRAS

Chair: Mark Ivey

PANEL OVERVIEW: *Alpha-1 Antitrypsin Deficiency (AATD) is an autosomal co-dominant genetic disorder first discovered in 1963. Considered among most providers to be primarily a lung or liver issue, the incomplete penetrance and varied clinical presentations add to the confusion and lack of confidence in screening practices. Most clinicians consider this a rare disorder; however, AATD is implicated in many chronic medical issues and frequently overlooked. Replicated studies have confirmed the average time from symptom onset to diagnosis is just over seven years including referrals to three specialists. Two issues emerge regarding AATD; it is relatively common and frequently under-recognized in the management of chronic disease. Research has shown that poor screening rates from lack of provider knowledge and comfort in the management of genetic disorders are linked to missed opportunities and delayed diagnosis. Since its discovery, persistence in research has led to effective methods of surveillance, treatment protocols and curative options. Despite the publication of the ATS guideline in 2003, only 10% of cases are diagnosed in the US. Increasing provider knowledge in risk stratification and identifying local resources will reduce delays to diagnosis, healthcare resource burden and improve patient QOL.* ***AEROMEDICAL IMPLICATIONS:*** *Civil AME's are often the first point of contact for medical care. In the military, the flight surgeon's team provides both direct and policy-driven care. It is important to note that there are no recommendations for screening asymptomatic members. But AATD must be considered in those with specific risk factors and those members should be tested.*

[206] ALPHA-1 ANTITRYPSIN DEFICIENCY: A SYSTEMIC DISEASE

Cynthia McNerlin
Lakeshore Pulmonology, PLC, Spring Lake, MI, United States

(Education - Tutorial/Review)

In the years of data accumulation since its discovery in 1963, AATD reported rates in the US are still only 10% of expected cases. The majority of the literature published focuses on the anatomic changes and functional impact on the pulmonary and hepatic systems. However, smaller studies and systematic reviews highlight AATD impact on other systemic chronic disease processes. AAT is an important inhibitor of proteolytic enzymes including elastase and collagenase and believed to play a role in maintaining the structural integrity of connective tissues. The balance between proteinases and their inhibitors is important in maintaining the structural integrity of the connective tissues in arterial walls. Studies suggest a correlation between the PiS and PiZ alleles and aneurysmal formation including Cerebral Aneurysms, particularly in those homozygotes. AATD is also implicated in 8% of patients with Primary Spontaneous Pneumothorax (SPTX) and rheumatological disorders including Fibromyalgia Syndrome. Multinational studies have recommended screening for AATD in those with Fibromyalgia. The full extent of the consequences from AATD aren't entirely realized in part due to low reporting rates and poor screening habits. Screening protocols and disease management practices may be reconsidered if AATD is identified in those individuals. Barriers to screening include provider knowledge, comfort in discussing genetic disorders, time commitments and personnel. Lack of screening, delays disease identification, prolongs time to treatment, patient education and counseling and family testing. Statewide and National resources are available for assistance in screening and referrals for patient management and support.

Learning Objectives

1. The participants will be able to identify risk factors of AATD in those patients with non-lung, non-liver related disease.
2. The participants will be able to recognize local and national resources for AATD support for providers and patients.
3. The participants will recognize the barriers to AATD screening and learn methods of implementing screening protocols within their own clinics.

[207] AATD CASE REVIEWS AND AEROMEDICAL IMPLICATIONS

Mark Ivey
Lakeshore Pulmonology, PLC, Spring Lake, MI, United States

(Education - Program/Process Review)

Alpha-1 is a common genetic disorder that presents with common symptoms attributable to other common pathologies. As a consultant to the airlines, the Federal Air Surgeon (FAS) and the DoD, our office is often the first to give consideration to Alpha-1. We will highlight 4 aeromedical cases presented to our office where Alpha-1 was first considered and ultimately found to be relevant. Case 1: Commercial pilot. FAS Consult for a 38 yo commercial pilot with recurrent SPTX. Case 2: USN Aviator with progressive obstructive lung disease and bronchiectasis. Case 3: Student pilot age 56 with new onset 4th CN palsy causing dipoplia and associated with a berry aneurysm. Case 4: "The brothers". Charlie PiMZ, lifelong smoker. FEV1 68%. Michael PiMM. Lifelong never smoker. FEV1 33%. Few patients present as 'text-book' cases of AATD. It is incumbent of each provider using a thorough history to include 3 generations of family history to recognize atypical patterns and use 'outside the box' critical thinking in order to identify the underlying genetic disorder. The main objective of these real patient presentations is to review common and uncommon presentations of AATD, decisions to screen, management decisions and extract take home lessons for other providers. Each case outlines non-standard presentations of AATD with common chief complaints. Not uncommonly, reports from the literature, or their absence, are cited that either directly support or contradict the findings. Outdated guidelines are often used in argument against screening those patients who do not fit into the typical profiles originally cited 20 yr ago.

Learning Objectives

1. Attendees will recognize the variability in the presentations of AATD.
2. Attendees will identify uncommon risk factors for AATD in the aeromedical community.
3. Attendees will learn when screening for AATD is appropriate by policy.

[208] ALPHA-1 ANTITRYPSIN DEFICIENCY: HISTORY AND DISEASE PATHOLOGY

David Mares
Medical Specialists of Madison County, PC, Anderson, IN, United States

(Education - Program/Process Review)

Alpha 1 Antitrypsin Deficiency (AATD) is an autosomal recessive disease with partial penetrance that results in a more rapid decline in lung function compared with nonaffected individuals and the potential for premature onset of chronic obstructive pulmonary disease, emphysema, and bronchiectasis. The gene codes for a protein that protects lung parenchyma from the oxidative damage that we experience daily, some more than others based upon occupation or personal habits. The disease is much more prevalent than other recessive diseases due to a high prevalence of carriers of AATD. This leads to the potential for serial generations to be impacted, otherwise not expected in autosomal recessive diseases. Partial penetrance also results in more persons affected through high level oxidative stress resulting in disease even among carriers. This disease can be devastating to its victims, causing severe morbidity and mortality but can also cause milder symptoms earlier in the process. Also, the symptoms of AATD mimic many other pulmonary processes. Unfortunately, while there are therapies for AATD, often much of the irreversible damage has occurred prior to the referral to a pulmonologist with experience in screening for and treating the disease. Earlier diagnosis is essential but is most effective if it occurs with screening prior to the onset of severe physiologic disturbance. Such screening programs are best suited to primary care offices and the Civil AME visit would be an ideal opportunity to incorporate a program to provide earlier detection of AATD.

Learning Objectives

1. The attendees will be able to identify who is appropriate to screen for AATD.
2. The attendees will recognize that AATD is not rare, but common enough that each of us is overseeing the care of carriers and potentially patients with AATD.
3. The attendees will understand that partial penetrance suggests the need for special care and scrutiny for patients who are carriers.

[209] THE HEPATIC MANIFESTATIONS OF ALPHA-1 ANTITRYPSIN DEFICIENCY

Ben Fiore
U.S. Navy, San Diego, CA, United States

(Education - Program/Process Review)

Alpha-1-Antitrypsin (A1AT), is a hepatically-produced and secreted serine protease inhibitor which prevents tissue destruction by neutrophil elastase. Prevalence is approximately 1:2000 among northern European ancestry with 4 million people carrying a deficient allele. Diagnosis is often delayed until irreversible end organ damage has occurred. Liver dysfunction is a major threat to the health of affected individuals. Under normal conditions, the wild-type protein, "M", is synthesized and secreted from hepatocytes. The most common disease variant, "PiZ", distorts the conformation of the protein causing retention in hepatocytes. This accumulation creates toxic liver injury. The classic presentation of A1ATD is homozygous for the Z allele. Compound heterozygotes with one Z allele have increased risk for liver disease when other processes are present. Current clinical guidelines recommend testing for A1ATD with the gold standard genotype test as part of a comprehensive serologic evaluation for chronic liver disease in patients with persistently elevated ALT > 6 months. Serum testing of A1AT level and liver biopsy are not helpful. Treatment goals are symptom-targeted including avoidance of hepatotoxic agents and treatments. Augmentation of A1AT does not improve liver disease, as it does not reduce accumulation of the Z protein. The only available treatment for decompensated cirrhosis is transplantation. After transplantation, there is no generation of the Z protein and results in an 85% five-year survival. New pharmaceuticals under investigation are poised to transform long term management. It is paramount for the safety of our aviators, crew, and passengers to recognize, diagnose and implement risk mitigation strategies early.

Learning Objectives

1. Attendees will identify the most pathogenic allele associated with liver disease.
2. Attendees will recognize those patients at risk for AATD and appropriate testing methods.
3. Attendees will identify methods to reduce additional stress on functional status of the liver.

[210] ALPHA-1 ANTITRYPSIN DEFICIENCY: A HORSE AMONG ZEBRAS

Mark Ivey
Lakeshore Pulmonology, PLC, Spring Lake, MI, United States

(Education - Program/Process Review)

Alpha-1 Antitrypsin Deficiency (AATD) is an autosomal co-dominant genetic disorder first discovered in 1963. Considered among most providers to be primarily a lung or liver issue, the incomplete penetrance and varied clinical presentations add to the confusion and lack of confidence in screening practices. Most clinicians consider this a rare disorder; however, AATD is implicated in many chronic medical issues and frequently overlooked. Replicated studies have confirmed the average time from symptom onset to diagnosis is just over seven years including referrals to three specialists. Two issues emerge regarding AATD; it is relatively common and frequently under-recognized in the management of chronic disease. Research has shown that poor screening rates from lack of provider knowledge and comfort in the management of genetic disorders are linked to missed opportunities and delayed diagnosis. Since its discovery, persistence in research has led to effective methods of surveillance, treatment protocols and curative options. Despite the publication of the ATS guideline in 2003, only 10% of cases are diagnosed in the US. Increasing provider knowledge in risk stratification and identifying local resources will reduce delays to diagnosis, healthcare resource burden and improve patient QOL. **AEROMEDICAL IMPLICATIONS:** Civil AME's are often the first point of contact for medical care. In the military, the flight surgeon's team provides both direct and policy-driven care. It is important to note that there are no recommendations for screening asymptomatic members. But AATD must be considered in those with specific risk factors and those members should be tested.

Learning Objectives

1. Increase provider knowledge of AATD physiology, common clinical presentations, disease course and surveillance.
2. The audience will become familiar with methods of screening patients and local resources available to assist in management of this disease.
3. The audience will learn about FAA-specific requirements of reporting and monitoring to maintain aeromedical certification and the impact of AATD on military members.

Tuesday, 05/23/2023 ***4:00 PM***
Grand Chenier

[S-40]: PANEL: SAFETY CULTURE IN AVIATION AND MEDICINE: EXPLORING APPROACHES TO ASSESSMENT AND INTERVENTIONS

Sponsored by Aerospace Human Factors Association

Chair: David Schroeder
Co-Chair: Brian Musselman

PANEL OVERVIEW: INTRODUCTION**:** *The Chernobyl nuclear power plant accident, the Challenger and Columbia accidents in space, the two Boeing 737 Max fatal accidents, the former Tennessee nurse who was found guilty of criminally negligent homicide in the death of a patient who was accidentally given the wrong medication, and numerous examples from other industries demonstrate the important role of an organization's safety culture in employee performance and safety.* ***TOPIC:*** *Meta analyses have demonstrated the relationship between measures of*

safety climate, safety knowledge, motivation, engagement, participation, and safety performance (Nahrgang, et al. 2010 and Clark 2006, 2012). Questionnaires are the most common approach to assessing safety culture/climate. The panel includes presentations concerning safety culture in five work environments. ***APPLICATION:*** *Each presenter will describe findings from the scientific literature or experience concerning organizational safety culture assessments, the development of intervention strategies and the overall effectiveness of those interventions. Kylie Key from the FAA Civil Aerospace Medical Institute (CAMI) will describe recent efforts to assess safety culture in aviation maintenance organizations. A representative from NASA will provide an overview of the development of NASA's safety culture program that represents an integration of health and safety. A representative from Delta Airlines will describe efforts to enhance the safety culture as a means of improving the organization's safety management system. A representative from the U.S. Air Force Safety Center will describe their efforts and the impact. Clayton Cowl from Mayo Clinic will provide an overview of safety culture in healthcare. The presentations will provide an up-to-date view of issues and concerns associated with efforts to assess and improve safety culture in space, aviation, and medicine.*

[211] TO ERR IS HUMAN: REVIEWING HEALTHCARE'S SAFETY CULTURE OVER TWO DECADES

Clayton Cowl
Mayo Clinic, Rochester, MN, United States

(Education - Tutorial/Review)

From the release of the groundbreaking book "To Err is Human" in 2000, the culture of safety within the healthcare framework has continued to transform and adapt. Experts estimate that as many as 98,000 people die in any given year from medical errors that occur in hospitals – more than die from motor vehicle accidents, breast cancer, or infectious diseases such as AIDS--three causes that receive far more public attention. The top five medical errors are misdiagnosis, delayed diagnosis, medication error, infection, and harmful medical devices. In the past two decades, there have been marked improvements in the response to critical of errors within the workplace and development of improved communication, team-based safety nets, and a variety of sequelae in response to the need for improved safety cultures within both the inpatient and outpatient healthcare settings yet there remains significant room for improvement. This review will focus on a brief historical outline of transformational improvement efforts, current safety statistics within the medical delivery platform, and efforts for continued improvement in the future.

Learning Objectives

1. To review top causes of error within the healthcare environment.
2. Understand strategies used to reduce error and fatal mistakes in medical delivery.

[212] SAFETY CULTURE IN AVIATION AND MEDICINE: EXPLORING APPROACHES TO ASSESSMENT AND INTERVENTIONS INTRODUCTION

Denise Zona
Air Force Safety Center, Kirtland AFB, NM, United States

(Education - Tutorial/Review)

INTRODUCTION: U.S. Air Force supports an Informed Safety Culture as described in Air Force Instruction 91-202, The US Air Force Mishap Prevention Program. An Informed Safety Culture is comprised of a Just Culture, Reporting Culture, Learning Culture and Flexible Culture. U.S Air Force Commanders and leaders are encouraged to promote the aspects of an Informed Safety Culture. **TOPIC:** The U.S. Air Force Safety Center supports Commanders and leaders assessment of their organization's safety culture through the management and execution of the Air Force Combined Mishap Reduction System (AFCMRS) culture surveys. Surveys are anonymous and confidential to allow members of the Department of the Air Force an opportunity to provide honest feedback about the organization's Informed Safety Culture. The U.S. Air Force Safety Center maintains 15 unique culture surveys to support the various aspects of U.S. Air Force Operations. Commanders and leaders can request a culture survey at any time, and many organizations choose to conduct a culture survey at regular intervals. **APPLICATION:** Commanders and leaders are provided a debrief on their culture survey results by subject matter experts at the U.S. Air Force Safety Center. Culture survey results can be compared across organizations within the same operational area, functional area, or Major Command. Additionally, Commanders and leaders can measure the effects of interventions using pre- and post-intervention safety culture comparisons, or conduct regular culture surveys over a long period of time for longitudinal evolution. Based on survey feedback, recommendations are made to seek to improve Informed Safety Culture. This presentation will provide a general overview of the AFCMRS program and provide examples of culture survey recommendation application. **RESOURCES:** Air Force Chief of Safety. (2022). The US Air Force mishap prevention program (AFI 91-202). Washington, D.C.: United States Department of the Air Force. Retrieved from http://www.e-publishing.af.mil Joint Planning and Development Office (2010). Safety Culture Improvement Resource Guide, v1.6. Retrieved from http://www.rasg-pa.org/RASGPA/SafetyJPDOSC1Gv1.6.pdf. Pantankar, M. S., Brown, J. P., Sabin, E. J., & Bigda-Peyton, T. G. (2012). *Safety culture: Building and sustaining a cultural change in aviation and healthcare*. Burlington, VT: Ashgate Publishing Company. Reason, J. (1997). *Managing the risks of organizational accidents*. England: Taylor and Francis.

Learning Objectives

1. Describe the Air Force Combined Mishap Reduction System (AFCMRS) culture survey.
2. Explain command safety climate culture survey and how it translates into recommendations.

[213] THE ROLE OF JOB DEMANDS AND RESOURCES IN PREDICTING SAFETY CULTURE AND OUTCOMES

Kylie Key[1], Inchul Choi[2], Peter Hu[2], David Schroeder[2]
[1]*FAA, Oklahoma City, OK, United States;* [2]*Cherokee Nation 3-S, Oklahoma City, OK, United States*

(Education - Tutorial/Review)

INTRODUCTION: Employee perceptions of how much the organization values safety (safety culture) is an important foundation of effective safety management in aviation. **TOPIC:** Recent research by Fogarty et al. (2018) demonstrated the utility of a Job Demands and Resources (JD-R) model for explaining safety culture. The model was used to determine the impact of individual factors, organizational factors, and safety culture on performance outcomes (e.g., self-reported errors and violations). We adapted the model for use in an investigation of safety culture in civil aviation. A 200-item questionnaire comprised of 10 job resources (JR) subscales, 6 job demands (JD) subscales, 4 individual outcomes, 3 organizational outcomes, demographics, and a usability subscale was administered to aviation maintenance personnel at five US maintenance organizations; items were tailored to meet the organizational needs of participating companies. Responses were received from 987 individuals. **APPLICATION:** The results provide initial validation evidence for the questionnaire. Structural equation modeling (SEM) revealed that JD-R predicted both individual and organizational outcomes; that the relationship between safety culture; and organizational outcomes are partially mediated through individual outcomes. Further research is needed to increase the small sample size, address the need for objective versus subjective performance measures, and reduce the length of the questionnaire. **RESOURCES:** Fogarty, G. J., Cooper, R. & McMahon, S. (2018). A demands-resources view of safety climate in military aviation. *Aviation Psychology and Applied Human Factors, 8*(2), 76-85. https://doi.org/10.1027/2192-0923/a000141

Learning Objectives

1. The audience will learn about recent efforts to develop a safety culture assessment toolkit for the aviation maintenance industry.

2. The audience will learn about the relationships among job demands, job resources, individual and organizational performance, and safety culture.

[214] THE ROLE OF SAFETY CULTURE IN ENHANCING AN AIRLINE SAFETY MANAGEMENT SYSTEM

Patricia Demasi
Delta Air Lines, Inc., Atlanta, GA, United States

(Education - Tutorial/Review)

INTRODUCTION: Safety Policy and Safety Promotion are two of the components of a Safety Management System, required under 14CFR Part 5 for U.S. commercial air carriers. Key to the success of a positive safety culture is confidential, non-punitive employee safety reporting, a requirement of Safety Policy. Within Safety Promotion, organizations should promote a positive safety culture, and leaders and managers should actively foster a positive safety culture (FAA, 2020). Safety culture has been described as the most important aspect of safety management (ICAO, 2018). **TOPIC:** Researchers have documented that a positive safety culture not only helps the safety management systems work more effectively (French & Steel, 2017; Piers et al., 2009), but also provides the basis for making continuous improvements to safety management systems (Akselsson et al., 2009). Safety culture has been linked to many important safety-related outcomes. These include organizational performance outcomes such as accident/incident rates, compliance, and production/profit; along with employee outcomes such as engagement, morale, strain/burnout, personal injury rates, willingness to report, and turnover intentions. These relationships between a positive safety culture and positive outcomes are stable across safety-critical industries and countries, attesting to their robustness (Zohar, 2014). A cornerstone in the creation of a positive safety culture is the establishment of voluntary, open, non-punitive reporting systems. (IFALPA, 2021). **APPLICATION:** Given the strength of the relationships between a positive safety culture and positive outcomes, it is reasonable to hypothesize that organizations that foster a positive safety culture will see (and benefit from) positive outcomes.

Learning Objectives

1. The participants will understand safety culture as a tenant of the safety management system.
2. The participants will understand the influence of just culture on safety culture.

[215] SAFETY CULTURE INFLUENCE ON SAFETY OUTCOMES

Brian Musselman[1], David Schroeder[2]
[1]*No affiliation, Albuquerque, NM, United States;* [2]*No affiliation, Oklahoma City, OK, United States*

(Education - Tutorial/Review)

INTRODUCTION: Safety Promotion is one of the four aspects of a Safety Management System. Within Safety Promotion, organizations should promote a positive safety culture, and leaders and managers should actively foster a positive safety culture. Safety culture has been described as the most important aspect of safety management. **TOPIC:** Researchers have documented that a positive safety culture not only helps the safety management systems work more effectively, but also provides the basis for making continuous improvements to safety management systems. Safety culture has been linked to many important safety-related outcomes. These include organizational performance outcomes such as accident/incident rates, compliance, and production/profit; along with employee outcomes such as engagement, morale, strain/burnout, personal injury rates, willingness to report, and turnover intentions. These relationships between a positive safety culture and positive outcomes are stable across safety-critical industries and countries, attesting to their robustness. **APPLICATION:** Given the strength of the relationships between a positive safety culture and positive outcomes, it is reasonable to hypothesize that organizations that foster a positive safety culture will see (and benefit from) positive outcomes.

Learning Objectives

1. The participants will understand safety culture as a tenant of the safety management system.
2. The participants will understand the influence of safety culture on safety outcomes.

Tuesday, 05/23/2023 ***4:00 PM***
Napoleon Ballroom C1-C2

[S-41]: SLIDES: FATIGUE COUNTERMEASURES - PERFORMANCE

Chair: Jochen Hinkelbein

[216] CAFFEINE GUM (200 MG) ADMINISTERED UPON ABRUPT AWAKENING FROM SLEEP DISRUPTS SUBSEQUENT RECOVERY SLEEP

Rachel Firth[1], Karen Robertson[1], Claire Turner[2], Michael Spencer[2], Victoria Revell[3]
[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*Affective State, Winchester, United Kingdom;* [3]*University of Surrey, Guildford, United Kingdom*

(Original Research)

INTRODUCTION: Sleep inertia is a transitory reduction in performance and alertness that occurs immediately on waking and is a potential risk for individuals working on-call. Caffeine gum has been proposed as a countermeasure to sleep inertia. However, it is unclear how effective it is in individuals who habitually consume moderate amounts of caffeine, or what is the impact on subsequent sleep quality. **METHODS:** A double-blind randomized crossover study comprising four conditions: control (no gum), placebo gum, 100 milligram (mg) and 200 mg caffeinated gum was completed. Following a one-hour sleep starting at their habitual bedtime, participants were abruptly woken. Gum was administered (if appropriate) upon waking, and chewed for five minutes. Individuals remained awake for two hours, completing a battery of tasks at regular intervals with continuous electroencephalography monitoring, after which they returned to bed and attempted to sleep for seven hours, recorded using polysomnography. Sleep was scored in accordance with the American Academy of Sleep Medicine guidelines. **RESULTS:** Twelve participants (six female, mean age (± standard deviation) 29.6 (2.2) years) completed the study. Sleep structure and duration of the one-hour sleep did not differ between conditions. Sleep structure and duration were not significantly different in the seven-hour sleep opportunity between the control, placebo and 100 mg conditions. Following the 200 mg dose, sleep onset latency (21.4 (4.8) minutes) increased compared with the control (8.2 (1.7)), placebo (10.5 (2.4)) and 100 mg (13.0 (2.9)) conditions ($p<0.05$). Similarly, latency to stage two sleep (32.7 (5.2) minutes) increased compared with control (13.0 (2.0)), placebo (17.4 (1.9)) and 100 mg (20.9 (4.2)) conditions ($p<0.05$). Duration of slow wave sleep was shortest with the 200 mg (75.7 (6.5) minutes) dose (control (105.0 (6.5)), placebo (96.8 (6.5)), 100 mg (93.9 (6.5)), $p<0.05$). Rapid eye movement sleep (75.2 (6.5) minutes) was also reduced compared with control (94.1 (6.5)) and 100 mg (97.4 (6.5)) conditions ($p<0.05$). **DISCUSSION:** The dose-response effect of caffeine gum indicates that, in the event of a return to sleep two hours after administration, 100 mg is unlikely to significantly affect recovery sleep, in contrast to the sleep disruption observed after 200 mg.

Learning Objectives

1. Understand the impact that different doses of caffeine gum has on sleep
2. Understand how caffeine gum can alter the structure of sleep

[217] CAFFEINE GUM REDUCES FATIGUE AND SLEEPINESS, AND IMPROVES MOOD AFTER A ONE-HOUR SLEEP PERIOD

Karen Robertson[1], Claire Turner[2], Rachel Firth[1], Michael Spencer[2], Victoria Revell[3]
[1]*QinetiQ PLC, Farnborough, United Kingdom;* [2]*Affective State, Winchester, United Kingdom;* [3]*University of Surrey, Guildford, United Kingdom*

(Original Research)

INTRODUCTION: For personnel on-call, abrupt awaking from sleep can result in sleep inertia, which is associated with poor cognitive performance. Caffeine gum has been proposed as one countermeasure to sleep inertia. However, it is unclear how effective caffeine gum is in individuals who habitually consume moderate amounts of caffeine and what is the duration of any beneficial effects. **METHODS:** A double blind randomised cross-over study was undertaken comprising four conditions: control (no gum), placebo gum, 100 and 200 mg doses of caffeine gum. Participants, habitual caffeine consumers, maintained their normal caffeine consumption throughout the study. They completed a six-minute task battery at half-hour intervals for two hours before retiring to bed at their habitual bedtime and sleeping for one hour. Researchers woke participants and, if appropriate, gum was administered and chewed for five minutes. The task battery was completed two minutes after waking and at regular intervals over the following two hours. It comprised mood assessments, Samn-Perelli fatigue rating, Karolinska Sleepiness Scale, the N-back and Digit Symbol Substitution Tests. **RESULTS:** Twelve individuals (six female), mean age 29.6 years, completed the study. Sleep inertia was evident on the cognitive tasks, with an improvement in performance from two to 23 minutes after waking. However, this was not the case for the subjective measures, with no reduction in fatigue or sleepiness over the same period. Caffeine gum did not reduce sleep inertia associated with cognitive performance tasks. Chewing placebo gum had a positive effect on some subjective mood states (e.g. irritability, calmness, passiveness; all $p<0.05$), with some effects observed from nine minutes after waking. Both doses of caffeine gum improved mood, and reduced sleepiness and fatigue compared to control and placebo ($p<0.05$), with 200 mg caffeine having a more consistent and longer duration of effect. **DISCUSSION:** Caffeine gum was effective in reducing fatigue and sleepiness, and improved mood after waking from a one-hour sleep. It was not possible to establish whether caffeine gum mitigates sleep inertia as most of the recovery of performance occurred from two to nine minutes after waking, which was before the onset of action of caffeine.

Learning Objectives

1. Understand the effects of caffeine gum on cognitive performance over two hours after abrupt awaking.
2. Understand the effects of caffeine gum on subjective measures of mood and fatigue over two hours after abrupt awaking.

[218] EFFECTS OF MODAFINIL ON RECOVERY SLEEP: FIRST RESULTS.

Yara Wingelaar-Jagt[1], Wim Riedel[2], Jan Ramaekers[2]
[1]*Center for Man in Aviation, Soesterberg, Netherlands;* [2]*Maastricht University, Maastricht, Netherlands*

(Original Research)

INTRODUCTION: Fatigue remains an important factor in major aviation accidents. Stimulants may counteract fatigue's adverse effects, with modafinil as a promising option with positive effects on performance. However, the negative effects of modafinil on recovery sleep are not clearly established. **METHODS:** Thirty-two volunteers of the Royal Netherlands Air Force were administered modafinil (200 mg) and placebo on non-consecutive trial days after being awake for a mean 17 h, according to an order-balanced, double-blind, crossover design. Afterwards, the subjects were kept awake for another 8 h, meaning that at the end of the test day subjects had been awake for a mean 25 h. Subjects were instructed to go to sleep and keep a sleep diary on the day and night after each test day. The sleep efficiency (defined as time asleep divided by time in bed x 100%) and Groningen Sleep Quality Scale (GSQS) after modafinil and placebo administration were compared using a Wilcoxon Signed Rank test. **RESULTS:** Median sleep efficiency during the day was 90.3% (IQR 9.7) in the modafinil group, compared to 93.7% (IQR 7.4) in placebo, but this was not statistically significant ($p=0.068$). During the night that followed this was 94.1% (IQR 9.7) and 94.5% (IQR 5.1) respectively, again not statistically significant ($p=0.970$). GSQS scores during daytime sleep was intermediately impaired (GSQS≥3) but did not differ statistically significantly ($p=0.605$) with a median of 4 (IQR 3) in the modafinil group versus 4 (IQR 2.5) in the control group. GSQS scores at night were normal, 2 (IQR 2.75) in the modafinil group versus 2 (IQR 4) in the placebo group respectively, and were not statistically significantly different ($p=0.353$). **DISCUSSION:** In this placebo-controlled study, daytime sleep quality after having been awake for 25 h, was intermediately impaired in both groups. Modafinil did not seem to negatively affect the recovery sleep during daytime compared to the control group. Nighttime sleep afterwards was of normal quality and similar between the two groups. We conclude that the negative effects of modafinil on recovery sleep are limited.

Learning Objectives

1. To determine the (negative) effect of a single dose of modafinil (200 mg) on recovery sleep after extended wakefulness.
2. To assess sleep difficulties in recovery sleep after stimulant use.

[219] SYSTEMATIC REVIEW OF LABORATORY FINDINGS IN EVALUATION OF AIRCREW PERSONNEL

Denis Bron[1], Jonas Mueller[1], Andres Kunz[1], Sibylle Grad[2]
[1]*Aeromedical Centre Swiss Air Force, Duebendorf, Switzerland;* [2]*AO Research Institute Davos, Davos, Switzerland*

(Original Research)

INTRODUCTION: A higher prevalence of back complaints in flying personnel compared to the general population is well documented. Various underlying causes have been described. While standard analysis approaches such as clinical diagnostics, imaging-based evaluation and electrophysiological testing are well established, the role of laboratory analyses is less known. The purpose of this study is to collect information about relevant laboratory parameters, especially bone turnover related angiogenic factors, and to evaluate their potential impact in the analysis of back pain symptoms in flying personnel. **METHODS:** Back complaints status of eighty military pilots and aircrew members have been evaluated during the last two years during their normal health check-ups integrating questionnaires with blood tests aimed at analyzing the following factors: Flt-1, Tie-2, VEGF-C, bFGF. PIGF, VEGF, VEGF-D. The participants were divided in a symptomatic versus an asymptomatic group. **RESULTS:** No significant differences in the values of the assessed factors were found between symptomatic and non-symptomatic air crew members. The values for following factors were however significantly higher [SGRAD1] than the reference values for a normal population: Flt-1, Tie-2, VEGF-C, PIGF, VEGF, VEGF-D. **CONCLUSION:** The results suggest that detection of diseases by analyzing systemic factors may be possible, as the measured values in Aircrew were higher than the reference values. However, the factors do not seem to be related to the symptom presentation. The reason why angiogenic factors are significantly higher in Aircrew compared to the reference values is unclear. Different explanations such as high G loads may play a certain role. What kind of impact this may have in Aircrew is so far unclear. Further analyses are necessary.

Learning Objectives

1. A higher prevalence of back complaints in flying personnel is compared to normal population present.
2. Relevant laboratory parameters, especially bone turnover related angiogenic factors, may have an impact of bone diseases.
3. The study results suggest that detection of diseases by analyzing systemic laboratory factors may be possible.

Tuesday, 05/23/2023 ***4:00 PM***
Napoleon Ballroom D1-D2

[S-42]: PANEL: INTERNATIONAL AEROSPACE NEUROSCIENCE CONSORTIUM- TRAUMATIC BRAIN INJURY

Chair: Joseph Connolly

PANEL OVERVIEW: *Traumatic Brain Injury (TBI) is the most common neurologic condition causing aeromedical disqualification and the pursuit of aeromedical waiver or Special Issuance certification. Aeromedical concerns with TBI are different that with TBI in the general population. Much research and media reports focus on disproportionate morbidity, disability and sequalae of TBI. In aerospace medicine, much of the focus is with aviators who have made a near-complete apparent recovery but may have subtle cognitive residua or a significant seizure risk. Pre-pilot training neurocognitive testing and post-TBI cognitive testing of 60 USAF pilots will be reviewed. We will learn about cognitive and exercise aspects of TBI rehabilitation in DoD aviators and special operations personnel. Brain MRI susceptibility-weighted imaging after TBI will be discussed in terms of prediction of post traumatic seizure risk in Aircrew. The utility of prolonged EEG monitoring in aviators with TBI will be explored regarding future seizure risk. Finally, two controversial aeromedical dispositions following head injury will be presented.*

[220] NEUROCOGNITIVE FUNCTIONING IN USAF PILOTS FOLLOWING TRAUMATIC BRAIN INJURY

Monica Malcein
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Aviation is a cognitively demanding occupation, and any decline in cognitive ability is of significant concern. Following traumatic brain injury (TBI), individuals can experience changes in cognitive functioning that do not always return to baseline. The impact TBI has on cognitive functioning tends to vary across levels of severity of the injury and across individuals. Changes in the areas of attention, concentration, information processing speed, and executive functioning are most commonly seen following TBI. Neuropsychological testing is a required component of the evaluation for return to flying after TBI to determine if functioning has returned to baseline. In highly skilled or highly intelligent and skilled population, identifying subtle changes in cognitive functioning can be difficult. Because pilots represent a unique population with respect to intellectual and cognitive abilities, traditional neuropsychological testing may not reliably detect subtle degradation of these high functioning individuals. For that reason, US Air Force requires medical flight screening (MFS) baseline testing that every pilot completes prior to entry into pilot training. These premorbid measures are useful in the neuropsychological evaluations that occur when pilots are being considered for return to flying duties after medically qualifying diagnosis. **OVERVIEW:** From 2000 to 2022, 61 USAF pilots who had baseline MFS data were seen at the Aeromedical Consultation Service for evaluation of return to flying duties following TBI. They took a measure of intellectual functioning (Multidimensional Aptitude Battery-II,) and a computerized neuropsychological screening exam assessing a number of cognitive domains (MicroCog). Assessment results from these measures completed at clinical evaluation at the ACS following TBI were compared to the baseline testing they completed prior to attending pilot training. **DISCUSSION:** On the MAB, there was no indication of decline across Verbal, Performance or Full-Scale IQ when examining group data for baseline and post-TBI testing. None of the subscales that make up the measure decreased from baseline to post-test. On the MicroCog, there were no significant differences between the baseline scores and those obtained following TBI. When groups were divided into those that sustained a mild, moderate, or severe TBI, no differences in functioning on the MicroCog were seen across severity levels.

Learning Objectives

1. The audience will learn about neurocognitive changes following traumatic brain injury in the aviator population.
2. The audience will understand the contribution of having baseline neurocognitive test data when evaluating pilots following TBI.

[221] OPTIMIZING COGNITIVE FUNCTIONING TO RETURN TO DUTY AFTER MILD TRAUMATIC BRAIN INJURY: LESSONS LEARNED FROM MILITARY MEDICINE

Jason Bailie
Defense Health Agency, Camp Pendleton, CA, United States

(Education - Tutorial/Review)

BACKGROUND: Many individuals who experienced a mild traumatic brain injury (MTBI) begin rehabilitation with the the goal of returning to their prior level of functioning. In certain professions, such as the military and aviation, before a patient who experienced cognitive changes after a MTBI can safely return to duty, we must ensure they can complete cognitively and psychologically demanding operations necessary for national security and public safety. In these instances, the traditional standard of care may not meet the patients' unique treatment needs. In order to optimize outcomes, treatments are needed that can be applied to the unique operational environments and prioritize functional improvement of the warfighter. Specific to cognition, traditional cognitive rehabilitation (TCR) interventions often rely on methods developed for more severe neurological injury and they use compensatory techniques that have little translation to a demanding and kinetic environment where small mental errors can have catastrophic consequences. **TOPIC:** This presentation will review research on cognitive rehabilitation for warfighters and evaluate comparable effectiveness of TCR to an alternative "top down" treatment approach, Strategic Memory Advanced Reasoning Training (SMART). SMART is an evidence-based training protocol that is more closely aligned with the cognitive domains key to warfighter readiness (mental agility, strategic learning, problem solving, focus, and psychological well-being). **APPLICATION:** Results from clinical trials with civilians and veterans indicate that SMART can positively impact cognitive functioning. Preliminary results from a randomized clinical trial with active duty warfighters revealed SMART to have comparable effectiveness to TCR in improving cognitive impairment and it was completed in less than half of the treatment time. SMART resulted in large improvements in mental processing speed, executive functioning, and memory. Rates of abnormal cognitive performance in the sample of warfighters reduced from 50% to 25% after treatment. These results suggest that SMART, or similar top-down treatment programs, can may be more effective at improving successful return to duty than traditional rehabilitation efforts.

Learning Objectives

1. Detail limitations of current techniques for cognitive rehabilitation of service members who have experienced a mild traumatic brain injury.
2. Identify Strategic Memory Advanced Reasoning Training (SMART) as a potential alternative treatment modality for cognitive rehabilitation in military personnel.
3. Describe preliminary results from a randomized clinical trial showing SMART has relative equivalence in improving cognitive performance and can be completed in fewer treatment hours with more relevance to cognitive demands of the warfighter.

[222] MRI SUSCEPTIBILITY WEIGHTED IMAGING AND THE PREDICTION OF POST TRAUMATIC SEIZURES IN AIRCREW

Peter Letarte
Boonshoft School of Medicine-Wright State, Akron, OH, United States

(Education - Tutorial/Review)

BACKGROUND: Post TBI, the presence of blood on intracranial imaging has long been felt to increase the risk of Post Traumatic Seizures (PTS) to a level unacceptable for continuing many flight duties.

Since many of the seminal papers on the risk of PTS after trauma were published, the resolution of intracranial imaging as improved by orders of magnitude. Much of the hemorrhage visible with modern imaging modalities, such as Susceptibility Weighted MRI or late generation CT, were clearly invisible on the imaging at the time many Post-Traumatic Epilepsy (PTE) papers were written. A Radiology reading of intracranial blood in 2023 likely does not mean the same thing as it did when the seminal papers were written. This observation raises a series of questions that will be explored in this presentation. **OVERVIEW:** The estimated size of hemorrhage in the key PTE literature will be presented. A review of the evolution of the sensitivity of intracranial imaging modalities over the last 50 years will be reviewed. SWI MRI will be used as a use case for this discussion. A comparison of the specifications established by the PTE literature and the capabilities of evolving imaging modalities will be made. A brief discussion of the evolution of thinking on Diffuse Axonal Injury (DAI), a similar clinical area where increasing imaging resolution has changed both our thinking about the pathology and our clinical decision making, will be included. **DISCUSSION:** This presentation will raise a series of questions for further study. Does an imaging reading of intracranial blood mean the same thing in 2023 as it did when the seminal papers were written? Is there a critical volume of intracranial blood, below which the seizure risk decreases? Is the presence of intracranial blood a direct cause of Post Traumatic Seizures or is it also a marker of other mechanisms, such as cortical disruption or axonal injury, that also lead to epilepsy. Can new imaging modalities give us insight into these other mechanisms. Are we removing the flight credentials from the correct patient population after a Traumatic Brain Injury?

Learning Objectives

1. The learner will understand that current brain Imaging is able to show us hemorrhages that are much smaller than anything visible when the key papers on post traumatic hemorrhage and epilepsy were written.
2. The learner will understand that the clinical impact of very small bleeds on epileptogenicity and fitness for flight is unknown.

[223] THE ROLE OF EEG AND IMAGING IN ASSESSING THE DEVELOPMENT OF TBI SEIZURES

Joseph Sirven
Mayo Clinic Florida, Jacksonville, FL, United States

(Education - Tutorial/Review)

INTRODUCTION: Traumatic Brain injury is an increasingly common and vexing problem for both pilots and aerospace medicine practitioners. Evaluating fitness for flight from a neurological perspective from TBI continues to be a significant issue with inconsistent application of testing and evidence to individual pilot cases. One of the most crucial concerns is the risk of post traumatic brain injury seizures and epilepsy. Predicting post TBI seizures is often based on EEG and imaging results. This presentation will outline current best evidence for predicting the risk of post traumatic brain injury seizures based on clinical history, imaging and EEG. Specific details to be covered include, type of MRI, type and length of EEG and whether a population of aviators can be identified that are at least risk for seizure development.

Learning Objectives

1. The audience will learn about the roll of EEG in evaluating an aviator with TBI for aeromedical certification.
2. The audience will learn about various MRI findings and post-traumatic epilepsy risk.

[224] TWO CONTROVERSIAL AEROMEDICAL DISPOSITIONS FOLLOWING HEAD INJURY

Aven Ford
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Traumatic brain injury (TBI) is graded as mild, moderate, or severe, based on clinical and imaging characteristics. The severity grades are helpful in predicting clinical outcomes and seizure risks after injury; however, due to changes in imaging modalities and diagnostic tools the classification systems have changed throughout the years, making it difficult to apply older studies on current cases. In this panel presentation two cases that defy easy classification and easy risk assessment. **TOPIC:** The waiting period prior to waiver consideration in pilots that have made a complete clinical recovery is often driven by high-risk imaging findings that are associated with high rates of seizure in the first 2-5 years following injury. The first case to be presented is a cargo pilot who fell while riding a rented electric scooter (unhelmeted). His initial loss of consciousness lasted less than 10 minutes and would be clinically classified as mild. However, his initial head CT had concerning features. When seen by neurology 3 weeks later, he had no complaints and a completely normal neurologic exam. MRI of his brain showed no evidence of previously noted blood products and was read as normal. This case had clinically mild features, CT features concerning for a severe injury, and essentially a normal MRI brain. Where should this pilot be classified and how long should he wait for a waiver? The second case is an RPA (drone) pilot with a head injury secondary to a motor vehicle rollover. His injury was clinically mild, as he had only brief loss of consciousness (LOC) lasting a few seconds and no post-traumatic amnesia (PTA) or other alteration of consciousness (AOC). However, his CT scan performed at the ER showed a depressed left parietal skull fracture. What is the proper observation period for this pilot? **APPLICATION:** This presentation will discuss the appropriate approach to an aviator with complicated traumatic brain injury, focusing on the clinical and imaging classification and the rationale behind waiting periods.

Learning Objectives

1. Discuss the approach to the aviator with various types of head injury.
2. Discuss the appropriate classification of aeromedical-head injury and use that information to guide observation periods prior to waiver recommendation.

Tuesday, 05/23/2023 ***4:00 PM***
Napoleon C3

[S-43]: SLIDES: HYPOXIA POTPOURRI

Chair: Benise Lester
Co-Chair: Rowena Christensen

[225] COGNITIVE AND PHYSIOLOGIC RESPONSES TO NORMOBARIC HYPOXIA VERSUS HYPOBARIC HYPOXIA

Bianca Cerqueira[1], Bria Morse[1], Zachary Kerns[1], Holly Chapapas[1], Pete Ramos[1], Kelly McKay[1], Jeremy Beer[1], Andrew Mojica[1], Megan Gallo[2], Paul Sherman[3]
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(Original Research)

The goal of this study was to compare effects of normobaric hypoxia versus hypobaric hypoxia on physiology and cognitive performance in a limited subject group (n=7). Cognitive performance was evaluated before, during, and after exposure using the SYNWIN multi-task synthetic workstation. SYNWIN assesses short term memory, arithmetic calculations, visual and auditory vigilance, and the executive timesharing required to perform the tasks simultaneously and has been used successfully to assess cognitive performance in hypobaric hypoxia conditions. The study included two "flights" per subject – hypobaric hypoxia (altitude chamber at 25,000 ft with no supplemental oxygen) and normobaric hypoxia (sitting in the altitude chamber breathing from the reduced oxygen breathing device set to hypoxia equivalent of 25,000 ft). Physiologic metrics included heart rate, SpO_2, and respiration metrics including rate and depth of breathing, minute ventilation, and the composition

of respiration gases, transcranial Doppler cerebral blood flow within the middle cerebral arteries, serum cytokine analysis, and blood miRNA sequencing. Epochs for analysis included 1) Ground Level, 2) Pre-Breathe, 3) 25k feet altitude or "ROBD 25k" including ascent time, and 4) Recovery. We found a significant effect of epoch on SYNWIN composite score with overall performance lower in the hypobaric condition. Within the physiology/oximetry metrics, we found significant effect of epoch on heart rate and heart rate spiked more in the hypobaric condition compared to normobaric condition. SpO_2 measures mirrored heart rate, with SpO_2 dipping more in hypobaric conditions. Blood analysis found that hypobaric hypoxia increased serum levels of Chemokine ligand 13, also known as B lymphocyte chemoattractant (BLC (CXCL13)) and Chitinase-3-like protein 1 (YKL-40 (CHI3L1)) compared to normobaric hypoxia. The effectiveness of aircrew training depends on the explicit assumption that inducing altitude-equivalent hypoxia effects via ROBD, physiologically and cognitively, is directly equivalent to hypobaric exposure as experienced in the cockpit. Our results suggest that in a limited dataset, cognitive and physiologic responses to normobaric hypoxia differ from those resulting from hypobaric hypoxia. This data can be used to inform decisions on aircrew training protocols and to determine the effectiveness of Altitude Physiology curricula primarily employing ROBD hypoxia exposures as opposed to hypobaric hypoxia.

Learning Objectives

1. The audience will learn that heart rate increases more during hypobaric exposure compared to normobaric hypoxia.
2. The audience will learn that oxygen saturation decreases more during hypobaric exposure compared to normobaric hypoxia.
3. The audience will learn that cognitive performance is affected more during hypobaric hypoxia compared to normobaric hypoxia.

[226] HYPOXIA TOLERANCE PREDICTORS

Barak Gordon, Idan Nakdimon, Oded Ben-Ari, Uri Eliyahu, Assaf Glass
Israeli Air Force, Ramat Gan, Israel

(Original Research)

INTRODUCTION: Hypoxia may be induced by either cabin pressure failure or oxygen system malfunction during flight. Personal tolerance will determine performance level under hypoxic conditions. Tolerance for hypoxia can be tested during altitude chamber training sessions, designed to expose aircrew to hypoxic conditions in a controlled setting. The aim of this study was to examine the influence of different parameters on hypoxia tolerance. **METHODS:** During altitude chamber training sessions participants reached simulated altitude of 25,000 feet (7,620 meters) and were exposed to oxygen partial pressure of 59.2mmHg. At this altitude they took off their oxygen masks in order to recognize their personal symptoms of hypoxia. Hemoglobin saturation level was measured at 10 second intervals until oxygen mask was returned. **RESULTS:** We retrospectively analyzed the records of 167 trainees. Mean age was 24.5±4.9, and 22 were women (13.2%). Lower hypoxia tolerance was significantly and independently correlated in men with hemoglobin level below 13.9gr/dL (p=0.01), nonsmoking (p=0.01), and BMI below 20.6kg/m^2 (p=0.03). Age, gender, and physical activity were not found to be correlated with hypoxia tolerance. **DISCUSSION:** Aircrew with hemoglobin level under 13.9 gr/Dl should perform ROBD training instead of altitude chamber training for exposure to hypoxic conditions in order to improve the safety of the trainee. Aircrew with BMI under 20.6 kg/m^2 should be aware of their lower resistance to hypoxic conditions, and therefore for their higher risk during pressurization or oxygen system failure.

Learning Objectives

1. Hemoglobin level, smoking and BMI may predict tolerance to hypoxia.
2. High risk trainees and mitigating measures should be implied during altitude chamber training.

[227] MEASURING ARTERIAL OXYGEN SATURATION USING WEARABLE DEVICES UNDER CONDITIONS RELEVANT TO THE FLIGHT ENVIRONMENT: A PRELIMINARY STUDY

Thomas Smith, Eleanor Hearn, Jack Byford, Christopher Wolfe, Cheryl Agyei, Peter Hodkinson, Ross Pollock
King's College London, London, United Kingdom

(Original Research)

INTRODUCTION: Pilots are increasingly flying with wearable monitoring devices ('wearables') that can provide arterial oxygen saturation (SpO_2) measurements. It is therefore important to establish whether these wearables determine SpO_2 reliably under conditions associated with the flight environment such as environmental hypoxia and concurrent body motion. The aim of this study was to conduct an initial evaluation of wearables under these conditions and generate preliminary results to provide a basis for further definitive studies. The hypothesis was that the performance of wearables in measuring SpO_2 would be the same as that of a standard pulse oximeter. **METHODS:** Ten healthy participants (six men and four women) were studied breathing air and breathing 11.8% oxygen in a normobaric chamber (≈ 15,000 ft equivalent altitude). SpO_2 was measured using two consumer-grade wearable devices (Apple Watch Series 6 and Garmin Fēnix 6 watch) and two wearables designed for clinical use (Cosinuss° Two in-ear sensor and Oxitone 1000M wrist-worn pulse oximeter). Data was collected while stationary at rest, during very slight body motion, and during moderate body motion, and was compared with simultaneous measurements from a standard pulse oximeter. Standardized body motion was induced by cycling on an ergometer at very low intensity (30W) and moderate intensity (150W) respectively. **RESULTS:** 'Missed readings', defined as failure to record an SpO_2 value within one minute, occurred commonly with all four wearable devices. Even in the presence of only very slight body motion, most wearables missed most readings (percentage of missed readings ranging from 12-82%). The percentage of missed readings increased with increasing body motion, ranging up to 20% at rest, 82% during very slight body motion, and 95% during moderate body motion. When values were successfully obtained, the wearables tended to under-report (one device) or over-report (three devices) SpO_2, and this was generally exacerbated under hypoxic conditions. **DISCUSSION:** The four wearable devices studied did not perform to the same standard as a traditional pulse oximeter. This could have important implications in safety-critical operations and, until further data are forthcoming, these preliminary results indicate a need for caution regarding the use of wearables for in-flight SpO_2 monitoring.

Learning Objectives

1. The audience will learn about recently-developed wearable monitoring devices that can be used to measure arterial oxygen saturation.
2. The audience will learn about the possible limitations of using wearables for arterial oxygen saturation monitoring during flight operations.

[228] RISK OF DECOMPRESSION SICKNESS IN JUMPMASTERS DURING HIGH-ALTITUDE MISSIONS

Rickard Ånell, Frode Gottschalk, Antonis Elia, Mikael Gennser, Ola Eiken
Swedish Aerospace Physiology Centre, Division of Environmental Physiology, Stockholm, Sweden

(Original Research)

INTRODUCTION: Military parachute operations, with drop of troops or equipment, are often performed at very high altitude, and without pressurization of the parachuter/cargo compartment. Present Swedish Airforce regulations permit exposure of the jumpmasters/loadmasters (JM) to altitudes up to 11000 masl (36000 ft), and the JMs are regularly exposed to 29500 ft for 60 min. Anecdotal information suggests that the JMs may experience decompression sickness (DCS) during such

high-altitude exposures. The aims of this study were to investigate (*i*) the risk of DCS during a simulated JM mission at high altitude and to (*ii*) compare two strategies of pre-oxygenation, conducted either at sea level before take-off or during ascent to mission altitude. **METHODS:** Ten JM were examined in a hypobaric chamber on two separate occasions, both during which they were breathing 100% oxygen during 60 min at 28000 ft, after 45 min of pre-oxygenation. In condition N, the pre-oxygenation was performed at sea-level, whereas in condition (H), pre-oxygenation was performed at 8200 ft. The degree of decompression strain was determined from ultrasound-derived assessment of the presence of venous gas emboli (VGE), using a 6-graded scale (0-5). **RESULTS:** During the exposure to 28000 ft, 2 JMs experienced DCS in condition H and none in condition N. The prevalence of VGE was higher in the H than the N condition, both at rest, median range (3.3 (0-4) vs 0 (0-4); $p<0.04$) and after weighted squats (3.7 (0-4) vs 0 (0-4); $p<0.01$). **CONCLUSIONS:** A preoxygenation/altitude procedure commonly used by Swedish military jumpmasters, with a 1-hr exposure to 28000 ft after pre-oxygenation for 45 min at 82000 ft is associated with high risk of DCS. It appears that the risk can be reduced if the pre-oxygenation is conducted at sea level. Presumably, the increased decompression strain after preoxygenation at altitude, reflects a stabilization of micronuclei by Boyle expansion.

Learning Objectives

1. The participant will be able to understand the risk of decompression sickness at high altitude missions even within regulated exposures.
2. The participant will be able to understand the increased risk of Decompression Sickness when preoxygenating in lower ambient pressure compared to sea level.

[229] CHALLENGES IN THE DIFFERENTIATION OF ATAXIA AND CONFUSION IN A PATIENT AT HIGH ALTITUDE

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(Education - Case Study)

INTRODUCTION: This case report describes a high-altitude hiker who develops nausea, ataxia, and acute confusion at a remote point without immediate EMS access. A decision was made to instead complete the ascent to access EMS care at the summit and then initiate a faster, safer descent. **BACKGROUND:** Increasing interest in extreme sports has prompted more high-altitude and remote travel, often without sufficient acclimatization or recognition of the risks of altitude-associated illnesses (e.g. Acute Mountain Sickness (AMS), High Altitude Pulmonary Edema (HAPE), and High Altitude Cerebral Edema (HACE)). Diagnosis and management of these conditions is challenging, particularly in austere environments or for those who have not encountered them. **CASE PRESENTATION:** A 25-35-year-old individual presented with bitemporal mild/moderate headache following gradual ascent to 11,000′. Despite oral NSAIDs, the headache worsened to severe intensity with associated nausea, ataxia, and acute confusion by 13,000′. The patient had consumed 5L of water without electrolytes and minimal solid food over 5 hours. Symptoms did not resolve despite electrolyte and glucose consumption following illness onset. Given medical care availability and road access at the summit, the hiking party continued its ascent to >14,000′ and notified EMS. Upon EMS arrival, the patient was confused, ataxic, had cool edematous extremities, and exhibited hypoxia that resolved with oxygen via nasal cannula. Ataxia resolved after descending 3000′, but nausea and headache persisted despite anti-nausea medications. After completing the descent and presenting to the Emergency Department (7000′ total descent to 6000′ above sea level), symptoms of ataxia, confusion, and hypoxia resolved completely. Electrolytes were found to be within normal limits, and non-contrast head CT showed no evidence of increased intracranial pressure or cerebral edema. Given concern for HACE, the patient was discharged with oral Dexamethasone and Acetazolamide and advised to temporarily avoid exposure to increased altitudes. **DISCUSSION:** Hyponatremia, hypoglycemia, and HACE may have overlapping symptoms, but all cases of altered mental status at altitude must be assumed to be HACE and treated with immediate descent if able. We discuss risk factors, decision-making in austere environments, and management including medications, complications, temporary altitude restrictions, and risk management for future high-altitude travel.

Learning Objectives

1. The audience will learn about the clinical diagnosis of and management for common high altitude illnesses, including Acute Mountain Sickness (AMS), High Altitude Pulmonary Edema (HAPE), and High Altitude Cerebral Edema (HACE).
2. The audience will be able to understand the decision-making processes for evacuation in austere environments without EMS access for rapid descent.
3. The audience will learn about travel planning processes to mitigate medical risk before, during, and after high altitude exposures, especially for participants with elevated risk factors to develop high altitude illnesses and their complications.

[230] NORMOBARIC HYPOXIA SYMPTOM RECOGNITION IN THREE RECURRENT TRAINING SESSIONS

Antti Leinonen[1], Nikke Varis[2], Hannu Kokki[3], Tuomo Leino[4]
[1]*University of Eastern Finland, Hollola, Finland;* [2]*Tampere University, Tampere, Finland;* [3]*University of Eastern Finland, Kuopio, Finland;* [4]*National Defense University, Helsinki, Finland*

(Original Research)

INTRODUCTION: In-flight physiological episodes compromise flight safety. Hypoxia training is mandatory for military pilots worldwide. Our previous study shows that only 64% of pilots recognize hypoxia faster in their 2nd normobaric hypoxia (NH) training compared to the first NH training. Our aim of the present study was to evaluate if the 3rd NH training session would enhance hypoxia recognition. **METHODS:** This study was conducted under normobaric conditions in a tactical F/A-18C Hornet simulator in three training sessions. The pilots performed visual identification missions and breathed 21% oxygen in nitrogen. Blinded to the pilot, the breathing gas was changed to a hypoxic mixture containing either 8%, 7% or 6% oxygen in nitrogen. Data were collected from 102 pilots from the Finnish Air Force (101 males and 1 female). The peripheral capillary oxygen saturation and the time taken to notice hypoxia symptoms were measured as the primary outcome parameters. The study was approved by the Committee on Research Ethics of the University of Eastern Finland, Joensuu, Finland (no. 24/2018). The study had the institutional approval of the Defense Command Finland. **RESULTS:** Hypoxia symptoms were recognized in the 1st training session with 8% O_2 in 101 s, with 7% O_2 in 91 s and with 6% O_2 in 78 s. In the 2nd training significantly faster, in 88 s, 80 s, and 72 s, and in the 3rd training in 80 s, 70 s, and 66 s, respectively. However, 24% of the pilots recognized hypoxia symptoms slower during the 3rd session compared to the 1st session. There was a large between-individuals variation in hypoxia symptoms recognition. **DISCUSSION:** Hypoxia symptom recognition time was improved the further the training went. The 3rd training further enlarged the group that improved their recognition time. More emphasis should be put on the group of slow hypoxia symptom recognizers and offer more individualized hypoxia training for this group on an annual basis.

Learning Objectives

1. The audience will understand the benefits of repeating normobaric hypoxia training.
2. The audience will understand that hypoxia training does not benefit all equally good and individual training should be held to gain more knowledge for all pilots.

WEDNESDAY, MAY 24, 2023

Wednesday, 05/24/2023 ***8:30 AM***
Grand Ballroom A-B-C

[S-44]: PANEL: COORDINATED NASA APPROACH FOR THE DEVELOPMENT OF MEDICAL CAPABILITIES AND TECHNOLOGIES FOR DEEP SPACE EXPLORATION

Chair: Kris Lehnhardt
Co-Chairs: Rahul Suresh, Moriah Thompson

PANEL OVERVIEW*: Building upon the success of the last two decades of human spaceflight medical operations onboard the International Space Station (ISS), NASA now must start to evolve to a deep space medical operations paradigm. This new paradigm will include myriad challenges such as communication delays and blackouts, infrequent or unavailable resupply opportunities, potentially significant vehicle resource constraints, and delayed or non-existent evacuation options. To overcome these challenges, two separate but highly coordinated NASA groups are working together to develop and test solutions to these problems: the Exploration Medical Capability (ExMC) Element of the NASA Human Research Program and the Exploration Medical Integrated Product Team (XMIPT) of the Environmental Control and Life Support System – Crew Health and Performance Systems Capability Leadership Team. Although the work of these two groups is very complementary, ExMC generally focuses more on research and early technology development work while the XMIPT works on maturing and integrating new medical capabilities for exploration. During this panel, these two groups together will present details on how medical capability gaps are defined and addressed, a new work plan in development to increase medical autonomy in spaceflight, a technology maturation effort to generate intravenous fluids from potable water onboard a spacecraft, multiple new technology demonstrations of in-situ laboratory analysis capabilities, and new onboard tools to advance medical care for deep space missions.*

[231] IDENTIFYING AND CLOSING MEDICAL CAPABILITY GAPS FOR HUMAN SPACEFLIGHT MISSIONS BEYOND LOW EARTH ORBIT

Moriah Thompson, Kris Lehnhardt, Ben Easter, Jay Lemery, Rahul Suresh
NASA, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Features of human space missions beyond low Earth orbit such as increasing distance from Earth, lack of real-time communication, and limited or no evacuation or resupply capability are expected to drive an increase in medical risk and require crews to operate in an increasingly autonomous fashion. A diverse set of stakeholders at NASA are seeking to fund the development of concepts of operations, medical requirements, and medical capabilities for such missions. However, a systematic approach to identification of current medical capability gaps and a strategic framework to gap closure is needed. **OVERVIEW**: The Exploration Medical Integrated Product Team (XMIPT) has developed a list of eight high-level medical capability gaps and associated activities required for gap closure. The list was derived based on inputs from subject matter experts at NASA including flight surgeons, other clinical providers, as well as operational and research communities regarding medical capabilities required to support humans' mission to the Moon and Mars surface. Responses were reviewed and distilled to identify common themes across capabilities. To ensure alignment with established human system risks, the gap list was further refined based on inputs from NASA's Human System Risk Board. Relevant medical gap closure activities outside of those funded by the XMIPT were identified through solicitation of inputs from Elements of NASA's Human Research Program (particularly Exploration Medical Capability), the broader medical operations community, and other stakeholders. This medical capability gap list is reviewed and updated regularly as new information becomes available or new stakeholders are identified. **DISCUSSION**: The medical capability gap list has matured to include a large group of NASA stakeholders and development activities. This has enabled articulation of priorities to funding entities and programmatic stakeholders, while serving as an accessible resource summarizing gap closure activities, relevant programmatic infusion points, and opportunities for collaboration between stakeholders. This presentation will provide an overview of the eight NASA medical capability gaps and their associated gap closure activities.

Learning Objectives

1. Understand the ways in which human exploration missions to Mars will increase medical risk relative to missions to low Earth orbit.
2. Describe the benefits of a medical capability gap list for exploration missions.

[232] EARTH INDEPENDENT MEDICAL OPERATIONS-FOUNDATIONS TO ADVANCE LONG DURATION MISSION HEALTH

Jay Lemery, Kris Lehnhardt, Ben Easter
NASA Exploration Medical Capabilities, Houston, TX, United States

(Education - Program/Process Review)

BACKGROUND: Earth Independent Medical Operations (EIMO) embodies a novel approach for long duration mission medical operations and will necessitate new innovations as well as draw upon validated work to support autonomous medical systems. **OVERVIEW:** Defining parameters of EIMO include limited medical resources with few resupply opportunities; communication disruptions; and few windows for evacuation. EIMO is an emerging paradigm to advance integrated, autonomous medical systems to optimize human health and performance for long-duration missions. For many years, ExMC has endeavored to augment the capacities of in-flight providers as well as ground-based support. Here we outline these constituent efforts which provide a foundation for integration into future EIMO work. **DISCUSSION:** For years, ExMC has embraced a multi-pronged strategy to advance autonomous medical operations. In so doing, it has established a foundational body of work to inform the future EIMO work for long-duration missions. We cite the following as examples: *Autonomous Medical Officer Support* (AMOS) demonstrated ultrasound performance by non-medical crewmembers without real-time ground support. The codification of *Identification of Medical Training Methods for Exploration Missions* provided an inventory of augmented capacities to astronauts with limited medical training. Point of care laboratory testing and in-situ medical analysis were performed through validated devices (ex: *rHealth and Hemocue*), and validated real time serologic and pharmacologic testing. Successful demonstrations of inventory management/medical consumables tracking and in-situ IV fluid generation provided evidence of enhanced capabilities and resources. The Tempus-ALS monitor demonstrations, utilizing medical scenarios to validate integrated diagnostics in the form of patient monitoring and ultrasonography provides proof-of-concept for rapid crew access to data from all on-board systems, leading to better-informed, real-time, autonomous decisions. Finally, the clinical decision support work supported by ExMC (including concept of operations and data architecture/requirements) has yielded invaluable insights into autonomous systems and has served as a stepping stone to a fully integrated data architecture. As the imperative to develop EIMO will accelerate in the near term, 'lessons learned' from disparate and historic ExMC efforts will be critical in taking this next step for long duration spaceflight.

Learning Objectives

1. Understand the constituent efforts which will inform the work of EIMO.
2. Understand the strategy and rationale for the novel paradigm of EIMO.
3. Understand the challenges of health and wellness for long duration spaceflight.

[233] PRODUCING STERILE IV FLUIDS ON THE INTERNATIONAL SPACE STATION: INTRAVENOUS GENERATION MINI (IVGEN MINI) PROJECT

Courtney Schkurko[1], Rahul Suresh[2], Moriah Thompson[2], Tyler Hatch[2], Alexandru Mezin[3], Alex Salimian[3], Brian Hromco[3]
[1]*NASA Glenn Research Center, Cleveland, OH, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*ZIN Technologies, Middleburg Heights, OH, United States*

(Education - Program/Process Review)

BACKGROUND: Expiration dates of commercially available IV fluids are shorter than the anticipated duration of a Mars surface mission and the volume needed to meet medical needs may be limited by mass and volume constraints. Production of medical grade IV fluids from the potable water supply of an exploration vehicle or habitat would reduce medical risk and the mass and volume footprint of the medical system. In 2010, the Exploration Medical Capability Element of NASA's Human Research Program funded the Intravenous Fluid Generation (IVGEN) International Space Station flight demonstration that produced two 1.5 L bags of sterile IV fluids from vehicle potable water. **OVERVIEW:** NASA's Exploration Medical Integrated Product Team is funding the IVGen Mini project to miniaturize the original IVGEN, increase the technology readiness level (TRL) of the system to 6, and conduct a flight demonstration. The design features inlet ports for vehicle potable water and 26% concentrated saline solution. These are pumped through the Fluid Generation Module via electrically driven peristaltic pumps. In this module passive mixing of fluids is performed to create 0.9% normal saline. Inline conductivity and flow sensors provide feedback control to achieve appropriate saline concentrations. Fluid then travels through the Filter Box Assembly where deionization occurs and filters remove bacteria, endotoxins, air and sterilize the solution. The final product is collected in a sterile 1 L bag. The unit is designed to operate on battery power. Two batches of ten 1 L bags will be produced inflight three months apart to assess the robustness of the system and its consumables. Some IV fluid will be returned to Earth and analyzed to determine compliance with U.S. Pharmacopeia standards for IV fluids. **DISCUSSION:** Compared to the IVGEN, the current design reduces system mass and volume, eliminates the need for gaseous nitrogen, a pressure chamber, or a dedicated mixing mechanism, increases fluid volume produced, enables portability by enabling the ability to operate on battery power, and allows rapid changeout of system consumables (Filter Box Assembly). Additional development efforts to mature the system to TRL 7 include inflight battery testing, radiation hardening of components, and further miniaturization.

Learning Objectives

1. Understand the IVGEN Mini design and how it enables production of sterile intravenous fluid in a microgravity environment using available vehicle resources (i.e., potable water, electricity).
2. Describe how the current IVGEN Mini design differs from the original IVGEN hardware flown by the NASA Human Research Program in 2010.

[234] AN IN-SITU LABORATORY ANALYSIS CAPABILITY FOR EXPLORATION SPACEFLIGHT

Courtney Schkurko[1], Gail Perusek[1], Emily Nelson[1], Kimesha Calaway[2], Rachael Miller[2], Russell Valentine[2], Brian Crucian[3], Benjamin Easter[3], Kris Lehnhardt[3]
[1]*NASA Glenn Research Center, Cleveland, OH, United States;* [2]*ZIN Technologies, Middleburg Heights, OH, NASA;* [3]*NASA JSC, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: Point-of-care medical diagnostic technology has been identified by NASA as a critical need for future human space exploration to enable diagnosis, monitoring, and treatment of spaceflight medical conditions. Future deep-space exploration missions will entail unprecedented and complex challenges including limitations in mass, volume, power, and consumables, and an inability to return biological samples back to Earth for analysis. Exploration Laboratory Analysis (ELA) technology maturation and in-space demonstrations of candidate technologies are needed for the development of exploration medical systems that will optimize crew health and performance monitoring. **OVERVIEW:** The Exploration Medical Capability (ExMC) Element of the NASA Human Research Program has developed a Concept of Operations and set of recommended requirements for an Exploration Laboratory Analysis capability. Recently, ExMC has demonstrated two commercially available portable analyzers that underwent minor modifications in order to function in the spaceflight environment of the International Space Station (ISS). In 2021, a five-part differential white blood cell analyzer provided the first-ever whole blood analysis capability in spaceflight, and the subsequent successful demonstration of a more comprehensive biomarker analyzer in 2022 proved out this critical in-situ analysis capability. In the future, ELA technologies will help to enable crew medical autonomy by providing broad capabilities for measurement of cells, cell counts, biomarkers, microorganisms, electrolytes, and enzymes – ideally with minimal consumables, and minimal biological sample volume - for a variety of sample types including blood, urine, sweat, and saliva. These technologies will need to meet acceptable clinical standards for accuracy and precision, as well as higher-level certification standards and/or applicable international standards. **DISCUSSION:** ELA technologies will enable astronauts on deep-space missions to diagnose, monitor, and treat spaceflight medical conditions in-situ without the need for biological sample return. This presentation will outline the ELA Concept of Operations, an overview of the recommended requirements necessary for an ELA exploration medical capability, and the results of the recent successful technology demonstrations on the ISS of two modified commercial laboratory analyzers.

Learning Objectives

1. Understand the need for an Exploration Laboratory Analysis (ELA) capability and how it enables point of care diagnostics, monitoring, and treatment and its role in advancing medical system design for exploration beyond low-Earth orbit.
2. Discover how recent successful ISS technology demonstrations flown by the NASA Human Research Program of modified commercial laboratory analyzers contribute to an enhanced understanding of recommended medical system requirements and increase technology readiness.

[235] IDENTIFYING TECHNOLOGIES FOR EXPLORATION MEDICAL SYSTEMS – THE MEDICAL EXPLORATION DEVELOPMENT AND IMPLEMENTATION SCOPING (MEDISCOPE) PROJECT

Rahul Suresh[1], Moriah Thompson[1], Courtney Schkurko[2], Alexandru Mezin[3], Tyler Hatch[2], Alex Salimian[3]
[1]*NASA, Houston, TX, United States;* [2]*NASA, Cleveland, OH, United States;* [3]*ZIN Technologies, Middleburg Heights, OH, United States*

(Education - Program/Process Review)

BACKGROUND: Exploration missions to Mars will require increasing crew autonomy and independence to account for communication delays and loss of real-time ground support. Medical system design and concepts of operations will need to be redefined to transition activities currently managed by the ground onto the vehicle and crew. Meanwhile, commercial industry, both in and out of the healthcare sector, has seen significant investment and development in "smart" systems designed to enable various modes of autonomous operations. **OVERVIEW:** NASA's Exploration Medical Integrated Product Team (XMIPT) developed and maintains a list of capability gaps identifying the necessary, but currently unrealized, capabilities for these mission concepts. The MEDIScope project sought to determine stakeholder requirements and identify candidate technologies for three of these capability gaps: an Automated Medical Inventory System (AMIS), a Multifunctional Integrated Medical Device (MIM Device), and an

Exploration Electronic Health Record (xEHR). Concepts of operations and functional requirements were developed by the project team and refined with inputs from internal stakeholders at NASA Johnson Space Center. These proposed concepts were then used to inform a market survey with an expressed goal of assessing the feasibility of utilizing commercial-off-the-shelf (COTS) items to provide these capabilities. **DISCUSSION:** The MEDIScope project enabled development and refinement of the concepts for these capabilities and reviewed commercially available technologies that might make those systems possible. This paper will introduce some of the operational concepts assessed as a part of this effort and will discuss some of the evaluation criteria, challenges, and opportunities associated with utilizing COTS items for exploration medical system development.

Learning Objectives

1. Describe three key medical capabilities identified by XMIPT to enable an exploration medical system.
2. Understand the opportunities, challenges, and figures of merit of medical commercial-off-the-shelf products for spaceflight.

Wednesday, 05/24/2023 ***8:30 AM***
Grand Ballroom D-E

[S-45]: PANEL: PLANNING COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

Chair: Talib Ali
Co-Chairs: Jason Burchett, Douglas Files, Paul DeFlorio

PANEL OVERVIEW: *Background: In addition to practicing clinical medicine flight surgeons perform a variety of operational and administrative tasks. Overview: The current panel will discuss how flight surgeons perform shop visits, work with fatigue countermeasures, prepare human factors briefings and perform food and water safety visits. Discussion: This panel will present recent information on recommended practices in performing non-clinical aerospace medicine tasks. Flight surgeons and other participants from different backgrounds will compare and contrast what they have learned. Through this process U.S. Air Force flight surgeons will complete requirements of the Comprehensive Medical Readiness Program for flight surgeons.*

[236] PLANNING FATIGUE COUNTERMEASURES

Russell Turner, Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Professionals working in aerospace medicine may be expected to improve aviator performance. One important consideration in this area involves the use of medication to improve operator performance. Flight surgeons may prescribe hypnotic medications to help aviators sleep prior to a sortie and in special circumstances stimulants to improve performance during certain phases of flight. The current presentation will remind aerospace medicine professionals about sleep hygiene and the use of performance-enhancing medication in military aviators. **OVERVIEW:** Practitioners of aerospace medicine study physiologic effects and the potential risks of flight. In order to improve individual well-being and mission completion flight surgeons sometimes prescribe medication for use. Hypnotic medications may assist aircrew to sleep prior to a mission while other medications improve pilot alertness during critical phases of flight. This program will update flight surgeons and other participants on medical and other fatigue countermeasures. **DISCUSSION:** U.S. military forces often require annual training regarding the use of performance enhancing medication which this session can provide. Many other services also stress sleep hygiene issues and use performance-enhancing medication. This program will demonstrate potential techniques and will renew participants' requirements for the Comprehensive Medical Readiness Program (CMRP).

Learning Objectives

1. Discuss several features of using non-pharmacologic measures for military operations.
2. Consider pharmacologic vs. non-pharmaceutical measures for fatigue avoidance in operational settings.
3. Renew Comprehensive Medical Readiness Program (CMRP) requirements for the flight surgeon career field.

[237] PLANNING THROUGH WORKSITE SHOP VISITS

Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Professionals in aerospace medicine maintain the well-being of various populations supporting flying missions. Performing worksite shop visits – particularly in concert with industrial hygienists - offer one method of achieving this goal. The current presentation will help aerospace medicine practitioners to maintain currency by participating in simulated shop visits. **OVERVIEW:** Frequent alteration of standards presents a challenge for professionals to maintain currency in readiness areas. The current program will update aeromedical professionals on how to perform various types of shop visits. Participants will participate in virtual shop visits and also discuss what to seek when at the worksite. **DISCUSSION:** Different types of shop visits may be performed by occupational health specialists as part of their attempts to improve the safety of employee populations. These shop visits are common practice in military and civilian settings. Participants will converse about the latest guidelines and techniques for performing a shop visit as well as the importance of shop visits to worker health.

Learning Objectives

1. Discuss useful practices for various types of shop visits with other participants.
2. Consider with other participants any updates on the flight medicine task of performing shop visits as part of an overarching occupational medicine program.
3. Renew and review USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (CMRP).

[238] PLANNING HUMAN FACTORS BRIEFINGS

Jeffrey Lawson, Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Professionals in aerospace medicine prepare and present briefings regarding safety, human factors, and other health topics to aircrew. The current presentation will aid professionals in sustaining readiness by participating in virtual human factors briefings. **OVERVIEW:** Commonly military flight surgeons present medical talks to aviators. These briefings occur during safety meetings, initial flying training or even after aircraft crashes. The current program will allow participants to review best techniques for flight surgeons to present human factors topics by providing an opportunity for individuals to prepare human factors briefing scenarios. **DISCUSSION:** One role aeromedical providers fulfill in the aviation community is to promote health and safety in aviation communities. The U.S. Air Force has decided that currency in human factors briefings should be performed on a recurring basis. Other services have similar recurring requirements. Attendees will discuss how to improve briefing styles.

Learning Objectives

1. Discuss aircraft mishap issues and how to brief aircrew about flying hazards.
2. Consider recommended and best practices regarding briefing styles and content.
3. Renew USAF requirements within the flight surgeon Comprehensive Medical Readiness Program (CMRP).

[239] PLANNING FOOD AND WATER SAFETY

Mary Brueggemeyer, Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: It commonly forms part of aerospace medicine professionals' duties to participate in public health and preventive medicine operations. Performing sanitation or food/water vulnerability assessments are some of the tasks they are asked to complete. The current presentation will help aerospace medicine professionals to maintain currency by participating in a virtual food or water vulnerability inspection. **OVERVIEW:** One responsibility aerospace medicine professionals take on is looking out for the safety and well-being of their assigned populations. Flight medicine experts commonly perform sanitation assessments in order to ensure flying safety and military mission completion. The present program will update aeromedical and allied professionals on sanitation and food/water vulnerability inspection issues through participants engaging in virtual inspections regarding water safety or epidemiology. **DISCUSSION:** Sanitation site visits involving food and water sources should be performed regularly at airfields and other workplaces. Any gaps in these areas can severely obstruct mission completion and flight safety. The current program will give preventive medicine personnel a chance to discuss the latest guidelines in how to perform these inspections with experts. International colleagues will gain insight into United States food standards and how performing these inspections might improve aviation health in their own countries. Professionals from all disciplines will benefit from these sanitation inspection cases.

Learning Objectives

1. Relate new information regarding food and water safety, with a focus on military settings.
2. Consider and discuss solid practices regarding virtual and real sanitation visits.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

Wednesday, 05/24/2023 ***8:30 AM***
Grand Chenier

[S-46]: PANEL: EVOLUTION OF CLINICAL CONTRIBUTIONS OF WOMEN IN OPERATIONAL MISSIONS IN AEROSPACE MEDICINE:LESSONS ON LEADERSHIP

Sponsored by Aerospace Nursing and Health Professionals Society

Chair: Marian B. Sides
Co-Chairs: Mary Cimrmancic, Allen Parmet

PANEL OVERVIEW: *This panel is the third annual event of the Mary F. Foley Endowment. The fund was established in her honor to perpetuate her passion and lifetime career in profiling exceptional women in aerospace medicine, and to encourage other women to follow in her footsteps. Presenters will portray the dynamics of leadership of women through clinical contributions in operational missions, who broke barriers in their fields, and who distinguished themselves by persevering through adversity, courage, and determination. Their qualities and virtues through their profession journeys will be highlighted The first presentation will profile Florence Nightingale, a nurse during the Crimean War, who cared for disease infested British soldiers, introduced the concept of sanitation, elevated the principles of public health to national attention, creating the foundation for the profession of nursing. She is followed by the recognition of Major Margaret C. McDonald, Matron-in-Chief, Canadian Army Nursing Services, nursing pioneer, historical figure in the Canadian Expeditionary Force, highest ranking woman in the British Empire WWI. The panel will highlight the heroic bravery of Lieutenant Mary T. Klinker, Air Force flight nurse, on board the C-5 Galaxy, Operational Babylift, who died in its crash during takeoff, while carrying over 180 helpless and terrified Vietnamese orphans to the USA. Presenters will honor Major Sandy Nestor, medevac nurse, USA, in Afghanistan, post "Dustoff," featuring Forward Surgical Teams and Cross-Disciplinary Critical Care Air Transport Teams, optimizing patient care in most extreme environments. Panel will also profile Dr. Elizabeth Bridges, nurse scientist, whose research enroute and whose combat casualty care illuminated our scientific knowledge base about the impact of the aerospace environment on patient care. The panel will culminate with a tribute to Cathy Dibiase, clinical nurse for NASA, by profiling her operational contributions, clinical research and substantial leadership during the U.S. Shuttle era. Cathy provided pre-flight and post-flight recovery care to astronauts during missions to and from the International Space Station. Leadership styles and unique qualities of these women pioneers will be discussed and how they navigated adversity and challenges will be recognized. This panel will offer illuminating insights, inspiration and mentoring opportunities in leadership development for the AsMA membership.*

[240] FLORENCE NIGHTINGALE

J. Karen Klingenberger
U.S. Air Force, Williamsburg, VA, United States

(Education - Tutorial/Review)

Florence Nightingale was known as the 'Lady of the Lamp' and founder of modern nursing. She was also an effective leader in the face of adversity, a statistician, epidemiologist, logistician and prolific author who influenced the founding of medical schools for military physicians. Florence Nightingale, born into Britain's social elite, was vigorously educated at home. Nightingale challenged society's strictures to take up the masculine vocation of nursing. She taught herself nursing principles, attended the ill and, received four months of medical training at the institute at Kaiserswerth-am-Rhein in Germany. In 1854, in her middle thirties, she traveled to Turkey, to care for British soldiers fighting the Russians in the Crimea. With a mere 38 nurses under her, she provided medical care to a seemingly endless stream of troops wracked by frostbite, gangrene, and dysentery, that were crammed into 4 miles of beds not 18 inches apart. Her own quarters were cramped and infested with rodents and vermin. During January and February of her first winter, Nightingale saw 3,000 of the soldiers die, while she worked 20 hours per day and took the most-severe cases herself. In May of the following year, she developed a near-fatal illness (most likely brucellosis). Although she was urged to return to England, she remained with the Army during her convalescence and did not leave her post until the last soldier had left for home 21 months after her arrival. Nightingale is described as "a true pioneer in the graphical representation of statistics." She made extensive use of coxcombs to present reports on the nature and magnitude of the conditions of medical care in the Crimean War to Members of Parliament and civil servants who would have been unlikely to read or understand traditional statistical reports.

Learning Objectives

1. The audience will learn about how Florence Nightingale's graphical representation of statistics impacted and benefited operational medicine.
2. The audience will learn about three improvements to military medical care that she instituted.

[241] FOLEY ENDOWMENT PANEL

Katie Samoil
University of Calgary, Calgary, Alberta, Canada

(Education - Tutorial/Review)

TOPIC: Chairing the Canadian Nursing core during the First World War, 1914-1918, was only of Major Margaret MacDonald's significant operational leadership accomplishments. Born in 1873 in Bailey's Brook, Nova Scotia, Canada, Maj MacDonald chose a career of service, academia, leadership, and global deployment. After graduating nursing in 1895 from the New York City Hospital Maj MacDonald practiced in Panama, the Spanish-American War, and the Second Boer War in South Africa. In 1901 Maj MacDonald was appointed as one the first full-time military nurses with the Canadians and recognized as one of the five founding members of the nursing service itself. Maj MacDonald advocated for standardized formal nursing education. Maj MacDonald also supported Orderlies and Physicians for work hours, recognition for service, medical benefits, and vacation. November 1914 saw Margaret MacDonald become the first women in the British Empire to be awarded the rank of Major. A career of exemplary practice from 1895 to 1923 saw Maj MacDonald earn recognition from many sources. **APPLICATION:** Current training opportunities exist for physicians with a national boarded exam for Aerospace Medicine. It may be that with increased frequency of space missions the time has arrived for a recognized formal national education process for aerospace medicine nursing. The evaluation of standardized education as it relates to field advancement, and further necessitates the inclusion of nursing as a distinct and contributing health services profession within the aerospace medicine field may be a key factor in patient care.

Learning Objectives

1. By the end of this presentation participants will be able to recognize the role of formal education as it relates to standardized patient care, teamwork with previously known colleagues, and the advancement of a profession within a field.
2. By the end of this presentation participants will be able to describe three unique characteristics of aerospace medicine nursing, distinct from the practice of a Flight Surgeon, Crew Medical Officer, or Paramedic.

[242] MARY T. KLINKER: WHY DID WE NAME AN AWARD IN HER HONOR?

Cathy DiBiase
Kennedy Space Center, Titusville, FL, United States

(Education - Program/Process Review)

INTRODUCTION: Captain Mary T. Klinker was the only nurse from the Air Force Nurse Corps killed in Vietnam. AsMA has an award named in her honor that recognizes significant contributions to or achievements in the field of aeromedical evacuation. **TOPIC:** This presentation will highlight the short life of Mary Klinker. She was only 27 when she was killed in a C-5A Galaxy cargo transport plane crash during "Operation Baby Lift" at Tan Son Nhut Air Base in Saigon. Captain Klinker joined the Air Force Reserve following completion of her nursing training. A few years later she went into active-duty status, serving in the Philippines and at Travis AFB in California. Many that knew Captain Klinker, including her family, are no longer alive to share her deepest dreams, achievements and obstacles. However, based on the little that is written about her and what can be gleaned from her military record, she was an upstanding officer. When asked on her reserve status paperwork why she wanted to continue her active-duty status she stated, "I desire to remain in the Air Force to serve my country, further my education and gain experience…I believe I have adjusted well to the Air Force way of life." Also, to be presented will be the thoughts of those who have received the Klinker award. For several decades this award has been presented at the annual AsMA award banquet. Many who have received this award have been outstanding leaders in not only AsMA but ANAHPS. Their contributions led to their nomination. Each recipient of this distinguished award has some of Mary's drive as they have served our country, the space program, and many other aeromedical arenas. **APPLICATION:** A life of service and commitment will be highlighted, with examples that can be followed.

Learning Objectives

1. Describe the commitment Mary Klinker had to her country.
2. Apply one example of contributions of the awardees to your life.

[243] THE EVOLVING CRUCIAL ROLE OF NURSING LEADERSHIP IN MEDEVAC CAPABILITIES AND SUSTAINABILITY: SPOTLIGHT ON MAJOR SANDY NESTOR

Annette Sobel
University of Missouri, Columbia, MO, United States

(Education - Tutorial/Review)

INTRODUCTION: Tactical medical evacuation has become a ubiquitous requirement for operational deployments. This capability has advanced substantially since the Vietnam era and 'DUSTOFF' platform to include iterative versions of Forward Surgical Teams and Critical Care Air Transport Teams, USA and USAF, respectively. **TOPIC:** This presentation will focus on the contributions of MEDEVAC nurse Major Sandy Nestor, U.S.Army, in Afghanistan and the synergy that nursing care and cross-disciplinary teams provide to optimize patient care in the most extreme conditions. **APPLICATION:** Effective leadership of cross-disciplinary teams in extreme environments is exemplified by the MEDEVAC platform. This environment requires rapid, adaptive leadership 'on-demand', irrespective of clinical rank or duty station. This presentation will profile the charactistics of effective leadership on a personal and team level, describing a continuum of communication, physical, intellectual, experiential and decision-making skills directly mappable to performance and patient outcome. The presentation will summarize the transferrable nature of these characteristics to other aspects of clinical medicine, with particular emphasis on extreme environments. In addition, opportunities for clinical research and technology insertion will be stressed that may enable and learn from leadership behaviors and outcomes, such as artificial intelligence, virtually augmented behavioral training and education, and sensor fusion technologies.

Learning Objectives

1. The audience will learn about the composite nature of effective leadership of MEDEVAC teams.
2. The participant will gain an improved understanding of the leadership challenges of extreme environments.
3. The audience will appreciate the evolution of medical capabilities and directly attributable improved patient outcomes enabled by effective MEDEVAC and aeromedical leadership.

[244] SCIENTIST, LEADER, ROLE MODEL - COL(RET) ELIZABETH BRIDGES, PHD, RN, CCNS, FCCM, FAAN

Tamara Averett-Brauer
711th Human Performance Wing, U.S. Air Force Aeromedical Research Lab, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Elizabeth Bridges is a distinguished scientist, leader, and critical care nurse, widely recognized across military and critical care audiences. Her rigorous yet approachable research has generated knowledge and evidence that impacts patient care at the bedside, at the litter side and at the plane side. **TOPIC:** Dr. Bridges is a tenured Professor at the University of Washington and Clinical Researcher. She's a Fellow of the Society of Critical Care Medicine and American Academy of Nursing, and Past President American Association of Critical-Care Nurses (AACN). She served 30 years in the USAF (active and reserve) as a clinician, scientist, and senior leader leading evidence-based approaches to critical war skills competencies. Her operational research experience in the Joint Combat Casualty Research Team directly contributed to the development of the DoD Trauma Registry demonstrating the value of real-time data collection leading to practice improvements in combat casualty care around the world. **APPLICATION:** Dr. Bridges' research is imminently practical and pragmatic, focusing on translation of knowledge across the combat casualty and aerospace medicine spectrum, with ramifications

for future operational environments. Dr. Bridges exhibited foresight and tenacity in her military-relevant research across the continuum of care from critical care hemodynamics at altitude to skin care during aeromedical evacuation. Her emphasis on translating research into practical tools led her to create the TriService Nursing Research Battlefield and Disaster Nursing Pocket Guide. She worked with the readiness community to physically distribute these guides to all nurses deploying to wartime theaters. She's a leading researcher in the evaluation of pressure relief devices in austere combat environments, including long-distance air medical transport. Dr. Bridges established a methodology to evaluate skin interface pressure on commonly used military litters and pads. She built a template that can be used to study devices or approaches to care in other operational environments (including microgravity, space, and prolonged care conditions). Dr. Bridges is the consummate role model of scientist, nurse, and leader, linking both military and civilian aerospace medicine clinical practice and evidence. **RESOURCES:** https://nursing.uw.edu/person/elizabeth-bridges/ (accessed 20221031)

Learning Objectives

1. The participants will be able to describe one practical outcome of Dr. Elizabeth Bridges' research that made a difference in combat casualty care.
2. The audience will learn about Dr. Elizabeth Bridges' program of research and its practical applications across the combat casualty and aerospace medicine spectrum.

[245] "THIS CAREER WILL BE MY LIFE": AEROSPACE NURSE CATHERINE "CATHY" P. DIBIASE

Aubrey Florom-Smith
Stanford Health Care, Stanford, CA, United States

(Education - Tutorial/Review)

INTRODUCTION: Cathy DiBiase has contributed to crew health and mission success over three decades at NASA Kennedy Space Center. This presentation will highlight Ms. DiBiase's personal history and contributions to aerospace nursing clinical practice and leadership. **TOPIC:** From an early age, Ms. DiBiase's intellect and drive for excellence were evident. An outstanding student, she obtained a Bachelor of Science in Nursing, and later practiced in intensive care, emergency care, and occupational health. A move to Central Florida prompted Ms. DiBiase to apply at Kennedy Space Center in 1994. She impressed: Ms. DiBiase was chosen over several other nurses, and a few weeks later, she supported the STS-65 landing. She soon realized that she could forge a rewarding career in aerospace nursing. In total, Ms. DiBiase supported 80 Shuttle missions by providing nursing care, education, and research, earning the respect of professional colleagues. As Lead Aerospace Nurse and a certified occupational health nurse, she now applies this vast experience through involvement in planning SpaceX Crew Dragon missions. Ms. DiBiase has received numerous awards and honors that demonstrate her effectiveness as a leader in aerospace. Active in AsMA, ANAHPS, and SMA, Ms. DiBiase champions aerospace nursing as an integral part of the space medicine team. As she notes when providing guidance to nursing students and others interested in aerospace nursing, it is an evolving, growing, interdisciplinary field - and Ms. DiBiase continues to lead the way. **APPLICATION:** Ms. DiBiase provides expert, specialized aerospace clinical care and education, and participates in important research focused on the health and safety of astronauts prior to flight and on launch day. Lessons learned from Ms. DiBiase's life and career are not just relevant to aerospace nurses, but to nurses and healthcare providers caring for patients in every setting. A true inspiration to the next generation of aerospace nurses, Ms. DiBiase exemplifies the best that nursing has to offer.

Learning Objectives

1. The audience will identify two leadership characteristics of Cathy DiBiase.
2. Learners will describe two key concepts of aerospace nursing clinical practice.

Wednesday, 05/24/2023 ***8:30 AM***
Napoleon Ballroom C1-C2

[S-47]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS I

Chair: Albert Lee
Co-Chairs: Serena Aunon-Chancellor, David Miller

PANEL OVERVIEW: *Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.*

[246] SERONEGATIVE RHEUMATOID ARTHRITIS IN AN AVIATOR

Robert Wright, Cady Blasser
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military aviator with an atypical presentation of rheumatoid arthritis (RA). **BACKGROUND:** RA is a chronic autoimmune disease characterized by progressive joint destruction with the potential for severe extra-articular manifestations and medication side effects of aeromedical concern. Early treatment with novel disease-modifying antirheumatic drugs (DMARDS) can prevent long-term progression and disability. **CASE PRESENTATION:** This case report describes a 38-year-old male aviator with a few months history of atraumatic bilateral pain in his shoulders and hips causing intermittent nighttime awakening, as well as night sweats and fatigue. His physical examination was unremarkable. Evaluation to rule out bony and hematologic malignancy, chronic infection, fatigue, and inflammatory/rheumatologic etiologies were normal except for mild edema in the hip and shoulder joints on MRI. A rheumatology consultant ultimately diagnosed him with seronegative RA. The aviator's RA flare was initially managed with a combination of prednisone and DMARDS including methotrexate (MTX) with folate and hydroxychloroquine (HCQ) with significant improvement in symptoms. **DISCUSSION:** This case highlights a severe rheumatologic condition affecting ~0.5% of US adults, with higher prevalence in women and adults over 50 years-old. Aeromedical risks are numerous, variable in severity, and can occur due to disease progression and/or treatment side effects. Progressive loss of fine-motor function and disability due to small joint damage can impair flight performance over time and be prevented with early treatment. Severe risks include spinal cord, brainstem, and vertebral artery compression due to neck flexion and extension during high G manuevers due to cervical disease, such as atlantoaxial instability, which is common in RA. Other significant aeromedical risks include MTX-pneumonitis, HCQ-retinopathy and steroid-induced neuropsychiatric effects which will be analyzed using the AMRAAM. Aeromedical standards vary by agency. For example, the FAA allows prednisone and MTX but the USAF usually does not. Early diagnosis of RA is critical as prompt treatment with novel DMARDS can improve symptoms and prognosis, and enhance return to flight status. **DISCLAIMER**: The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the Department of Defense or of the United States Air Force.

Learning Objectives

1. Participants will be able to discuss the aeromedical concerns surrounding the RA disease process and treatment modalities using the AMRAAM.
2. Participants will learn civilian and military aeromedical standards associated with RA.

[247] HEMOCHROMATOSIS FOLLOWING CMV INDUCED HEPATITIS IN A FLIGHT SCHOOL STUDENT: A CASE REPORT

Julissa Mendoza, Jelaun Newsome
Department of Aviation Medicine, U.S. Army Medical Center of Excellence, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military flight school student who was diagnosed with hemochromatosis following CMV induced hepatitis. **BACKGROUND:** Hemochromatosis is a disorder in which increased iron absorption can lead to total body iron overload. It may lead to a variety of complications including cardiac, CNS, and hepatic. Cardiac complications include dilated cardiomyopathy, heart failure, and conduction disturbances. Patients are also at an increased risk of CNS complications such as weakness and fatigue. Occupational factors, such as in aviation, in addition to history of hemochromatosis, vastly increases the risk of developing arthritis. Untreated hemochromatosis can lead to early death through various mechanisms such as heart failure, cirrhosis, and hepatocellular cancer. **CASE PRESENTATION:** The patient is a military flight school student who presented to the emergency department due to abdominal pain and was diagnosed with viral hepatitis due to CMV infection. His AST, ALT, and ferritin were noted to be 140 U/L, 264 U/L, and 603ng/mL respectively. After his liver associated enzymes began to trend to normal, his ferritin increased to 802 ng/mL. Further evaluation with ultrasound, CT, and MRI were normal. Upon further testing by gastroenterology, he was diagnosed with hemochromatosis. The patient was treated with monthly phlebotomy for 3 months, then every 3 months for 6 months until his ferritin levels returned to <100 ng/mL. The flight surgeon then submitted a request for a medical exception to policy (waiver). The exception to policy was approved by the Army, with a requirement of an annual iron panel. The patient began training without subsequent health related incident. **DISCUSSION:** Flight surgeons assess and perform risk mitigation; this case highlights a few considerations and complications of blood disorders in a flight school student. The flight school student in this case presented with an acute illness of viral hepatitis that may have been complicated by his previously unknown history of hereditary hemochromatosis. He was appropriately treated with phlebotomy and stabilized without need for further treatment. This case illustrates the various considerations a flight surgeon must contemplate when determining appropriate risk mitigation in the medical screening of flight applicants.

Learning Objectives

1. The audience will learn about the symptoms of hemochromatosis and its related complications.
2. The audience will learn about the aeromedical implications and flight considerations of patients with a history of hemochromatosis.

[248] DON'T BURST MY BUBBLE: BULLOUS EMPHYSEMA IN A COMMERCIAL SPACEFLIGHT PARTICIPANT

Bashir El-Khoury, Rebecca Mendelsohn
UTMB, Galveston, TX, United States

(Education - Case Study)

INTRODUCTION: This case report describes a 57-year-old man from the United States with a past medical history significant for bilateral, moderately severe bullous emphysema complicated by a history of spontaneous right sided pneumothorax who underwent medical screening prior to training for a 10-day mission on the International Space Station (ISS). **BACKGROUND:** Bullous emphysema is a type of chronic lung disease that is characterized by air cysts exceeding 1 cm in diameter. It is characterized by destruction of the lung parenchyma resulting in limitations in airflow from loss of lung architecture and enlargement of the alveolar space. Bullous emphysema is a subset of chronic obstructive pulmonary disease (COPD), which is currently the third leading cause of death in the United States and fourth leading cause of death worldwide. **CASE PRESENTATION:** This spaceflight participant was seen for medical screening and optimization prior to commercial space travel. He was a slender man with a history of bullous emphysema and spontaneous pneumothorax in 1999 treated with thoracoscopy, lung biopsy, and talc pleurodesis. He admitted to smoking 1.5-2 packs per day for about 17 years, but quit 40 years ago. He denied any history of difficulties with commercial air travel and had no limitations with regular exercise. His chest radiograph demonstrated bilateral mild hyperinflation with flattening of the diaphragms, symmetrical apical pleural thickening, and blunting of the left costophrenic angle. High resolution computed tomography demonstrated multiple thin-walled cystic air spaces. Pulmonary function tests demonstrated moderately severe obstruction with significant reversibility. Additional testing was performed to assess his ability to tolerate launch, landing, and any possible changes in air pressure during the spaceflight. **DISCUSSION:** This case report, initially published by Jennings et al. in *Aviation, Space, and Environmental* Medicine in May 2006, describes a relatively rarely encountered condition in the spaceflight community, but one that has implications for medical clearance in the prospective spaceflight participant. Despite the presence of known intrinsic pulmonary disease, this spaceflight participant was able to be medically optimized prior to spaceflight by utilizing preflight testing to inform aeromedical risk.

Learning Objectives

1. Understand the presentation, diagnosis, treatment and complications of bullous emphysema in the aviator or spaceflight participant.
2. Understand how to assess aeromedical risk in the spaceflight participant with bullous emphysema and determine the potential implications of the condition on spaceflight.

[249] HIGH-G PILOT WITH INCIDENTAL DISCOVERY OF ARTERIOVENOUS MALFORMATION: A CASE STUDY

Noel Colls, Matthew Hoyt
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case describes an experienced pilot flying in a high-G platform with an incidentally discovered arteriovenous malformation (AVM). **BACKGROUND:** Intracranial surgery is often incompatible with high-performance aircraft operation. Intravascular embolization and stenting prevented disruption of the blood-brain barrier, allowed for use of the Aeromedical Consult Service Medical Risk Assessment & Airworthiness Matrix algorithm, and resulted in a categorical waiver and skill preservation of an experienced pilot. **CASE PRESENTATION:** Subject presented to clinic with slight left ear muffled hearing and Valsalva difficulty and treated for an ear infection; however, it was refractory to treatment. Subject was referred to Otolaryngology for possible conductive hearing loss. Thin-slice temporal bone computed tomography was normal. Magnetic resonance imaging had an incidental finding of a 2.5x1.5-cm Spetzler-Martin grade I AVM involving the anterior right frontal lobe without hemorrhage. Neurosurgery recommended Onyx™ endovascular embolization for a high likelihood of AVM cure and nearly zero postoperative seizure risk. Subject embolized twice; an iatrogenic right internal carotid artery dissection from the first embolization resulted in intravascular stenting. Subject tolerated the procedures well without further symptoms from initial diagnosis or treatment. **DISCUSSION:** Assessment by the subject's operational command found no limitations or flight safety concerns. The Aeromedical Consult Service focused on stressors applied to the carotid stent in high-G exposure and concomitant traction/rotation as well as the potential for seizure activity. Follow-up arteriogram showed incomplete obliteration of the AVM. Subject was recommended for a waiver restricted to multiplace, non-high-performance, non-ejection-seat aircraft, annual Neurology and Neurosurgery consultation, and repeat imaging to assess stability. Subject remained asymptomatic without signs of epileptiform activity, stent damage, or AVM recurrence. Subject's ejection seat restriction was removed. This exemplifies balancing risk mitigation with preservation of a combat pilot. The airworthiness matrix is an easy-to-use risk management tool for algorithmic discussion

of condition recurrence compared to outcome severity. Additional risk can be reduced by flight characteristic alteration, requiring a co-pilot, and ejection seat restrictions until subsequent evaluations demonstrate condition stability.

Learning Objectives

1. List additional diagnoses to consider when presented with a common complaint that is refractory to initial treatment.
2. Describe how to apply the Aeromedical Consult Service Medical Risk Assessment & Airworthiness Matrix to help guide a risk mitigation discussion.
3. Identify possible endovascular treatment modalities when dealing with a potentially career-ending intracranial pathology.

[250] MEDICAL CLEARANCE OF A MEDICALLY COMPLEX COMMERCIAL SPACEFLIGHT PARTICIPANT WITH CARDIAC, PULMONARY, ENDOCRINE, AND MUSCULOSKELETAL CONDITIONS

Karen Ong[1], Craig Kutz[1], Ed Powers[2], Michael Harrison[3], Serena Auñon-Chancellor[1]
[1]*UTMB, Galveston, TX, United States;* [2]*Houston Methodist, Houston, TX, United States;* [3]*Mayo Clinic, Jacksonville, FL, United States*

(Education - Case Study)

INTRODUCTION: With advancements in commercial spaceflight, individuals of older age and with complex medical conditions are interested in participating in spaceflight. However, the physiological and functional effects of having multiple potentially interacting medical conditions in spaceflight is still not well understood, including the long-term effects of previous COVID-19 infection. This case report describes an older individual with multiple systemic health conditions (previously considered disqualifying) who subsequently was cleared for and successfully participated in a commercial spaceflight. **CASE PRESENTATION:** 65-80M commercial spaceflight participant with an extensive medical history including well-controlled cardiovascular (CAD, cardiac arrhythmia, HTN, HLD), pulmonary (previously mild COVID-19 infection, COPD), endocrine (hypothyroidism), and musculoskeletal (lumbar stenosis and rotator cuff injury) conditions along with mild hearing impairment. To our knowledge, the patient is the first commercial spaceflight participant known to have flown after COVID-19 infection (mild-to-moderate symptoms that self-resolved without hospitalization or medical interventions in the setting of mild COPD and pulmonary nodule). Additionally, the individual had previously had a positive stress test but subsequent unremarkable cardiac catheterization, resulting in medical management of his coronary artery disease. He also had a history of asymptomatic low-burden atrial ectopy without ventricular arrhythmia. The patient demonstrated sufficient function for spaceflight conditions and potential emergency operations despite mild hearing impairment and currently asymptomatic musculoskeletal conditions including a rotator cuff injury (status post-surgery) and asymptomatic spinal stenosis. **DISCUSSION:** Despite these multiple disqualifying health conditions, the patient's well-characterized and well-controlled conditions were deemed to pose an acceptable risk in the context of the patient's overall health and function. The patient was approved for commercial spaceflight and subsequently had a successful and enjoyable mission during which he continued his multiple regular oral medications without incident. In summary, individuals with a complex medical history including past mild COVID-19 infection may be able to safely undergo spaceflight if these medical conditions are thoroughly investigated and well-controlled in an individual with adequate physical function.

Learning Objectives

1. Understand the potential risks of common medical conditions for spaceflight.
2. Discuss the possible interactions of multiple medical conditions for spaceflight.
3. Better understand risk mitigation of common medical conditions in spaceflight.

[251] THE MARATHONER CONUNDRUM: COMPLETE CORONARY ARTERY OCCLUSION WITHOUT ISCHEMIA

Brit Geisler, Salvatore Bertucci
U.S. Army, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: Heart disease is the leading cause of death in the United States and the leading cause of permanent flight duty suspensions. Flight surgeons need to be aware of the screening and treatment pathway, but many are not straight forward. Asymptomatic complete right coronary artery (RCA) occlusion in a high functioning aviator without any evidence of ischemia is a downright conundrum. **BACKGROUND:** Heart disease is the leading cause of death in the United States with coronary artery disease (CAD) at the top. Slowly progressing occlusion in CAD can foster development of collateral blood flow, but the prognosis of those patients is controversial. Studies suggest that having collateral blood flow with maintenance of heart function have lower overall risk of mortality, even with complete occlusion. They also could have better outcomes if they were to have an ischemic event. It has also been established that exercise improves coronary collateral growth. **CASE PRESENTATION:** A 51 years old male presents with an incidental ultrasound finding of an non-occlusive carotid plaque. He underwent an extensive workup that found complete occlusion of the RCA with collateral blood flow. Rest of the work up were normal. He is a non-smoker, non-drinker, very active with only medical problem is presumed familial hyperlipidemia. Repeat nuclear perfusion and angiography after 18 months showed preservation of heart function and no evidence of ischemia. He excelled his Army Combat Fitness Test, hiked Pikes Peak and continues to run marathons without symptoms. **DISCUSSION:** CAD is a common issue in the aviation community. An aviator with total occlusion of RCA without any evidence of ischemia, wall dysfunction, or abnormalities over an 18 month period presents a conundrum. Although not indicated, successful angioplasty could make him eligible for a waiver. He is extremely high functioning with regular high intensity exercise, has maximized his lipid management, and still remains symptom free. Studies support that his lifestyle is protective and he has a better prognosis than most other aviators. The conundrum is to fly or not to fly.

Learning Objectives

1. The audience will learn about the causes and symptoms of Coronary Artery Disease.
2. The audience will learn about the aeromedical implications and flight considerations of patients with Coronary Artery Disease.
3. The audience will learn about coronary collateral circulation growth and prognosis.

Wednesday, 05/24/2023 ***8:30 AM***
Napoleon Ballroom D1-D2

[S-48]: SLIDES: OPERATIONAL ISSUES IN FATIGUE MANAGEMENT

Chair: Tom Nesthus

[252] THE IMPACT OF FATIGUE ON THREAT AND ERROR MANAGEMENT PERFORMANCE DURING LINE OPERATIONAL SAFETY AUDIT (LOSA) OBSERVATIONS

Daniel Wyman, Stephen Powell
Synensys, LLC, Peachtree City, GA, United States

(Education - Program/Process Review)

BACKGROUND: The Line Operations Safety Audit (LOSA) is a proactive safety assessment developed by the FAA and implemented across commercial and military aviation to improve safety and enhance performance. During normal operations, peer-to-peer observations are conducted using the Threat and Error Management (TEM) framework to collect and analyze data for trends and opportunities for improvement.

In 2018, USAF Air Mobility Command began collecting crew fatigue data during LOSA observations to better understand the state of fatigue across different aircraft/aircrew. Over 2400 crew members voluntarily completed fatigue surveys during LOSA flights. This presentation provides the initial analysis of the potential impact of aircrew fatigue on the management and mismanagement of Threats, Errors, and Undesired Aircraft States (UAS) during crew operations. **OVERVIEW:** The LOSA fatigue survey used was adapted from the Samn-Perelli and Karolinska Sleepiness Scales. The survey was anonymous and crew members were asked by the LOSA observer to complete the survey prior to the top of descent. The response rate was 91%. Our fatigue data analysis to determine TEM performance differences initially focused on cockpit crews due to the similarity of duties across aircraft type for comparison purpose. A total of 552 sorties were included in the analysis. Threats, Errors, and UASs were coded as *managed or mismanaged* by the LOSA observer and the most significant performance differences between fatigued and non-fatigued cockpit crews were identified. Our analysis showed that fatigued crews mismanaged more threats in only 3 of the 13 threat categories but mismanaged more errors in 11 of 14 error categories and significant differences were noted in key UAS categories. Additionally, during the C-40 Cockpit Crew LOSA in 2019, it was determined that 72% of observed UASs included a fatigue contributing factor. **DISCUSSION:** While most crew members are aware of the negative performance effects of fatigue, we may not be aware of how fatigue directly impacts TEM performance that is critical to maintaining safe flight operations. Our data suggests that fatigue most negatively impacts pilot error management performance and some critical UAS categories. Future LOSA data collection will continue to include fatigue surveys, Aviation Operational Risk Management fatigue scoring data, and other fatigue-related narrative data to develop actionable information to optimize TEM performance.

Learning Objectives

1. The audience will learn about the association of fatigue and the management/mismanagement of Threats, Errors, and Undesired Aircraft States as noted by observers during the Line Operational Safety Audit (LOSA) process.
2. The audience will learn to identify key categories of Threats, Errors and Undesired Aircraft States that were mismanaged by fatigued cockpit aircrew during LOSA observations.

[253] SOFTWARE ASSISTED FATIGUE AVOIDANCE INITIATIVE IN INDIAN NAVAL AVIATORS

Ranjan Sarkar, SS Mohapatra
Institute of Aerospace Medicine, Indian Air Force, Bengaluru, India

(Original Research)

INTRODUCTION: Aircrew fatigue is an omnipresent threat in Naval Aviation, especially in settings of onboard operations. Presently there are no objective assessment of fatigue in Indian Naval aviators and the assessment is based on following of laid down work/rest schedules. Fatigue Avoidance Scheduling Tool (FAST®) is a patented computer application derived from the physiological model validated by the US DoD. Wrist based devices are also used widely to keep a schedule of work and rest. This study was an attempt to assess the employability of these software-based assessment independently or in combination and measurement of their diagnostic accuracy in detection of fatigue in Indian Naval Aircrew. **MATERIAL & METHODS:** A total of 51 Indian Naval aircrew wore a wrist based actigraphy device for recording of work-rest/sleep data. The study was carried out in three different naval air stations and one ship (aircraft carrier) after receiving appropriate administrative and ethical clearance. Data was fed into a computer running FAST®. The 'measures of diagnostic accuracy' namely sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), likelihood ratio positive (LR +ve), likelihood ratio negative (LR -ve) and Youden's Index were determined using SPSS. **RESULTS:** The diagnostic measures calculated sensitivity (68.4%), specificity (92.8%), positive predictive value (68.4%), negative predictive value (92.8%), likelihood ratio positive (9.5), likelihood ratio negative (0.34) and Youden's Index (0.61) . With actigraphy integrated FAST® these values were: sensitivity (84.2%), specificity (96.4%), positive predictive value (94.2%), negative predictive value (94.4%), likelihood ratio positive (23.5), likelihood ratio negative (0.16) and Youden's Index (0.80). **DISCUSSION:** The increase in sensitivity (from 68.4% to 84.2%), specificity (from 92.8% to 96.4%), positive predictive value (from 68.4% to 94.2%), negative predictive value (92.8% to 94.4%), likelihood ratio positive (9.5 to 23.5) and Youden's Index (0.61 to 0.80) indicated that actigraphy integrated FAST® is a better screening tool in comparison to the independently employed FAST® in *IN* aircrew. We have recommended Employing actigraphy integrated FAST as screening and guiding tool during selected mission specific operational flying after necessary clearances

Learning Objectives

1. The findings of the study will lead to better understanding of operational fatigue especially in Carrier operations.
2. Scientifically validated Actigraphy devices could become standard issue supply for Indian Naval Aircrew.
3. It will lend objectivity to fatigue assessment in Indian Military aircrew and will lead to better crew scheduling.

[254] FOCUS GROUP STUDY OF US PILOTS ON FATIGUE IN SHORT-HAUL FLIGHT OPERATIONS

Cassie Hilditch[1], Kevin Gregory[2], Lucia Arsintescu[1], Nicholas Bathurst[2], Thomas Nesthus[3], Hannah Baumgartner[3], Amanda Lamp[4], Laura Barger[5], Erin Flynn-Evans[2]
[1]*San Jose State University, Moffett Field, CA, United States;* [2]*NASA, Moffett Field, CA, United States;* [3]*FAA, Oklahoma City, OK, United States;* [4]*Washington State University, Spokane, WA, United States;* [5]*Brigham & Women's Hospital, Boston, MA, United States*

(Original Research)

INTRODUCTION: There are few studies investigating the impact of fatigue in short-haul flight operations conducted under United States (US) Federal Aviation Regulations (FAR) Part 117 flight and duty limitations and rest requirements. In order to understand the fatigue factors unique to short-haul operations, we conducted a series of focus groups across four major commercial passenger airlines in the US. The outcomes of this study were intended to inform the scope of a larger study of fatigue in short-haul operations. **METHODS:** Ninety short-haul pilots were recruited through emails distributed by airline safety teams and labor representatives. Fourteen focus groups were conducted via an online conferencing platform in which participants were asked to identify, specific to short-haul: a) schedules and operations that lead to elevated fatigue; b) schedules and operations that are not fatiguing, and c) important fatigue factors to study. Data were collected anonymously and coded using conventional qualitative content analysis, with axial coding and summative analysis used to identify main themes and over-arching categories. **RESULTS:** Participants had an average of 12,348 (6,483) lifetime flying hours with 71 (14.5) hours of monthly flying. Forty-six percent of participants were captains. The six fatigue factor categories identified were: circadian disruption (e.g., circadian switches, redeyes), high workload (e.g., hassle factors, number of flights per duty), inadequate rest opportunity (e.g., minimum rest layovers, quality of rest facilities), schedule changes (e.g., unpredictability), regulation and policy issues (e.g., scheduling up to FAR 117 limits), and long sits (e.g., long wait times between flights). **DISCUSSION:** A field study informed by these results and designed to investigate the prevalence and impact of these factors in US short-haul operations is currently underway.

Learning Objectives

1. The participant will be able to describe the most common fatigue factors experienced by US short-haul pilots.
2. The audience will learn about current and future research agendas to help quantify and mitigate fatigue in short-haul operations.

[255] FATIGUE OPTIMIZATION DURING UNIVERSITY HELICOPTER PILOT TRAINING

Krisztina Szabó, Botond Szűcs
PharmaFlight Aeromedical Center, Debrecen, Hungary

(Original Research)

INTRODUCTION: Fatigue risk management plays a paramount role in optimizing everyday performance. Our aim was to evaluate the applicability of a fatigue risk management measuring and optimizing program during SWAT helicopter pilot training at a local university. Measurements included heart rate variability tests for peripheral nervous system activation, sleep data monitoring, cardiovascular risk factor monitoring. Intervention was changes in diet, physical activity and changing simulator training load according to the changes in individual data. **METHODS:** A total of 12 helicopter pilots (all males, age: 30.47±5.39 years) participated in a 36-month program. We measured cardiovascular risk factors: blood pressure, pulse, augmentation index (AIX), pulse wave velocity (PWV), diastolic area index (DAI). Changes in autonomic regulation were evaluated by using heart rate variability (HRV). R-R intervals were measured for 6 minutes in a supine position. Parameters used: minimal pulse (p.min), average pulse (p.avg), maximal pulse (p.max), maximum-minimum pulse difference (p.max-p.min). Long-term continuous RR intervals (stda), standard deviation of instantaneous beat-to-beat variability (stdb), the number of pairs of adjacent NN intervals differing by more than 50 ms divided by the total number of all NN intervals (pNN50). Spectral analysis provided the low-frequency/high-frequency ratio (LF/HF). Sleep assessment included the measurement of sleep quantity, heart rate, breaths per minute, snoring. **RESULTS:** Systolic (133.38±22.15 vs. 126.48±20.22 mmHg) and diastolic blood pressure (76.95±14.37 vs. 75.4±12.7 mmHg) showed a reduction tendency. Pulse decreased (76.95±14.37 vs. 72.53±13.65 bpm). AIX showed slight improvement (-33.54±5.59% vs. -31.93±3.79%); PWV data showed minimal change (7.74±2.13 vs. 7.4±2.73 m/s); DAI showed moderate improvement (49.32±6.81 vs. 51.1±7.01 m/s). HRV showed decreased p.max-p.min difference (18.78 ± 9.2 bpm vs. 15.5 ± 9.01 bpm), normalized dynamics (stda: (stda: 44.56 ± 35.97 vs 69.63 ± 33.5; stdb: 30.88 ± 41.5 vs. 32.72 ± 35.84), slight sympathetic overload (pNN50: 7.33 ± 6.76 vs. 11.17 ± 5.24, LF/HF: 169.52 ± 208.83 vs. 252.01 ± 351.16) during the program. Sleep quality showed undulating results in accordance with training load. **DISCUSSION:** Individualized intervention protocols, normalizing circadian rhythms and changes in simulator training load made it possible to shorten the university training from 36 months to 18 months.

Learning Objectives

1. The audience will learn about the close connection between autonomic nervous system and cardiovascular parameters.
2. The participants will understand how important it is to monitor even healthy young adults to predict their possible future risks for certain diseases.

[256] EYE TRACKING AS A FATIGUE SENSOR

Daniela Algranati[1], Idan Nakdimon[1], Gal Sapir[2], Anna Morozov[3], Boaz Yariv[3], Oded Ben-Ari[1]
[1]*Israeli Air Force, Ramat Gan, Israel;* [2]*Israeli Defense Forces, Ramat Gan, Israel;* [3]*Eyeviation Ltd, Herzelyia, Israel*

(Original Research)

INTRODUCTION: Fatigue is a significant consideration in flight safety. Therefore, the development of a sensor that will objectively detect and quantify the level of fatigue is of the essence. Sleep deprivation was found to extend the duration of eye fixations in the literature. The aim of this study was to analyze eye movements under fatigue in the Israeli Air Force (IAF). **METHODS:** IAF physiological qualification syllabus mandates a "Dead Tired" workshop, in which aircrew are exposed to sleep deprivation in a controlled manner. We analyzed the number and duration of fixations, the number and velocity of saccades, and pupil diameter. **RESULTS:** An eye tracking device was used to monitor 37 trainees (21 pilots, 11 navigators, and 5 unmanned aerial vehicle operators) during these workshops between November 2020 and March 2021. Duration of fixations, and the number of both fixations and saccades were found to be significantly higher following sleep deprivation. However, fatigue did not have a significant effect on either the velocity of saccades or pupil diameter. Unmanned Aerial Vehicle operators were found to be significantly resilient to sleep deprivation compared with pilots. **DISCUSSION:** Based on our preliminary results, we believe that eye tracking shows good potential to be used as a fatigue sensor. Although UAV operators was small group, their eye tracking metrics were less influenced by sleep deprivation.

Learning Objectives

1. Recognizing significant differences in eye tracking metrics during sleep deprivation.
2. The necessity of developing a fatigue Go / NoGo switch.

[257] HUMAN FACTORS CONSIDERATIONS TO MITIGATE FATIGUE EFFECTS IN SPACEFLIGHT OPERATIONAL PERFORMANCE

Erin Flynn-Evans
NASA Ames Research Center, Moffett Field, CA, United States

(Education - Tutorial/Review)

INTRODUCTION: Fatigue arising from sleep loss and circadian misalignment is a threat to successful human performance during spaceflight missions. Combatting fatigue during spaceflight operations requires a multi-factorial approach including vehicle design that facilitates sleep, schedules that maintain circadian entrainment, and countermeasures to minimize the impact of fatigue when it does occur. **TOPIC:** Human factors must be considered at every phase of a mission. The habitable volume of a space vehicle must allow crewmembers to achieve adequate sleep. This means that the vehicle must be designed so that the sleep environment achieves a comfortable sleeping temperature, with adequate airflow, and a quiet environment, free from intrusive background noise. The sleep environment must also include enough volume to allow for movement during sleep, potentially in multiple gravity environments, with private sleep accommodations for long-duration missions. The lighting in the vehicle must be sufficient to maintain circadian entrainment, while minimizing light pollution during the sleep episode. These design elements must be paired with other human factors considerations, including maintenance of a regularly timed schedule to maintain circadian entrainment. Fatigue countermeasures, such as lighting changes and increased cross-checking, should be available when crewmembers experience insufficient sleep or when sleep shifts are required. **APPLICATION:** Human factors are key to mitigating fatigue during spaceflight operations and should be incorporated into every phase of a mission, from vehicle design and conceptualization to mission planning and execution.

Learning Objectives

1. The participant will learn how human factors can mitigate fatigue when considered during the mission design phase.
2. The participant will learn how human factors can mitigate fatigue when considered during the implementation phase.
3. The participant will learn how human factors can mitigate fatigue when considered during the execution phase.

Wednesday, 05/24/2023 ***8:30 AM***
Napoleon C3

[S-49]: PANEL: CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: DIAGNOSIS, TREATMENT AND OPERATIONAL MISSION IMPACTS

Chair: Richard Scheuring
Co-Chair: Rainer Effenhauser

PANEL OVERVIEW: INTRODUCTION: *The authors describe the diagnosis, acute treatment, and rehabilitation of a mission impacting musculoskeletal medical condition in an astronaut during long-duration space flight on board the International Space Station.* ***BACKGROUND:*** *Rarely does a medical condition present in astronauts during the on-orbit phase of a space mission that has direct impact on crew health and mission objectives. During the record setting, long-duration mission of a U.S. astronaut, the team of NASA flight surgeons, astronaut strength conditions and rehabilitation experts along with outside consultants in neuro- and orthopedic spine surgery were presented with a case of acute onset cervical spine pain. The condition progressed in severity ultimately forcing the mission planners to reschedule an extravehicular activity (EVA), or spacewalk, modify the existing on orbit exercise prescription, and consider factors for an unscheduled return to Earth. There is no precedent for this type of musculoskeletal condition occurring in space prior to this case. The medical team had to develop an rehabilitation program on the ISS and consider alternatives to mission continuation in the event the individual did not respond to treatment.* ***CASEPRESENTATION:*** *A previously healthy US astronaut developed acute cervical spine pain during his 12-month mission on board the International Space Station (ISS). Details regarding the medical condition and treatment, rehabilitation plan, associated operational impacts, and spinal pathophysiology will be presented during this panel.* ***DISCUSSION:*** *Human space flight poses unique challenges to the diagnosis, treatment and monitoring of medical conditions. Flight surgeons rely on telemedicine for patient care, and the microgravity environment presents unknown physiological and anatomical changes to the human spine. A musculoskeletal rehabilitation treatment program was required to treat this medical condition, which prior to this mission, had never existed. Lastly, impacts to the mission objectives need to be considered.*

[258] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: PANEL OVERVIEW

Richard Scheuring[1], Rainer Effenhauser[1], Danielle Anderson[2], Paul Holman[3], Melvin Helgeson[4], Mark Vande Hei[5]
[1]*NASA JSC, Houston, TX, United States;* [2]*U.S. Air Force, San Antonio, TX, United States;* [3]*Houston Methodist Hospital, Houston, TX, United States;* [4]*Walter Reed National Medical Center, Bethesda, MD, United States;* [5]*NASA, Houston, TX, United States*

(Education - Case Study)

INTRODUCTION: The authors describe the diagnosis, acute treatment, and rehabilitation of a mission impacting musculoskeletal medical condition in an astronaut during long-duration space flight on board the International Space Station. **BACKGROUND:** Rarely does a medical condition present in astronauts during the on-orbit phase of a space mission that has direct impact on crew health and mission objectives. During a long-duration mission of a U.S. astronaut, the team of NASA flight surgeons, astronaut strength, conditioning and rehabilitation experts along with outside consultants in neuro- and orthopedic spine surgery were presented with a case of acute onset cervical spine pain. The condition progressed in severity ultimately forcing the mission planners to reschedule an extravehicular activity (EVA), or spacewalk, modify the existing on-orbit exercise prescription, and consider factors for an unscheduled return to Earth. There is no precedent for this type of musculoskeletal condition occurring in space prior to this case. The medical team had to develop an rehabilitation program on the ISS and consider alternatives to mission continuation in the event the individual did not respond to treatment. **CASE PRESENTATION:** A previously healthy U.S. astronaut developed acute cervical spine pain during his 12-month mission on board the International Space Station (ISS). Details regarding the medical condition and treatment, rehabilitation plan, associated operational impacts, and spinal pathophysiology will be presented during this panel. **DISCUSSION:** Human space flight poses unique challenges to the diagnosis, treatment and monitoring of medical conditions. Flight surgeons rely on telemedicine for patient care, and the microgravity environment presents unknown physiological and anatomical changes to the human spine. A musculoskeletal rehabilitation treatment program was required to treat this medical condition, which prior to this mission, had never existed. Lastly, impacts to the mission objectives need to be considered.

Learning Objectives

1. The audience will understand how telemedicine applied to diagnosing and treatment spinal disorders in space is accomplished.
2. The learner will become familiar with how a rehabilitation program for spinal musculoskeletal disorders in space is developed and executed.

[259] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: DIAGNOSIS AND TREATMENT

Richard Scheuring[1], Rainer Effenhauser[1], Paul Holman[2], Melvin Helgeson[3], Danielle Anderson[4]
[1]*NASA JSC, Houston, TX, United States;* [2]*Houston Methodist, Houston, TX, United States;* [3]*Walter Reed National Medical Center, Bethesda, MD, United States;* [4]*U.S. Air Force, Houston, TX, United States*

(Education - Case Study)

INTRODUCTION: A previously healthy, 55-year old male astronaut, with prior military and spaceflight experience, developed non-specific cervical spine pain approximately four months into his 12 month mission. **BACKGROUND:** Non-specific, limited musculoskeletal spine pain in astronauts in microgravity have been acknowledged during the six decades of human spaceflight. More recently, spinal changes have been studied and documented with pre- and post-flight imaging and on orbit stature measurements. Clinically, flight surgeons routinely observe mild, transient low back pain upon initial introduction of microgravity exposure in their crew members. However, standard screening assessments of spine integrity have not been routinely performed unless clinically indicated. Therefore, flight surgeons have had little insight to what underlying spine pathology may be brought into spaceflight. **CASE PRESENTATION:** The exact mechanism of injury in this astronaut was not clearly evident from his history. Despite conservative management, he subsequently developed an acute left sided C7 cervical radiculopathy 3-4 weeks after initial presentation of pain. His symptoms primarily consisted of radiating arm pain and numbness in a C7 distribution in addition to left sided triceps weakness noted during exercise. He did not have any changes in fine motor skills or evidence of myelopathy, although gait analysis was obviously limited. **DISCUSSION:** Despite the relatively permanent spine traction state in microgravity and conservative treatment measures, the individual developed unilateral C7 sensori-motor radiculopathy attributed to a C6-7 herniated nucleus pulposis. The crew member was removed from a scheduled EVA and began a treatment program on ISS to relieve his symptoms and return him to exercise. Upon consultation with experts in neurosurgery and orthopedic spine surgery assisted in the diagnosis, given the constraints of telemedicine during space flight, and guided conservative therapeutics regimen. Serial ultrasound imaging was conducted to evaluate the suspected levels in the cervical spine and aid in the differential diagnosis. The on orbit exercise prescription was modified in consultation with the astronaut strength, conditioning and rehabilitation (ASCR) team. Approximately 8-10 weeks after his initial presentation his symptoms improved to the point he was able to resume his full exercise routine and ultimately completed his entire mission duration.

Learning Objectives

1. The audience will become familiar with how ultrasound can be used for diagnostic imaging of the cervical spine on board the ISS.
2. The learner will gain insight into how the medical team during ISS Increment 65 diagnosed an acute cervical spine intervertebral disc herniation.
3. The participant will understand how microgravity impacts human spine anatomy and physiology.

[260] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: OPERATIONAL MISSION IMPACTS

Rainer Effenhauser, Richard Scheuring
NASA, Houston, TX, United States

(Education - Case Study)

INTRODUCTION: On-Orbit medical Issues have the potential to significantly impact spaceflight mission timelines and operations. This panel segment will discuss the Operational Impacts of a medical issue that occurred during spaceflight and the associated challenges and impacts to subsequent mission schedule and operations. These include things such as performing extravehicular activity (EVA, or spacewalks), exercise, and potential impacts to mission completion and subsequent landing operations. Familiarization with how daily crew activities developed by NASA Mission Operations planners are implemented and used by the astronauts during spaceflight will also be discussed. **CASE PRESENTATION:** A 55-year old male American astronaut developed cervical spine pain during his year-long mission on board the International Space Station (ISS). Symptom severity and confounding symptom presentation, ie parasthesia in the upper extremity, which may present during an EVA and represent acute decompression illness, prompted the mission medical team, mission managers and planners, along with medical specialists and the individual crew member to reconsider several mission objectives. **DISCUSSION:** At the end of this panel presentations, participants will be familiar with what a spaceflight mission schedule looks like, and how both minor and major medical issues have the potential to significantly impact mission timelines, operations, activities such as EVA, exercise, mission completion, and landing planning/operations.

Learning Objectives

1. The learner will become familiar with NASA spaceflight operations and how the medical operations team handles on orbit medical conditions that may have mission impact.
2. The audience will understand factors the flight surgeon considers during the on-orbit phase with impacts to performing mission objectives, such as EVA, exercise, contingency return planning and landing logistics.

[261] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: ON-ORBIT MUSCULOSKELETAL REHABILITATION

Danielle Anderson[1], Richard Scheuring[2]
[1]*U.S. Air Force, Houston, TX, United States;* [2]*NASA, Houston, TX, United States*

(Education - Case Study)

INTRODUCTION: Cervical radiculopathy is a common condition seen within the civilian population. The incidence and prevalence are higher in operational environments with frequent exposures to g-forces and microgravity. The implications for mismanagement can be extreme and lead to severe disability and increased healthcare cost and utilization. In an environment that is 250 miles above earth, these implications are even more severe with operational impacts, minimal ability to medically evacuate and treat an individual, and an obligation to maintain the full health and safety of a crew member. Due to these demanding requirements and limited capabilities, innovative rehabilitation strategies are necessary to treat and mitigate long term impacts of the condition. **BACKGROUND:** ~10-20% of cervical radiculopathy cases require surgical intervention, leading to the majority of cases being managed conservatively by physicians and physical therapists. There is plenty of evidence to support conservative treatment through appropriate medication management, manual physical therapy intervention, and individually tailored exercises targeted to resolve symptoms of radicular pain, numbness/tingling, and cervical pain and dysfunction. Although well established in 1-g, this evidenced based approach to treat cervical radiculopathy is unknown in the microgravity environment. The evidence-based principles of physical therapy evaluation and treatment of cervical radiculopathy will be discussed and applied to a real case of an astronaut on-board the International Space Station. The rehabilitation program consisting of individually tailored cervical and thoracic mobility exercises and manually applied cervical traction and cervical rotation, performed by a seasoned Astronaut physician in microgravity, will all be discussed. **CONCLUSION:** Relying on advanced clinical decision making, evidenced based principles of effective management in 1-g, and crew member ingenuity, effective treatment can be applied to fully resolve, maintain fitness, and mitigate long-term disability in microgravity, as demonstrated by a case of a 1-year long mission crew member on-board the International Space Station. Although the management of this case demonstrates a unique strategy to treatment, these cases are common in microgravity and will require imaging surveillance and pathological and physical characteristics assessment, to effectively prevent and treat future spine conditions in microgravity.

Learning Objectives

1. The learner will have a general overview of conservative evidenced based treatment strategies for cervical radiculopathy.
2. The learner will be able to discuss the clinical prediction rule for cervical radiculopathy and patients who will respond best to traction-based interventions.

[262] CERVICAL SPINE INTERVERTEBRAL DISC HERNIATION ON BOARD THE INTERNATIONAL SPACE STATION: SPINE PATHOPHYSIOLOGY

Melvin Helgeson[1], Paul Holman[2]
[1]*Walter Reed National Medical Center, Bethesda, MD, United States;* [2]*Houston Methodist, Houston, TX, United States*

(Education - Case Study)

INTRODUCTION: The spinal pathophysiology of long-duration space flight is not fully understood. We present a case discussion of spinal pathology in relation to a recent astronaut who developed cervical radiculopathy during flight. **BACKGROUND:** Throughout the history of human spaceflight, researchers have sought to better understand the significant impact on the musculoskeletal system and the spine. Several case reports exist within the literature describing the acute impact on spinal morphology and it is widely accepted that the spine elongates up to six centimeters when humans are exposed to the microgravity environment. While the spine anatomy changes, decreasing the normal sagittal alignment of kyphosis/lordosis, the spine also undergoes traction during flight. This traction and loss of loading across the intervertebral disk undoubtedly leads to changes within the microarchitecture of the disk space. There has been an increase in disk herniations, with up to 10% of US astronauts sustaining disk herniations post flight. There have not been any reports of disk herniations developing during space flight or any episodes of cervical/lumbar radiculopathy. **CASE PRESENTATION:** Without the ability to perform standard cervical spine imaging (MRI) on board the International Space Station, the assumption was this individual's signs and symptoms represented an acute disk herniation. Knowing traction occurs within the microgravity environment caused concern among the medical team members, and led to a conservative approach to activities, cancelling his scheduled EVA. The team could also not rule out spinal cord compression without available imaging. Proceeding cautiously with conservative management, his symptoms improved over the next 3 months, consistent with the natural history of cervical radiculopathy. His post-flight MRI obtained 24 hours after landing, eight months after the development of symptoms, revealed significant degenerative changes at the suspected level. **DISCUSSION:** The management of acute cervical radiculopathy is well accepted to be conservative initially in the absence of myelopathy. Conservative treatment was appropriate in this case, but the medical team was concerned about the possibility of spinal cord compression and the uniqueness of symptoms within a traction, microgravity environment. The pathophysiology of disk herniations within this environment needs to be better understood as we seek more frequent and longer duration flights.

Learning Objectives

1. The audience will become familiar with cervical spine anatomy as it relates to physical exam findings in the setting of acute radiculopathy.
2. The learner will be able to describe how conservative management of an acute cervical spine herniated disc in an austere environment can be diagnosed and treated.

3. The learner will understand the criteria for returning an individual with an acute cervical spine herniated disc from space.

Wednesday, 05/24/2023 ***8:30 AM***
Napoleon Ballroom A1-B3

[S-50]: PANEL: TECHNICIAN PERSPECTIVE ON PHYSIOLOGICAL ADVANCEMENTS

Chair: Rachelle Lang

PANEL OVERVIEW: *The Aerospace Physiology career field fills a unique niche in supporting today's flying operations with its diverse experience and involvement in providing training, research, and operational support all over the world. From the establishment of the "Altitude Training Program" in 1942 during WWII, it has continued to advance in its mission of protecting aviators. Even to this day, the Aerospace Physiology Training Teams have continued to expand their extensive involvement and understanding parallel to the world-wide ever growing aircraft inventory. From standing up the newest Chamber Training Unit at Joint Base San Antonio-Lackland, to launching U-2 pilots to the edge of space, to providing G-induced Loss of Consciousness prevention training or assisting special operator parachutists; each member of this elite community actively contributes to numerous flying missions world-wide. In this panel we will discuss the Aerospace Physiology enlisted tier's impact on operations. These technicians are intertwined within day-to-day operational missions providing a bridge between Team Aerospace and operational communities. This panel provides unique insights into an operational support mission not frequently understood and in so doing elucidates key components critical to enhancing team aerospace's integration into the operational community. Panelists will discuss aspects learned in their day-to-day interactions, from running the only US Department of Defense centrifuge, by training pilots to stay conscious at 9 Gs, to challenges with equipment, use and procedures for U-2 missions and much more. These members hold a critical role as the gatekeepers to flight for every aviator and their last line of defense between life and death.*

[263] SUPPORTING ENLISTED FLYERS: LESSONS LEARNED FROM STARTING SOMETHING NEW

Christina Ingram
Joint Base San Antonio-Lackland, San Antonio, TX, United States

(Education - Program/Process Review)

BACKGROUND: The 344 Training Squadron at JBSA-Lackland is the newest chamber unit in the aerospace physiology inventory. It is the only chamber to directly support two enlisted pipelines, the Career Enlisted Aviator (CEAs) and Special Warfare training pipelines. This presentation will describe lessons learned in establishing chamber operations to include collaborations with the medical community. **OVERVIEW:** Hurricane Michael destroyed Tyndall AFB in 2018. Reevaluating the need for a second chamber unit in San Antonio, the altitude chamber was moved to JBSA-Lackland and was officially opened 15 June 2022. Starting chamber operations from a blank slate provided both struggles and opportunities. Additionally, the unique mission of this chamber enabled a new perspective on enlisted aircrew support. Supporting roughly 2,300 students a year provided unique insight into common concerns, complaints, and issues that affect the CEA community. Broken down by AFSC, this presentation will describe training and unique AFSC concerns as provided by cadre. **DISCUSSION:** This topic will provide current data to DCS and chamber reaction rates as an overview to JBSA-Lackland operations. Additionally, this presentation will describe common injury and medical complaints in Career Enlisted Aviators for each AFSC and developed holistic AFSC specific solutions.

Learning Objectives

1. The audience will learn the current data for DCS and chamber reaction rates for JBSA-Lackland.
2. The audience will learn about some of the common injuries/medical complaints experienced by CEAs (career enlisted aviators) for each AFSCs, and solutions to rectify.
3. The audience will learn about the problems encountered/lessons learned with standing up a new unit.

[264] THE ROLE OF AEROSPACE PHYSIOLOGY TRAINING TEAM (APTT) IN OPERATIONS SUPPORT

Luciano Cattaneo
Community College of the Air Force, Ramstein Air Base, Germany

(Education - Program/Process Review)

BACKGROUND: In October 2021, the Air Force re-aligned the Aerospace Physiology (AP) career field under Line of the Air Force (LAF). Said transition from Medical to line streamlined our reach to the operators we support. This presentation will highlight the key role of Aerospace Physiology Training Teams (APTTs) and some of the born challenges post migration. **OVERVIEW:** Effective physiological training of aircrew demands AP personnel have operational experience. This is achieved by exposing aerospace physiologists and technicians to the actual flying environment thus enhancing their credibility with their audience—we should have one foot firmly planted in science and one in operations. **DISCUSSION:** In order to prepare aircrew to anticipate, recognize, correct and survive a Physiologic Event (PE), its imperative APTTs possess the tools to relate to the daily challenges aviator's encounter. As we are now under the operations umbrella, APTTs solidify a bridge between Team Aerospace and the line. Said relationship promotes training opportunities and exposes medically based professionals to the operations world; one of the many advantages the LAF provides. A drawback, however, is that each APTT is faced with unique challenges within their respective squadron and base agencies. Uncertainty from aircrew on the services provided by the APTT and ambiguity in our relationship with the MDG regarding the role and responsibilities of the APTTs, have proven to be common pitfalls. **CONCLUSION:** Since transition, the enlisted tier has evolved to take on responsibilities traditionally reserved for officers. With our medical roots and operational experience APTTs are thriving whilst influencing aircrew, base agencies, and strengthening Team Aerospace worldwide. **RECOMMENDATIONS:** Continue to mold and develop AP personnel in aviation without losing our medical background while promoting flying on different platforms which will only emphasize our footprint in Aerospace Medicine.

Learning Objectives

1. The audience will learn about the roll of APTTs in the LAF.
2. Listeners will understand the advantages and challenges presented after Aerospace Physiology was aligned to the LAF.
3. This presentation will highlight the critical role of enlisted members in APTTs.

[265] AEROSPACE PHYSIOLOGY ACCELERATION TECHNICIAN/PROCESS REVIEW

Queneth Salazar
Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: The job of centrifuge technicians at Wright-Patterson AFB is to prepare aircrew for the physiological stressors of high-G flight. The airframes that we support are T-38, A-10, EA-18, F-15C/E, F-16, F-22, and F-35. The three standard syllabus courses we execute are the Primary, Advanced, and Non-Pipeline Acceleration Training courses. **OVERVIEW:** At Wright-Patterson AFB, we provide acceleration training to the fighter community. We instruct students on a proper G-straining technique to combat threats associated with fighter operations. We support war efforts by utilizing a 35-million-dollar centrifuge to expose aircrew to the high-G environment prior to their first flight in a high-G platform. The primary objective of centrifuge training is to train aircrew on a high-quality Anti-G Straining Maneuver (AGSM) and evaluate

their performance in a controlled environment. The technique consists of three major components which include a lower body muscle contraction, a respiratory component, and a relaxed upper body. Compared to the previous "hook" method, which included a tight breath hold, the newer approach stresses a calmer breath hold to enhance air management and reduce instances of G-induced loss of consciousness (GLOC). We also now emphasize a relaxed upper body to decrease fatigue levels and improve air management. During program execution, we have found Primary students typically require more time in the centrifuge (respins) to learn the proper technique when compared to Advanced pilots. Our respin rates went from 49% in Primary students to 28% in Advanced students due to their previous experience in the centrifuge and time executing the AGSM in the aircraft. **DISCUSSION:** With Wright-Patterson AFB being the sole centrifuge owned by the Department of Defense, it is crucial for aircrew to receive high quality training during their time at Wright-Patterson. This allows aircrew to understand, apply, and improve their AGSM to ensure combat effectiveness. Lessons learned over the years have provided a refined approach to training that will help minimize GLOCs and pilot fatigue, providing a direct benefit to high-G aviators. The skillset of the technicians at the centrifuge is also utilized to provide training for international pilots from more than 20 countries worldwide. With more advances in aircraft technology, we must continue to adapt our training to enhance human performance and continue to defeat the threats associated with high-G flight.

Learning Objectives

1. The audience will learn about the Anti-G Straining Maneuver and the benefits of it.
2. The audience will learn how big of a difference the technique is from the "hook" to "relaxed breath hold."

[266] HIGH ALTITUDE AIRDROP MISSION SUPPORT

George Wild, Jeffrey Nelson
U.S. Air Force, Scott AFB, IL, United States

(Education - Program/Process Review)

BACKGROUND: Air Mobility Command (AMC) is pursuing an increased use of augmented minimum manned aircrews (Single Pilot and Load Master). Additionally, AMC has implemented go/no-go pill use to aircrew. Furthermore, the Air Force allows for single Jump Master operations. Specific entities within the DoD would like to have non-Aerospace Physiology (AP) technicians become trained in High Altitude Airdrop Mission Support (HAAMS). Aerospace Physiology (AP) HAAMS technicians are vital to be able to bridge the gap between United States Air Force (USAF) Aircrew and parachutist to reduce overall mission risk. The AP HAAMS personnel at JB Charleston are the best and most qualified personnel to perform the HAAMS mission. **OVERVIEW:** Expected increased ops tempo/duration, minimum manned crews, go/no-go pill implementation and potential decreased experience in the Aircrew and Parachutist community have the potential to widen the operational safety gap and increase the risk to achieve overall mission success. AP HAAMS technicians need to increase their presence and capacity to bridge the gap as demands increase. Air Mobility Command and JB Charleston have been authorized additional HAAMS manpower positions to double the overall unit manning to meet increased operational requirements and tempo. Additionally, updated HAAMS operational guidance via AFMAN 11-409 is routing for approval and will mirror Aircrew requirements. The additional manning positions are needed to support increased mission requirements and updated guidance to outline HAAMS 1H/13H upgrade training requirements. Additionally, further clarification is required on what other entities within the DoD should or can perform HAAMS duties on non-Air Force aircraft or involving non-Air Force personnel. **DISCUSSION:** What are the limitations to the human body with regards to time, fatigue, situational awareness, and cognitive limitations as it pertains to operational decision making in regard to risk reduction and management as we draft OPLANs to fight in INDOPACOM? Can the Air Force safely support single pilot, single load master on an extended duty day, operating on go pills, dropping a US ARMY SOF team in INDOPACOM? Highly trained HAAMS personnel are critical to safe mission execution, are HAAMS personnel still operationally effective after a 48-hour transport in the back of a C-17?

Learning Objectives

1. Understand the potential for increased AMC ops tempo and increased parachutist ops within SOF.
2. Understand the potential for increased human error with decreased experience, decreased crew compliment and increased go/no-go pill usage.
3. Understand the safety role that AP HAAMS technicians provide to bridge the gap between Aircrew and Parachutist.

[267] U-2 PHYSIOLOGICAL SUPPORT TECHNICIANS – BETWEEN LIFE AND DEATH

Michael Heatherly, Jimmy Sayarath
U.S. Air Force, Beale AFB, CA, United States

(Education - Program/Process Review)

BACKGROUND: Since the first days of operating the U-2 in 1955, physiological support technicians have kept aircrew safe--from inspecting life support equipment to dressing and integrating pilots inside the cockpit of the aircraft. As time progressed, technology advanced, and equipment was upgraded but the Physiological Support Squadron is still conducting the same job with a lot of the same equipment from U-2 inception. Despite antiquated equipment and low manning, they keep the High-Altitude Intelligence, Surveillance, and Reconnaissance mission alive worldwide providing vital intel to Higher Headquarters and our allies. **OVERVIEW:** Physiological support technicians are an elite cadre of specially trained Aircrew Flight Equipment and Aerospace Physiology personnel. The Physiological Support Squadron houses the Air Force's only depot, maintenance, training, and utilization for space suits. These experts are responsible for sizing all pilots, maintaining the space suits and sub-assemblies, donning and doffing the pilot's space suit, and integrating the pilot into the aircraft every flight. They also maintain the personal egress and survival equipment used with the U-2 airframe. Although the aircraft and sensors have improved over the U-2's seventy-year life, the systems and technology protecting the human remain largely unchanged creating unique challenges. **DISCUSSION:** The men and women of the 9th Physiological Support Squadron adapt and overcome these obstacles through innovation, dedication, and the leveraging of relationships with the System Program Office, Original Equipment Manufacturers, and pilots. This panel will explore this unique mission set and what it takes to safely launch pilots to the edge of space every day despite the inherent challenges.

Learning Objectives

1. The audience will lean about the 9th Physiological Support Squadron and how they are accomplishing the mission given with outdated equipment.
2. The participants will be able to understand the skillsets our Airmen at the 9th Physiological Support Squadron gain while performing the duties.

Wednesday, 05/24/2023 ***10:30 AM***
Grand Ballroom A-B-C

[S-51]: SLIDES: TO INFINITY AND BEYOND

Chair: Jaime Rivas-Harvey

[268] A COMPUTATIONAL MODEL OF MOTION SICKNESS DRIVEN BY SENSORY CONFLICT FROM SPATIAL ORIENTATION PERCEPTION

Aaron Allred, Torin Clark
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Most astronauts experience motion sickness upon transitioning to a microgravity environment from Earth and particularly upon returning to Earth following extended exposure to microgravity. To improve crew health and performance during future NASA exploration class missions, more effective countermeasures to motion sickness must be developed. However, effective motion sickness countermeasures are not always intuitive (e.g., in some instances, the addition of 'countermeasures' such as the addition of visual cues and various behavioral approaches may result in more motion sickness). In order to better predict motion sickness severity, a computational model of motion sickness is necessary. Previous motion sickness models have placed a decreased emphasis on the spatial orientation perception stage for the processing of sensory conflict to drive motion sickness and instead have relied on model predictions of motion sickness (commonly motion sickness incidence) alone to dictate model accuracy. **METHODS:** Our motion sickness severity model is driven by sensory conflict resulting from a perceptual model validated across several motion paradigms (i.e., the "observer model" for spatial orientation perception during passive motions). The downstream motion sickness dynamic pathways are based on Oman's heuristic model with modified parameters to achieve characteristic emetic responses across motion frequencies. To determine how the individual conflict components from the perception processing should be rectified and weighted for input into the motion sickness dynamics, weighting terms were fit via an optimization scheme using existing motion sickness data for passive motions as ground truth data. **RESULTS:** With passive motion over time as an input, the model produces predictions of motion sickness severity, dependent on specific sensory conflict signals from the observer model. Additionally, the model captures previously noted motion frequency dependencies, and the severity can be mapped to common reporting metrics, such as the Misery Scale (MISC). **DISCUSSION:** Following model predictions motion sickness, this cohesive model enables further development of countermeasures for motion sickness during passive motions. Furthermore, this model can produce motion sickness severity predictions from conflict arising from an altered or adapting sensorimotor state such as that experienced by astronauts adapting to gravity transitions.

Learning Objectives

1. Understand the role of individual sensory conflicts, from the Observer model, in contributing to motion sickness.
2. Explore how to optimize a computational model of motion sickness for various reporting scales.
3. Computationally predict motion sickness for arbitrary passive motions.

[269] ASTRONAUT TRAINING AND ANALYSIS OF SLEEP AND PERFORMANCE DURING THOR SPACE ANALOG SIMULATION

Marian Farfan, Diego L. Malpica
Colombian Air Force, Bogota, Colombia

(Original Research)

INTRODUCTION: Human exploration of space beyond Low-Earth Orbit will require crews to stay under isolated, confined, and extreme (ICE) environments with restricted resources and limited mission control support while maintaining optimal performance, being critical for mission safety and success. We aim to investigate the possible effects of sleep patterns, fatigue, and emotions on cognitive performance in five crewmembers on a six-day campaign for a Lunar mission as part of The Human Operation Research space analog. **METHODS:** Data collection began five days before launch and continued for six days in the space analog habitat. We ran daily psychomotor vigilance task (PVT) tests using NASA PVT+ on an iPad which objectively assessed reaction time and also gathered crewmember's self-reports of sleep-wake behaviors and fatigue. In addition, sleep and activity patterns were permanently monitored with wrist-worn actigraphy with scheduled nighttime sleep and day-work hours (within-subject design). The Positive and Negative Affect Schedule (PANAS) scale was also used to assess emotions daily. **RESULTS:** Although the average individual sleep duration was 7.65 ± 0.8 h, there was substantial sleep deprivation during the second and primarily on the fourth day of the campaign, with significantly less accurate psychomotor vigilance on the same days. In the survey, subjects reported significantly worsening mood during the days of reduced sleep time on several affective domains. **DISCUSSION:** The results suggest that sleepiness, fatigue, and emotions affect the cognitive performance of crewmembers during a space analog mission. These findings underline the importance of managing the cumulative effects of sleep-deprived crews and enhancing coping strategies for positive adaptability to improve efficiency on critical tasks in isolated, confined, and extreme (ICE) environments.

Learning Objectives

1. The participant will understand the effects of negative affection on total sleep time, restless sleep, and reaction time in a Lunar analog simulation.
2. The audience will understand further how emotional factors may impact crewmembers' performance in a Lunar analog simulation.

[270] USING MARKERLESS MOTION CAPTURE IMAGING FOR THE FUNCTIONAL ASSESSMENT OF ASTRONAUTS BEFORE, DURING AND AFTER SPACEFLIGHT

Douglas Hamilton
University of Calgary, Calgary, AB, Canada

(Original Research)

INTRODUCTION: Recent advancements in markerless motion capture and analysis technology along with the science of 'Clinical Biomechanics', clinicians can now measure and treat their patients with observations which are automated, accurate and objective compared to the previous methods of subjective observation and primitive measurement techniques such as goniometers. **METHODS:** Our motion lab utilizes an 8-camera "markerless" 3-dimensional motion capture system solution that can perform a whole-body examination in 15 – 30 minutes. The research team has adapted the Theia3D™ technology to employ lower cost high resolution cameras and a user interface for clinical medicine and occupational therapy environments to create a portable motion capture capability. This research was compliant with all appropriate ethics, privacy and security procedures and protocols. (i.e. Conjoint Health Research Ethics Board of the University of Calgary). **RESULTS:** This system now has a normative motion database which uses temporal and spectral autocorrelation to time align the total body motion and gait of 40 subjects. This system is unique in that it measures joint and limb range of motion and temporally tracks in 3-dimensions, the whole-body motions used by the participant to achieve these ranges. This study created the world's first normative waveform database for over 50 standard physiotherapy/kinematic motions commonly used for body motion analysis. **DISCUSSION:** Mulavara et al* performed seven functional tests to investigate the sensorimotor, cardiovascular, and neuromuscular adaptations to spaceflight. We are proposing to perform markerless image capture and analysis of functional testing pre/post spaceflight and on the ISS during treadmill, bicycle ergometer and ARED training. Over time, statistical tracking of an astronaut's career can be measured with reference against themselves or our normative data set. As our data set grows this normative waveform database is being expanded to include risk cohorts according to age, body habitus, gender, mechanism of injury, treatment, or pathology such as lower back injury. *Mulavara et al Pysiological and Functional Alterations after Spaceflight and Bed Rest. Med. Sci. Sports Exerc., Vol. 50, No. 9, pp. 1961–1980, 2018.

Learning Objectives

1. The audience will learn how clinicians can now measure and treat their patients with observations of motion which are automated, accurate and objective compared to the previous methods of subjective observation and primitive measurement techniques such as goniometers.

2. The audience will learn how the research team created the world's first normative waveform database for over 50 standard physiotherapy/kinematic motions commonly used for body motion analysis.
3. The audience will learn how this motion capture technology can be used for the statistical tracking of an astronaut's motion over their career with reference against themselves or our normative data set.

[271] MEDICINE, MOON, AND MOTIVATING THE ARTEMIS GENERATION: ELEVEN TIPS FOR EFFECTIVELY ENGAGING AUDIENCES

Jason-Flor Sisante[1,2]
[1]*Kansas City University, Kansas City, MO, United States;* [2]*NASA Jet Propulsion Laboratory Solar System Ambassadors, Kansas City, MO, United States*

(Education - Tutorial/Review)

INTRODUCTION: The Artemis program heralds the new age of human space exploration. The technological vanguard and historic goals of Artemis offer an opportunity to boost interest in the STEM fields, particularly in aerospace medicine, across global audiences. This case study provides eleven tips garnered from a decade's worth of presentations about Artemis' component programs. These tips may be useful in engaging audiences as our return to the moon approaches. **TOPIC:** The ambitious Artemis program aims to send the first woman and the first person of color to the surface of the moon, establish a lunar outpost, and assemble an orbiting lunar space station. It is the foundation for future deep exploration missions. Thus, with the unique challenges of the program arousing the general public's interest in space exploration, aerospace medical professionals have a unique opportunity to leverage this excitement and spur interest in the biomedical sciences and other STEM fields. **APPLICATION:** To successfully engage a wide variety of audiences, aerospace professionals should: (1) highlight the unique intersection among aerospace engineering, medicine, isolated environments, and exploration; (2) leverage social media and mass media outlets; (3) show the inherent joy of the scientific endeavor through fun demonstrations; (4) create an atmosphere contradictory to the typical lecture; (5) collaborate with non-scientific experts and artists; (6) practice respectful, but ardent, debunking of conspiracy theories; (7) advertise the technological advancements developed from space agencies; (8) individually engage local and national STEM pipelines by speaking and volunteering at schools, colleges/universities, public libraries, and science fairs/competitions; (9) use virtual meeting spaces and movie production software to reach faraway audiences; (10) tactfully use humor to emphasize key points; and (11) distill their professional expertise into lay language. At the dawn of our lunar return, the aerospace medical community is in an exclusive position to address the public's interest in both the cosmos and the human body. Through inspiring, informative, and interesting outreach, aerospace medical professionals can influence the next cadre who will push the future phases of exploration and clinicians and scientists who will push medical knowledge.

Learning Objectives

1. The audience will learn how to enhance their public presentation skills.
2. The audience will learn how to uniquely advocate for STEM pipelines and engage these pipelines.

[272] INTEGRATED VIRTUAL REALITY VISUALIZATIONS AND INFORMATION DISPLAY TO UNDERSTAND UNCERTAINTY IN TRAINING FOR SPACEFLIGHT OPERATATIONS

Savannah Buchner, Noah Abeson, Jennifer Wood, Hanspeter Schaub, Allison Anderson
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: With the planned increase in on orbit operations, such as satellite service and repair, there is a need for easy-to-interpret displays for complex missions. Human operators will assist in tasking on-orbit activities and act as supervisors to autonomous systems, aiding them in making decisions and executing actions. Humans will be separated both spatially and temporally from the spacecraft and will be required to process complex data. Operators will need to understand how small uncertainties in planned actions, such as a potential imperfect thruster burn or noisy sensor readings, can impact future states to make appropriate operational decisions. Thus, effective training is needed. Virtual reality can provide immersive, high fidelity, realistic simulations of the environment, but little work has been done in the realm of spaceflight operations and remote supervision. **METHODS:** We developed a simulation of a servicer satellite in proximity operations around a dead target satellite using Basilisk, a high-fidelity physics-based spacecraft simulation tool. Uncertainties are introduced through simulated imperfect thruster burns and noisy sensor readings. These uncertainties propagate and impact the future states of the satellites, leading to collision possibilities between the two simulated satellites. The simulation is visualized using Unity and an HTC Vive headset and controls to create an immersive visualization of proximity operations. Operators can see the states of satellites, actions with their associated uncertainties and impact on future states, and a host of other displayed information. **RESULTS:** Human factor approaches were used to identify appropriate choices of displays and visualization to convey information to the operator. The best practices from traditional 2D displays are combined with the immersive experience that VR provides to facilitate understanding of the environment, uncertainties, and their importance. Operators can change their viewpoint to better understand the relative orientations, drawing from immersive display benefits, as well as toggle on or off pieces of information designed with traditional display philosophies, as desired. **DISCUSSION:** We assess usability through user evaluations to evaluate the approaches taken and their effectiveness at conveying the information in an appropriate way to improve operators understanding on the environment and impacts of uncertainty in the operational environment.

Learning Objectives

1. The audience will learn about using virtual reality to train operators on the impact of uncertainties on spacecraft operations.
2. The audience will learn about integrating the human factors of virtual reality and traditional 2D aerospace display design.

[273] TO MARS AND BEYOND: PARKINSON'S DISEASE IN THE AGE OF COMMERCIAL SPACE TRAVEL

William Hoffman
Brooke Army Medical Center, San Antonio, TX, United States

(Education - Case Study)

INTRODUCTION: A theoretical case of a 61-year-old male with past medical history of medically managed Parkinson's Disease with mild tremor and bradykinesia, mild orthostatic hypotension and REM sleep behavior disorder who presents to the outpatient neurologic clinic for evaluation prior to commercial space travel at the direction of the commercial space company. **BACKGROUND:** Commercial space operations are expected to increase the pool of eligible space travelers, to include patients with chronic neurological disorders such as Parkinson's Disease. Commercial space companies are directing patients to their primary and specialty care physicians for medical optimization prior to space travel, but there is limited data to guide the management of certain neurological disorders in the space environment. Parkinson's Disease is among the most common neurodegenerative disorders with diverse manifestations potentially worsened in the space environment. We propose an approach for medical optimization of the commercial space traveler with Parkinson's Disease. **CASE PRESENTATION:** The patient underwent evaluation in the neurology clinic focused on (1) motor symptoms, (2) orthostatic hypotension, and (3) REM sleep behavior disorder with the space environment in mind. The presenter will also suggest other topics of counseling to include helping a patient select a medically appropriate mode of space travel, pre-travel preparation and safety planning. **DISCUSSION:** Commercial space travel is expected to increase the number of eligible travelers, to include patients with Parkinson's Disease. The current proposed case and

discussion are intended for the non-aerospace neurologist seeing patients wishing to participate in commercial space travel.

Learning Objectives

1. Identify medical-legal considerations for the neurologist caring for a patient wishing to participate in commercial space travel.
2. Describe three aeromedical considerations for commercial space travel in a patient with Parkinson's Disease.

Wednesday, 05/24/2023 ***10:30 AM***
Grand Ballroom D-E

[S-52]: PANEL: FORTIFYING COMPREHENSIVE MEDICAL READINESS PROGRAM FOR FLIGHT SURGEONS

Chair: Anthony Waldroup
Co-Chairs: Jason Burchett, Douglas Files

PANEL OVERVIEW: *Background: Flight medicine professionals often perform duties in sites outside their normal workplace. Military and civilian aerospace medicine providers prepare to work in alternate sites much of the time. Overview: This panel includes discussions of solid practices in performing those duties in a deployed setting. Additionally, the current panel and its sister panel renew U.S. Air Force flight surgeons' Comprehensive Medical Readiness Program (CMRP) requirements to make them as ready as possible to perform deployed duties. Discussion: Sessions in this panel will involve travel medicine, mass casualty response, in-flight physiologic emergency response and aeromedical evacuation of sick patients, along with other relevant topics. Participants update their knowledge and consider whether they can incorporate good practices from other bases in their next deployment.*

[274] FORTIFYING PREVENTION AND TRAVEL MEDICINE

Cady Blasser, Douglas Files, Jason Burchett
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Aerospace medicine providers support flying operations that affect the safety of populations supporting the flying mission. However, airfield operations are not always in the nation of origin, thus flight surgeons and the people they support need to be prepared to deploy worldwide. This discussion will encourage aerospace medicine professionals to maintain currency by participating in travel medicine briefings and administrative tasks. **OVERVIEW:** Regular responsibilities of flight surgeons include serving as the medical expert on travel health issues. This task is complicated by the wide variety of locations where airfield operations can occur. Medical travel guidelines are always changing. Emerging technology may also be involved. This program will prepare aeromedical professionals to participate in travel medicine briefings and clinical tasks such as the prevention of tropical diseases. **DISCUSSION:** Safety risks to aircrew have increased with global travel, which was particularly experienced in the recent pandemic. Risks are so high that currency in travel medicine must include regular participation in briefings and administrative tasks. Numerous venues exist for flight surgeons to mitigate health risks. This program offers international aerospace medicine specialists an opportunity to incorporate some of the latest medical guidelines along with tips and techniques.

Learning Objectives

1. Study updates regarding deployed flight medicine tasks and medications for travel.
2. Discuss good practices for patient care and travel medicine in a deployed environment.
3. Renew USAF requirements for the flight surgeon Comprehensive Medical Readiness Program (MCRP).

[275] FORTIFYING MASS CASUALTY RESPONSE

Mitchell Radigan, Jason Burchett, Douglas Files
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Enterprising aerospace medicine professionals provide mishap response capability including for aircraft crashes and potential mass casualty scenarios. This presentation encourages professionals to maintain currency by participating in a response exercise. **OVERVIEW:** Aerospace medicine professionals are first-in and may be last-out during disaster relief operations. They analyze the medical aspects of toxic and hazardous materials used on an airfield and they consult on hazardous spills. They may respond to aircraft mishaps, caring for the initial responders as well as those directly injured. This vibrant program will update aeromedical professionals on response issues by providing an opportunity for individuals to participate in a mishap exercise involving a crash or other disaster scenario. **DISCUSSION:** Remaining current in disaster response requires recurring training. Aerospace medicine professionals will improve their understanding of the subtleties of dealing with other airfield organizations (i.e. - fire dept, civil engineering, etc), with federal authorities, and with local facilities that interact with the airfield during disaster responses. Participants will study and discuss the latest disaster response information.

Learning Objectives

1. Discuss the features of investigating a mass casualty or other disaster situation.
2. Interface with military and civilian authorities during a disaster scenario.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

[276] FORTIFYING IN-FLIGHT PHYSIOLOGIC EMERGENCY RESPONSE

Charles Shurlow, Jason Burchett, Douglas Files
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: One common duty of aerospace medicine practitioners is to treat aircrew who suffer physiologic problems in flight. This presentation will use simulated patient cases to train flight surgeons and allied professionals in physiologic emergency response. **OVERVIEW:** Aerospace medicine personnel specialize in the effects of normal physiology in abnormal environments. This program will reinforce in aeromedical professionals' minds how to respond to a physiologic incident. **DISCUSSION:** U.S. military services may require annual updates regarding physiologic incident response. Flight medicine personnel from other nations and from civilian organizations will also benefit. Flight surgeon instructors will demonstrate how to discuss aircrew issues and potential physiologic causes, and also how to treat a patient. This physiologic response discussion will offer flight surgeons an opportunity to learn about responses, incorporating the latest physiologic response information.

Learning Objectives

1. Consider the features of military physiologic incidents, especially in a deployed setting.
2. Interact with other organizations to treat injured aircrew and investigate what occurred during an aviation physiologic incident.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

[277] FORTIFYING AEROMEDICAL EVACUATION

Jason Burchett, Douglas Files
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Practitioners of aerospace medicine commonly oversee the safety of patients in flight. They may also medically clear patients being transported in an aeromedical evacuation system. The current presentation will encourage professionals to maintain currency by performing medical clearances for simulated aeromedical evacuation patients. **OVERVIEW:** Professionals in aerospace medicine specialize in the physiologic effects of flight at altitude. At times, patients with compromised physiology may also be flown. This program will help flight surgeons protect patients being transported in aeromedical evacuation systems. One example might be a patient with pain issues being transported. **DISCUSSION:** Some U.S. military services require recurring training for flight surgeons. Yet some flight surgeons have never participated in aeromedical evacuation cases. This program will give aerospace medicine professionals an opportunity to participate in the medical clearance of simulated aeromedical evacuation patients. It will cover the latest trends and techniques and will be beneficial to all attendees participating in the session.

Learning Objectives

1. Discuss specific features of military aeromedical evacuation out of a deployed setting, transporting patients back to a higher level of care.
2. Interface with other organizations to prepare injured persons for air transport in an aeromedical evacuation situation.
3. Renew Comprehensive Medical Readiness program requirements for the flight surgeon career field.

Wednesday, 05/24/2023 ***10:30 AM***
Grand Chenier

[S-53]: PANEL: IANC AEROSPACE NEUROLOGY PANEL

Chair: Joseph Connolly

PANEL OVERVIEW: *Major goals of Aerospace Neurology, as in all of Aerospace Medicine, include flight safety, mission accomplishment and well-being of aviators and passengers. In this panel we will explore in-flight incapacitation from Transport Canada with the view of using Artificial Intelligence to predict and prevent in-flight incapacitation. This will be followed by a presentation on in-flight incapacitation from the FAA perspective, covering difficulties in medical certification and Special Issuance. Benign Paroxysmal Positional Vertigo (BPPV) can be a cause of sudden incapacitation, disorientation or distraction in flight. We will review the USAF aeromedical waiver program for BPPV through the lens of the published rates of BPPV recurrence and the USAFSAM Aeromedical Consult Service Medical Assessment and Airworthiness Matrix (AMRAAM) versus the actual recurrence rate of BPPV in USAF aviators with waivers compared with the AMRAAM. Cervical disc arthroplasty is a commonly-used procedure, but as these implanted devices have not been adequately proven in the high-G environment and pose a risk for sudden incapacitation, their use is not approved by most militaries for high performance jet pilots. We will review the USAF experience with this setting. Certification challenges from neurologic injuries such as traumatic brain injury (TBI) and cerebral vascular accidents (CVA) focus on subsequent seizure risk (incapacitation) from TBI and CVA recurrence and post CVA seizure risk. We will explore why published seizure rates after TBI by severity and post CVA as well as CVA recurrence may over-estimate the risk for the military aviator population.*

[278] A REVIEW OF CRITICAL INCIDENTS CAUSING SUDDEN NEUROLOGICAL INCAPACITATION OF AIRCREW IN FLIGHT. CAN AI SYSTEMS MITIGATE THE RISK OF FATAL OUTCOMES?

Christopher Skinner
University of Ottawa, Ottawa, ON, Canada

(Education - Tutorial/Review)

The objective of this presentation is to explore the different types of sudden neurological incapacitation of pilots in flight. These events are rare but the process of evaluating the effects of these critical events on cockpit operations is lacking. Feedback from agencies investigating accidents due to possible neurological causes should be an essential part of developing evidence based regulatory processes. The presentation will illustrate several different scenarios of neurological incapacitation including the analysis of a case of probable sudden incapacitation of unknown cause. Several other conditions such as seizures, migraine and stroke in the cockpit will be also discussed. The development of AI systems to warn or intervene in such situations using non-invasive sensing systems might assist in mitigating the risk of fatal outcomes and assist aviation safety regulators in development of advanced risk assessment methodologies.

Learning Objectives

1. Discuss different types of sudden neurological incapacitation of pilots in flight
2. Discuss the shortcomings of the current review process of accidents ascribed to sudden incapacitation of unknown cause
3. Discuss several different scenarios of incapacitation including seizures, migraine

[279] INFLIGHT INCAPACITATION CASE STUDIES

Richard Ronan Murphy[1], Farhad Sahiar[1], Roger Hesselbrock[2]
[1]*FAA, Oklahoma City, OK, United States;* [2]*FAA, Dayton, OH, United States*

(Education - Case Study)

INRODUCTION: We are presenting illustrative cases highlighting the neurology and aerospace physician's approach to in-flight incapacitation and medical certification. **BACKGROUND:** In-flight events of sudden incapacitation may occur with or without a mishap or accident, but nonetheless pose a serious risk for aviation safety. Numerous medical and physiological reasons exist for sudden incapacitation, all the more so in the aerospace environment. Identification of neurologic or other conditions against this backdrop is challenging. Neurologists are often tasked to help determine the root cause, the risk for recurrence and potential risk mitigation. **CASE PRESENTATION:** Case studies of in-flight incapacitation, evaluated for aeromedical certification, are presented that highlight: 1) Information sources that may be used, and how such information may be obtained, 2) Critical history elements and confounds, 3) Use of ancillary testing. **DISCUSSION:** Determination of aeromedical risk is often challenging in such cases due to incomplete, inaccurate or contradictory information provided post-event. Methodological approaches to improve diagnostic efficiency and accuracy emphasize obtaining first hand, objective and timely historical reports, and consider "drift" in history when information is obtained more temporally remotely from the event. We will also discuss the approach to dealing with persisting uncertainty after events of incapacitation from the aeromedical certification perspective, to include mitigation of risk over time, as well as the timing and usefulness of clinical evaluations and testing.

Learning Objectives

1. The audience will learn about Information sources that may be used in the evaluation of aeromedical risk in cases of in-flight incapacitation, and how such information may be obtained.
2. The audience will learn about critical history elements and confounds in the evaluation of aeromedical risk in cases of in-flight incapacitation.
3. The audience will learn about use of ancillary testing in the evaluation of aeromedical risk in cases of in-flight incapacitation.

[280] AEROMEDICAL CONSULTATION SERVICE MEDICAL RISK ASSESSMENT & AIRWORTHINESS MATRIX AND USAF BENIGN PAROXYSMAL POSITIONAL VERTIGO WAIVER PROCESS REVIEW

John DiModica[1], Roger Hesselbrock[2], Aven Ford[2], Michael Lang[3], Glenn Nagasawa[2], Jared Haynes[2], Joseph Connolly[2]
[1]*Wright State University Boonshoft School of Medicine, Centerville, OH, United States;* [2]*Aeromedical Consultation Service, Dayton, OH, United States;* [3]*Epidemiology Consult Service, Dayton, OH, United States*

(Original Research)

BACKGROUND: The U.S. Air Force School of Aerospace Medicine (USAFSAM) developed a conceptual framework for a risk matrix approach to evaluating and communicating aeromedical risk; this resulted in the Aeromedical Consult Service (ACS) Medical Risk Assessment and Airworthiness Matrix (AMRAAM). Prior to implementation, the ACS conducted a study to evaluate results using the AMRAAM to results using the legacy ACS risk assessment process; this study included a re-analysis of multiple cases from each specialty represented within the ACS using the AMRAAM. Using available BPPV recurrence data, rates of 15-18% at 1-year and up to 50% in 5-years from the general population, pilots with BPPV did not meet Airworthiness criteria. Applying the AMRAAM to BPPV the likelihood of recurrence is considered Occasional and severity level is considered Catastrophic, resulting in an aeromedical risk score of 4 representing High risk which does not support waiver. This prompted a review of the BPPV waivers issued and outcomes. **DESCRIPTION:** A review of waivers for BPPV from the Aeromedical Information Management Waiver Tracking System (AIMWTS) powered a study to determine the true rate of recurrence for Benign Paroxysmal Positional Vertigo (BPPV) among the US Air Force aviator population. 60 aviators (284 person-years) were included in the final data analysis. Mean age at initial waiver was 36.8 (SD=7.3) years and mean follow-up time was 56.8 (SD=50.2) months. The median time of observation from known resolution to the first aeromedical waiver for BPPV was 6 months (n=50). In total, there were 6 (10.0%) recurrences of BPPV. There were no recurrences in one year (N=60) and six recurrences (24%) over 5 years. Our Kaplan-Meier curve calculated BPPV recurrence-free probability at 85% across 20 years, 95% CI [0.69-0.93]. Post review AMRAAM for BPPV changed the occurrence to Remote with a score of 8-10 representing Serious -Medium risk supporting possibility of waiver. **DISCUSSION:** The differences in outcome may be due to social determinants of health, comorbidity, ascertainment criteria and observation period after recovery before waiver. This program review demonstrates the need for military aviator specific outcome data to predict aeromedical risk and airworthiness in the military aviator population.

Learning Objectives

1. The audience will learn how data from aeromedical databases were used to improve aeromedical risk assessment for cases of Benign Paroxysmal Positional Vertigo (BPPV) in an aviator population.
2. The audience will learn to use raw data from aeromedical databases for the Aeromedical Consult Service (ACS) Medical Risk Assessment and Airworthiness Matrix (AMRAAM).
3. The audience will be able to design studies that target data specific to aviator populations for more pertinent aeromedical risk assessment.

[281] SPINAL DISC ARTHROPLASTY OUTCOMES IN U.S. AIR FORCE AVIATORS: A CASE SERIES

Roger Hesselbrock
FAA, Dayton, OH, United States

(Original Research)

INTRODUCTION: Artificial disc replacement is the standard surgical option for younger patients with intervertebral disc disease. Military aviators with spinal disc arthroplasties have routinely been granted aeromedical waivers for non-high-performance or ejection-seat aircraft operations. However, arthroplasty devices have not been sufficiently tested for stress levels encountered in high-performance aircraft operations or aircraft ejection, which has limited their utility for these aircrews. The U.S. Air Force recently implemented an evaluation process to grant short-term unrestricted waivers to selected aviators with single-level cervical disc arthroplasty. The primary aim of this study was to assess outcomes in military aviators with artificial disc replacement compared to legacy procedures such as spinal fusion. The secondary aim was to specifically review the outcomes of high-performance aircraft crew with single-level cervical disc arthroplasties. **METHODS:** A retrospective record review was performed on 55 military aviators with spinal disc arthroplasty and 73 military aviators who underwent standard surgical procedures, such as spinal fusion. Flight-hour information was obtained for the arthroplasty subjects. Statistical Analysis was performed using SAS Enterprise Guide® software. Descriptive statistics (Odds Ratio, p-values) were calculated for each variable of interest. **RESULTS:** Average follow up ranged from 1.8 years in high-performance aircrew with single-level cervical disc arthroplasties to 8.1 years for all aviators with legacy procedures. The reoperation rates were comparable between groups. The arthroplasty group had over 6,300 flying hours, including 375 high-performance hours in cervical arthroplasty subjects. Ten single-level cervical disc arthroplasty patients were granted waivers for unrestricted or less restricted flying. No adverse outcomes were noted in this group. **DISCUSSION:** Overall, spinal disc arthroplasty was found to be equivalent to the standard spinal procedures. Single-level cervical disc arthroplasty devices had an uneventful performance in limited follow-up of high-performance aircraft subjects. Correlation with arthroplasty device structural testing is recommended to further validate safety under high-performance aircraft operational stresses.

Learning Objectives

1. The audience will become familiar with aeromedical safety concerns of cervical disc arthroplasty in high performance aircraft operations.
2. The audience will be able to note outcome information in aviators with cervical disc arthroplasty.
3. The audience will become familiar with future studies to assess disc arthroplasty performance under high +Gz stresses.

[282] WHY MILITARY AVIATOR POPULATION NEUROLOGIC OUTCOMES RESEARCH IS ESSENTIAL IN AEROSPACE MEDICINE, SOCIAL DETERMINANTS OF HEALTH ARE A THING!

Joseph Connolly
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

BACKGROUND: Aeromedical concerns after a neurologic event and recovery can be the recurrence of the event such as another stroke or new remote sequalae such as a seizure after traumatic brain injury (TBI) or stroke (CVA). Rates of neurologic event recurrence and sequelae are gleaned from the general population neurologic literature. The recurrence data is then put into a risk acceptance scheme such as the 1% rule or the USAFSAM Aeromedical Consult Service (ACS) Medical Risk Assessment and Airworthiness Matrix (AMRAAM), and an aeromedical recommendation is made. This process ignores the social determinants of health, baseline health and near complete recovery affecting the neurologic event in a military or professional aviator and so likely over-estimates the aeromedical risk. **DESCRIPTION:** Common social determinants of health are socioeconomic status, being subject to racism, gender, housing, neighborhoods, access to healthy food, transportation, education, employment and social support networks. Most military members have favorable social determinants of health, with some stratification by rank, likewise most professional pilots have favorable social determinants of health. We will explore the effect of social determinant of health on traumatic brain injury recovery, stroke rates, stroke outcomes, the incidence of epilepsy and low back pain outcomes. **DISCUSSION:** To estimate the risk of stroke recurrence or seizure in a pilot who has experienced a CVA or TBI requires a study population with specific characteristics that mirror a pilot's social determinants of health and the pilot's recovery from the neurologic event. The ideal study population would have high educational attainment, uniformly excellent health, meeting medical standards, adequate socioeconomic status, decreased discrimination based on race or gender, adequate housing, have good employment and social support networks. Importantly, regardless of the severity of the neurologic injury the subjects in the study population would need to make a near complete recovery and demonstrate the ability to maintain significant employment. Military aviators, or as a surrogate officers, who remain on active duty after a TBI or CVA are the ideal populations to study, to estimate the risk of stroke recurrence or seizure after TBI or CVA in a pilot.

Learning Objectives
1. The audience will learn about the effect social determinants on outcomes from TBI.
2. The audience will learn about the risk of a new diagnosis of epilepsy by occupation in the military.

Wednesday, 05/24/2023 ***10:30 AM***
Napoleon Ballroom C1-C2

[S-54]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS II

Chair: Serena Aunon
Co-Chairs: Thomas Jarnot, Jonathan Elliot

PANEL OVERVIEW: *Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.*

[283] WHAT FACTORS SHOULD FLIGHT SURGEONS CONSIDER FOR PREGNANT PASSENGERS FLYING ON MILITARY AIRCRAFT?

Jesse Schonau[1], Jeffrey Brown[2]
[1]*U.S. Navy, Pensacola, FL, United States;* [2]*U.S. Army, Fort Rucker, AL, United States*

(Education - Case Study)

Flight surgeons need to consider all the pertinent factors when making recommendations for pregnant women flying on military aircraft as pilots, crew, and passengers. This presentation will use a patient case to review the literature and discuss the military service specific guidelines as well as other civilian guidelines flight surgeons can reference to provide medical recommendations to enhance crew and passengers safety and protect mission integrity when pregnant passengers fly on military aircraft. It will also emphasize the need for the United States Department of Defense to establish a standard to guide military flight surgeons in the decision making process.

Learning Objectives
1. Understand there is no comprehensive guideline covering all the military services that discusses when pregnant patients should be allowed to fly on military aircraft as pilots, crew, or passengers.
2. Understand that military flight surgeons will need to use multiple resources including service specific guidelines and civilian guidelines to make recommendations about when pregnant patients should be allowed to fly on military aircraft.

[284] A CASE OF ALTERNOBARIC-STABLE DECOMPRESSION SICKNESS FROM NASA'S EXPLORATION ATMOSPHERES STUDY

Kristi Ray[1], Isaiah Reeves[1], Robert Sanders[2], Leisa Deutsch[1]
[1]*UTMB, Galveston, TX, United States;* [2]*NASA JSC, Houston, TX, United States*

(Education - Case Study)

INTRODUCTION: This case report describes a research test subject who presented with pressure-resistant Decompression sickness (DCS) symptoms during NASA's Exploration Atmosphere Study. **BACKGROUND**: Exploration Atmosphere is NASA's study to validate prebreathing protocols for planetary EVA's. Subjects lived at a pressure of 8.2 psi and had excursions to 4.3psi for simulated EVAs during a 3 and 11-day study. DCS is a risk due to pressurization changes. Type 1 DCS most commonly presents as joint pain, and type 2 DCS commonly includes more complicated and severe neurological and cardio-pulmonary manifestations. The accepted DCS risk based on computer calculations is <15% risk of type 1 DCS with no cases of type 2 DCS. Case: A 34 y/o male presented with the development of multiple joint pain >24 hrs after return to sea level. The subject participated in the 11-day study and completed 5 excursions to 4.3psi with no issue. The joint pain started in the bilateral elbows, gradually progressing to include bilateral knees. The pain was described as a deep ache, and did not get better with OTC medications. The subject was evaluated by the on-call physician and was diagnosed with Type 1 DCS. Due to the delayed declaration of DCS, this patient was treated with a USN TT5 at an outside facility. All pain resolved with treatment. **DISCUSSION:** This case represents an aviation/ hypobaric DCS with an interesting presentation that differs from commonly taught pathogenesis (changes in severity correlate with changes in ambient pressure) and stabilization when placed under hyperbaric conditions. The effect of habitation pressure on the natural history of DCS symptoms may be greater than originally thought. If this is the case then a change in nominal and contingency operations may need to occur as NASA prepares for the ARTEMIS missions back to the Lunar surface.

Learning Objectives
1. The audience will learn about NASA's exploration atmospheres and DCS risk.
2. The audience will learn about DCS presentation in hypobaric environments.

[285] DOC, WHY IS MY WRIST NOT GETTING ANY BETTER?

Ryan Thompson
Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: A 23-year old U.S. Student Naval aviator presented to the Aviation Medicine department with right wrist pain following golfing injury. This case study report reviews the work up and eventual diagnosis, as well as duty disposition decisions. **BACKGROUND:** Musculoskeletal complaints are incredibly common in the flight clinic and special care is needed examine joint involved, underlying cause, strength, mobility, and duty impact. All aircrew require strength and joint mobility to maintain aircraft stability and safety fight, especially in aircrew who experience +Gz forces or dynamic flight. **CASE PRESENTATION:** A previously healthy flight student presented to flight medicine for right wrist pain, swelling, and decreased range of motion after golfing 3 weeks prior and was sent to physical therapy for treatment. Conservative management for suspected TFC sprain showed no improvement, and subsequent MRI confirmed TFC tear, but also large joint effusions with significant synovitis/debris, multiple boney erosions, and marrow edema suggestive of inflammatory arthropathy. He showed minimal response to initial CSI and NSAID use and extensive rheumatology workup was performed to determine underlying diagnosis. He showed seronegative arthropathy (other than elevated ANA), and additional causes ruled out by laboratory testing. Synovial biopsies showed thickening/significant inflammation, but no evidence of infection or other process. New bilateral rash on extensor elbow surfaces showed psoriasis on biopsy. Therefore, he was diagnosed with psoriatic arthritis by CASPAR criteria and started on disease-modifying antirheumatic drugs for treatment. Given progressive nature of condition and location (stick hand) and side effects of treatment, the student was found not qualified for flight training and continued military service. **DISCUSSION:** This case highlights how the condition and treatment of psoriatic arthritis has significant implications on the deployability and continued flight status of aviators, especially when involving joints integral to flight control. While psoriatic arthritis may affect up to 30% of psoriasis patients, peak diagnosis is not until third to fourth decade of life. As it and other inflammatory arthropathies are progressive, irreversible conditions, recognizing and providing early treatment are essential to maintain quality of life and reduce disability. This is especially true in younger patients.

Learning Objectives
1. Participants will understand the basic workup and causes of undifferentiated early inflammatory arthritis in adults.
2. Learners will review aeromedical duty status eligibility in relationship to psoriatic arthritis.
3. Learners will consider additional occupational concerns in patients taking immunosuppressive therapies.

[286] NEED A HAND? HAND AMPUTATION WITH REPLANTATION IN A PILOT: A CASE STUDY

Dane Newell, Alexander Haley
U.S. Air Force, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case describes an aviator who sustained a traumatic hand amputation. Prompt medical and surgical intervention with extensive rehabilitation led to a positive outcome. **BACKGROUND:** Prior to William Balfour's successful digital replantation in 1814, traumatic amputation of digits or upper extremities was an irreversible injury with potentially catastrophic impact. Over the next 150 yr, surgical techniques and medical technology improved significantly, allowing for the first successful clinical replantations of upper extremities. Developing microsurgical techniques continued to improve outcomes, with successful replantation rates now exceeding 80-90% in some studies. **CASE PRESENTATION:** A 26-yr-old female pilot sustained a complete amputation of her left, non-dominant hand across the base of metacarpals after it was pulled through the blade of a table saw. Her spouse was home and placed a tourniquet over the wrist and put the amputated hand on ice. She was transported to the hospital and transferred to a hand replantation specialist for surgery. Successful replantation of the severed hand was performed within 5.5 hours after injury. The aviator underwent extensive rehabilitation with follow-up surgery to release palmar scar tissue. She remained at work performing administrative duties including participating in simulator duties during the recovery and non-flying period. A limited waiver was approved 11 mo post-injury, and she flew a 7-h B-52 sortie without issues. A 2-yr restricted Flying Class II waiver was approved and recently renewed as an unrestricted Flying Class II waiver. She is currently serving as a Reserve B-52 evaluator pilot and flying commercial cargo aircraft with no limitations from the injury. **DISCUSSION:** This case highlights how a catastrophic and seemingly career-ending loss of an upper extremity can be successfully treated. Effective pre-hospital interventions with rapid transfer to definitive care allowing for timely replantation, followed by intensive rehabilitation, optimized the patient's outcome, allowing her to regain function and continue a military aviation career. This case emphasizes the importance of both aviators and flight surgeons understanding what pre-hospital interventions should be taken, as well as the importance of rapid transfer to definitive care to allow for the best chance of successful replantation of an amputated upper extremity.

Learning Objectives
1. Describe proper techniques in preserving amputated limbs prior to replantation as well as timelines regarding ischemia of amputated limbs prior to replantation surgery.
2. Describe the Federal Aviation Administration processes for special issuance and Statement of Demonstrated Ability (SODA) in the civilian aviator.

[287] BUSTING THE MYTHS: A CASE STUDY ASSESSING THE RISK OF ASTHMA IN A FIGHTER PILOT

Shana Hirchert, Monica Pierce-Wysong
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case study describes a pilot with undetected asthma leading to an in-flight emergency. **BACKGROUND:** Asthma is a chronic inflammatory lung disease with common symptoms of dyspnea, shortness of breath, and cough, but it is often asymptomatic in athletic patients. An aviator with underlying asthma is at high risk of an exacerbation, particularly in high-performance aircraft. **CASE PRESENTATION:** A 31-yr-old male F-16 pilot presented to clinic after three physiologic in-flight emergencies. After the third incident involving shortness of breath at altitude as well as dizziness, pulmonary function tests were obtained that showed a moderate obstructive pattern. The aviator denied any symptoms of dyspnea or exercise intolerance. Lung function normalized with tobacco cessation and treatment with Fluticasone/Salmeterol. Based on his aeromedical risk, he was given a 1-yr Flying Class IIC waiver with limitations of no routine use of aviator mask, no high-performance aircraft, and flying only with another qualified pilot. His waiver requires pulmonary function tests every 6 mo and annual follow-up with Pulmonology. **DISCUSSION:** There is a high prevalence of asthma in elite athletes. Fighter pilots often have similar exercise routines that may predispose them to asthma in a similar fashion. These groups may experience dyspnea less frequently than other populations. Environmental exposures common in flight can trigger a life-threatening bronchospasm. The United States is the only North Atlantic Treaty Organization country that is not screening for lung disease in pilot candidates. Screening could be used to vector candidates to airframes with less triggers, limiting exacerbations and risk of worsening. Guidelines that encourage pulmonary function tests after physiologic events may identify at-risk individuals, allowing early treatment and possibly delaying or slowing of worsening lung function in this highly trained and specialized population. Fully trained pilots have been granted waivers for well-controlled disease, and there has been a significant recent increase in flight-approved medications, which widens the aperture for waivers. Flight surgeons should educate the flying community of the risks as well as ease their fear of being removed from flying duties.

Learning Objectives
1. Describe how to evaluate patients with suspected asthma and educate them on common misconceptions.
2. List the safety concerns with lung disease and high-performance, single-piloted aircraft.
3. Describe the use of risk assessment to educate both the aviator and leadership.

[288] MEDICAL EVALUATION AND CLEARANCE OF NASA ASTRONAUTS WITH ATRIAL FIBRILLATION

Michael LaBarbera, Brian Hanshaw
UTMB, Galveston, TX, United States

(Education - Case Study)

INTRODUCTION: This case series describes the medical clearance of NASA astronauts after diagnosis of atrial fibrillation seeking to fly to the International Space Station (ISS). **BACKGROUND:** Atrial fibrillation is the most common sustained arrhythmia with increasing incidence with age and is associated with increased lifetime risk of stroke. Treatment may consist of pharmacologic rate control and anticoagulation. Although it is not yet known how spaceflight modifies risk of cardioembolic event or adverse treatment effects, these can have significant impact on mission and crew health for spaceflight and granting a medical waiver for flight is a complex, case-by-case consideration. **CASE PRESENTATION:** We reviewed all records of waivers granted by NASA for atrial fibrillation and flutter, and identified 6 cases (4 short-duration [<18 days] and 2 long-duration missions [>60 days]) where waiver was granted with subsequent spaceflight. **DISCUSSION:** NASA has approved astronauts with a history of atrial fibrillation or flutter for flight following an appropriate medical evaluation. With the high prevalence of atrial fibrillation in the general population, we anticipate that consideration of medical waiver will become increasingly common as commercial spaceflight grows. These cases provide a potential framework for risk assessment and management of this population, to balance potential risk modification inherent in the microgravity environment against implications to crew performance, mission success, and personal health of spaceflight participants.

Learning Objectives
1. The audience will gain an appreciation for the potential crew health and mission considerations for considering medical waiver in cases of atrial fibrillation.
2. The audience will gain an appreciation for the impact of spaceflight, crew performance, and health risks in treatment of atrial fibrillation.

Wednesday, 05/24/2023 ***10:30 AM***
Napoleon Ballroom D1-D2

[S-55]: PANEL: CLINICAL PRACTICE GUIDELINES-AEROMEDICAL RISK ANALYSIS

Chair: Daniel Van Syoc

PANEL OVERVIEW: *Annual review of timely medical conditions of importance to both the military and civilian aviation communities. Presenters will share topics, treatments, and any recent research, and emphasize standard development or modifications. Will address standards from the US military services and civilian policy from FAA perspective.*

[289] ADJUSTMENT DISORDERS, PART 1

Terry Correll
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The U.S. Air Force School of Aerospace Medicine Aeromedical Consultation Service's Neuropsychiatry Branch regularly reviews and evaluates aviators with a diagnosis of adjustment disorder, which is our most prevalent diagnosis. Such a diagnosis is disqualifying, typically impairs the ability of the aviator to fly, and can damage mission effectiveness. **TOPIC:** Extended "down" times for the aviator are common in aviators with adjustment disorders. It is very common for aviators with adjustment disorders to be prescribed a long-term antidepressant, receive no psychotherapy, and even not to be evaluated and treated by mental health. This presentation discusses the treatments for adjustment disorder along with the potential waiverability following treatment and stabilization of the aviator. When managed well, many adjustment disorders never require "down" periods, and even when they do, their length can be minimized. **APPLICATION:** Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can not only minimize and even avoid "down" periods, but can enhance resilience to avoid recurrence of similar future episodes. A discussion of problems noted with aeromedical summaries and waiver packages will be addressed. Although specific for US Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations. **RESOURCES:** 1. Wood J, Heaton J, and Van Syoc D. Post-Traumatic Stress Disorder (PTSD) (June 2017). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2019. 2. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives
1. To understand the impact that adjustment disorders have in the aviation community.
2. To discuss risk assessment, management, and mitigation for US Air Force aviators and aircrew with adjustment disorders.

[290] ADJUSTMENT DISORDERS, PART 2

Ryan Peirson
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Conceptualized as a trauma- and stressor-related disorder, Adjustment Disorder is a common and often minimized disorder. In fact, it is the most common diagnosis (26% reviewed for waiver at the U.S. Air Force (USAF) Aeromedical Consultation Service (ACS) (26%). Disqualifying for all classes of flying in the USAF. Depending on the severity and duration of the presentations, adjustment disorder may or may not require a waiver. **TOPIC:** Part 2 of this presentation will focus on the not-anticipated occurrence of Adjustment Disorder as the most commonly referred diagnosis to the ACS Neuropsychiatry branch and potential factors that contribute to this phenomenon. Additionally, the experience of using medication treatment, which is not a scientifically validated or generally accepted approach, and potential reasons of this will also be discussed. Due in part to its status as representing a cluster of symptoms often less intense or numerous than other disorders (for example, Major Depression or Generalized Anxiety), and the influence of third-party payers in limiting available treatments or levels of care, it can be misconceived as a low-level syndrome. Risk for suicide, risk for future or comorbid disorders, treatment, and aeromedical risk mitigation will be discussed in this teaching session. **APPLICATION:** Adjustment Disorder is a prevalent condition among military members and is potentially waiver-eligible in USAF aircrew. Excellent evaluation and management (including potentially healthy lifestyle interventions, psychotherapy, and medication) can minimize DNIF periods, and can enhance resilience to avoid recurrence. This presentation will highlight these concepts and is primarily relevant to USAF flight surgeons, but it also has utility for other military services and civilian flight medicine. **RESOURCES:** 1. Dickey M, Heacock K, Van Syoc D, Speakman R, Adjustment Disorder (Aug 2020). In: Air Force waiver guide. Wright-Patterson AFB (OH): U.S. Air Force School of Aerospace Medicine; 2022. 2. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders: DSM-5-TR* (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives
1. The audience will understand the status of formal medication approval for Adjustment Disorder.
2. The audience will understand the great variability in Adjustment Disorder presentations.

[291] SAURON: SOPHISTICATED ARTIFICIAL INTELLIGENCE USE REGARDING OPHTHALMOLOGIC NEEDS. A PRIMER

Jonathan Ellis
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

TOPIC: The ACS Ophthalmology Branch has used published data regarding certain eye conditions as well as findings within the management groups to craft recommendations for changes/advances in vision standards for the USAF. The use of Artificial Intelligence (AI) has expanded rapidly as a method of pattern recognition to identify associations among data sets that may not be readily apparent to the human observer. The ACS Ophthalmology Branch has begun a multiyear study to use AI to review data sets within select management groups. This presentation will discuss what SAURON is, the progress of the initial study that is currently underway and the planned future studies that will be completed using SAURON, as well as the strengths and limitations of AI used for deep learning in Ophthalmology and Aerospace Medicine. **APPLICATION:** Discuss AI use in deep learning for Ophthalmology and Aerospace Medicine to advance vision standards. **RESOURCES:** Ting DSW, et al. Aritificial Intelligence and Deep Learning in Ophthalmology. Br J Ophthalmol. 2019 Feb;103(2):167-175. Balyen L, Peto T. Promising Artificial Intelligence-Machine Learning-Deep Learning Algorithms in Ophthalmology. Asia Pac J Ophthalmol (Phila). 2019 May-Jun;8(3):264-272. Ferro DL, et al. The Upcoming Role of Artificial Intelligence (AI) for Retinal and Glaucomatous Diseases. J Optom. 2022 Oct 7:S1888-4296(22)00054-1. Online ahead of print.

Learning Objectives
1. The audience will learn the conditions the ACS Ophthalmology plans to investigate using SAURON.

2. The participant will learn how AI has been used in ophthalmology in other investigations and how that can be applied to vision standards.
3. The listener will learn what SAURON stands for.

[292] ASAMS AEROMEDICAL RISK ANALYSIS: CHRONIC OBSTRUCTIVE PULMONARY DISEASE

Charles Mathers
FAA, Washington, DC, United States

(Education - Program/Process Review)

BACKGROUND: Chronic obstructive pulmonary disease (COPD) is a major cause of morbidity and mortality worldwide. COPD has significant aeromedical implications, from symptoms including exertional dyspnea and fatigue, hypoxia at typical cabin altitudes in commercial aircraft, and the potential for pulmonary barotrauma. While there is much scientific literature dedicated to the assessment of COPD patients traveling as passengers in aircraft and to high-altitude terrestrial destinations, very little research has focused specifically on evaluating pilots with COPD. **OVERVIEW:** This talk will provide an overview of recent efforts to update Federal Aviation Administration (FAA) policy regarding pilots with COPD, including implementation of a new condition an AME can issue (CACI) and AME-assisted special issuance process (AASI). **DISCUSSION:** The presentation will cover evidence-based clinical decision-making tools to evaluate pilots with COPD such as the GOLD multi-dimensional assessment, the utility and significance of the 6-minute walk test and its correlation to high altitude simulation testing, and review ICAO and military service specific polices for evaluating pilots with COPD. It will conclude with a brief overview of research efforts at the Civil Aerospace Medical Institute evaluating pulmonary physiologic criteria associated with safe operation of an aircraft.

Learning Objectives

1. Understand the aerospace medical implications of Chronic Obstructive Pulmonary Disease.
2. Understand the FAA's updated process for evaluating pilots with COPD.

[293] TRAPS, ARTEFACTS, LIMITATIONS AND OPPORTUNITIES OF MENTAL HELATH SCREENING INSTRUMENTS

Marion Venus[1,2]
[1]*Venus-Aviation Research, Training & Pilot Support, Universität Bern;* [2]*Institut für Psychologie, Zurich, Switzerland*

(Education - Program/Process Review)

BACKGROUND: EASA made the mental health assessment of pilots mandatory after the Germanwings crash. In this context, ASMA and other organizations have recommended the use of established screening tools for the mental health assessment of pilots, in context with their first and recurring medical class 1 certification. **DESCRIPTION:** Even though this recommendation sounds reasonable, there are limitations regarding screening instruments. Positive screening results are not diagnoses. Screening instruments cast a finer net and discover more suspected cases than can be confirmed diagnostically, regarding depression, anxiety, and common mental disorders. Individuals with positive screening results should be examined psychologically and diagnostically for possible existing depressive or anxiety disorders. Artifacts must be avoided, e.g., what looks like a positive depression screening (PHQ8/9≥10) might be an exhausted, severely fatigued pilot, whose mood is impaired due to exhaustion and roster-related sleep deprivation. What may look like a positive anxiety screening result (GAD≥10) or generalized anxiety disorder, maybe a pilot, who fears losing his medical class 1 certification due to excessive fatigue, exhaustion, and progressing health problems. The worried pilot with positive anxiety screening may also fear a crash or accident due to microsleep events at the controls. Item scores of depression and anxiety screenings are compared with item scores of fatigue item ratings (Fatigue Severity Scale), sleep problems and mental health. **DISCUSSION:** Recent research results do not imply a 'sudden outbreak' of depressive or anxiety disorders among pilots. High rates of positive depression and/or anxiety screenings indicate that many pilots are exhausted and – associated with high levels of fatigue, sleep problems and sleep restrictions – suffer from impaired mood, irritability, and worries. Knowing about safety risks associated with fatigue in the cockpit, many pilots are worried about flight safety, their jobs, and their livelihood. Along with aeromedical examiners, clinical and aviation psychologists should cooperate regarding qualified evidence-based decisions in case of mental health issues, fitness to fly, and the medical recertification of pilots.

Learning Objectives

1. The audience will learn about the weaknesses of screening instruments for the mental health assessment
2. The audience will learn about the most common artifacts and traps, when mental health screening instruments are used for the mental health assessment of pilots.

[294] A COMPARATIVE STUDY BETWEEN AN INDIGENOUS PSYCHOMETRIC TEST BATTERY 'PSUMEDHA' AND 'COGSCREEN-AE'

Anitha T, Vipin Sharma, Sowgandhi Ch N, Punyashlok Biswal
Institute of Aerospace Medicine, Bengaluru, India

(Original Research)

INTRODUCTION: In today's combat environment, a pilot's duty necessitates a higher level of precision, agility, speed, attention, memory, situational awareness, risk assessment, and planning. The critical aspect of the psychometric testing is to assess these distinctive abilities of the pilot. 'pSuMEDhA' an indigenous test battery robustly evaluates the impact of aviation stressors on the cognitive abilities of the pilot. Furthermore Cogscreen-AE is a cognitive screening instrument which assesses deficits or changes in the cognitive abilities and extensively used in pilot testing. The present study aimed to compare the performance measures of these psychometric test batteries. **METHODS:** Randomly selected healthy adults (N=50,M=32,F=18) who met the inclusion criteria were administered both the psychometric test batteries with an interval of 24 hours. The comparable variables identified are speed measures, accuracy measures and process measures of the psychometric tests that taps the vigilance, reaction time, dual tasking, working memory, attention, visuo-spatial orientation and executive function of the participant. The comparable variables pertaining to speed, accuracy and process measures were analyzed using Bland Altman analysis and Pearson's product moment correlation coefficient. **RESULTS:** The mean age of the sample was 31.78 ± 0.74 yr. The speed and accuracy measures of tests tapping working memory were found to be congruent as the plots were within the upper and lower limits of agreement (mean diff- 0.25 sec, p value=<0.0001) and ***r value of 0.6*** implying pSuMEDhA would assess the corresponding cognitive domain optimally. Other comparable variables showed insignificant correlation. **CONCLUSION:** Few tests of pSuMEDhA and CogScreen AE assess the same cognitive ability with distinct administration methods. However, each cognitive test battery measures the individual differences with respect to cognitive abilities effectively. pSuMEDhA, designed for military aviators, has a test that assesses the risk index of the individual. Whereas, CogScreen AE is designed for screening of neurocognitive dysfunction and Taylor's aviation factor score in an aviator. Further, the exclusive variables demonstrated uniqueness in the design of the tests fulfilling the purpose for which they were developed.

Learning Objectives

1. Understand about the psychometric test batteries which assess cognitive functions of a pilot and deficits if any.
2. Acquire knowledge or widen the horizon on two unique psychometric test batteries by their comparable outcome variables that taps same cognitive abilities of the individual.

Wednesday, 05/24/2023 ***10:30 AM***
Napoleon C3

[S-56]: PANEL: MAXIMIZING VALUE OF IN-FLIGHT ENVIRONMENTAL & PHYSIOLOGICAL DATA FROM A JOINT PERSPECTIVE.

Chair: Stephanie Warner
Co-Chair: Christopher Dooley

PANEL OVERVIEW*: Globally, many efforts exist to develop and integrate devices to monitor physiologic status and environmental conditions experienced by tactical aviators. However, non-standard approaches to validation, airworthiness, data merging, and integration can result in challenging decisions regarding technology transition and acquisition, ultimately increasing the timeline for delivery to the fleet. This panel will review a method used to maximize the value of in-flight physiologic data from a joint Department of Defense (DoD) perspective. Researchers from the Naval Medical Research Unit-Dayton (NAMRU-D), the 711th Human Performance Wing (HPW), the Naval Air Warfare Center Aircraft Division (NAWCAD) Human Systems Engineering Department, and the Naval Air Systems Command (NAVAIR) will describe the step by step process using information from existing studies. PANEL STRUCTURE: The first presentation describes NAMRU-D's process for hierarchical validation and evaluation of environmental and physiological monitoring systems prior to transition for flight testing. The second presentation describes the requirements necessary to achieve airworthiness via a specific effort by NAVAIR and NAWCAD to flight test an environmental and physiological sensing system developed by Dräger. The third presentation describes an approach for merging multiple streams of data via an effort by the 711th HPW to develop a wired, integrated cockpit sensing system. The fourth presentation describes a wire-free method by NAVAIR/NAWCAD, and Athena GTX to integrate various sensing systems into a single low power blue tooth enabled hub to stream data from multiple sensors in order to assess pilot state. The final presentation will address the strategic view of how the current pool of data will be used in a pilot warning system, as well as the pitfalls and successes regarding how to best leverage the existing data and ensure that appropriate and correct information is shared across services.*

[295] HIERARCHICAL VALIDATION & EVALUATION OF ENVIRONMENTAL & PHYSIOLOGICAL MONITORS FOR MILITARY AVIATION

Stephanie Warner[1], Dain Horning[1], Samantha Keller[2], Jesse Leiffer[2], Joseph Williamitis[3], Margaret Gallagher[2]
[1]*Naval Medical Research Unit-Dayton, Wright-Patterson AFB, OH, United States;* [2]*Oak Ridge Institute for Science and Education, Wright-Patterson AFB, OH, United States;* [3]*Leidos, Wright-Patterson AFB, OH, United States*

(Education - Program/Process Review)

BACKGROUND: There is high awareness across the aeromedical research and military health system communities regarding the efforts to develop devices to monitor the physiologic status and environmental conditions experienced during military aviation. Successful development efforts should result in validated, reliable, and accepted devices prepared for in-flight use. However, the process to evaluate and validate the performance of each device and prepare it for fleet use has been less socialized. Utilizing VigilOX as an example, this presentation will inform the relevant communities of the initial and necessary phases of a hierarchical approach to validate and evaluate environmental and physiological monitors under simulated aviation conditions. **OVERVIEW:** NAMRU-D, in collaboration with the 711th HPW, NAVAIR, and NAWCAD, developed and implemented a multiphase verification and validation (V&V) protocol to evaluate environmental and physiological monitoring systems. The approach involved unmanned benchtop, environmental, and hypobaric chamber testing, manned normobaric testing, and manned simulated flight testing (e.g., altitude chamber and centrifuge). To ensure consistency across the device evaluation, predefined accuracy requirements were identified as qualifications to move to the next phase of testing. As most of the devices were developmental, these procedures were iterative and incremental, allowing device improvements to be made throughout the process. This initial qualification approach ensures suitability, accuracy, and reliability of each device to measure its specified variables. Consistent application of a pre-defined V&V protocol minimizes risk associated with cost, schedule delays, and poor device performance in the tactical aviation environment. **DISCUSSION:** To support the safety of military aviators, much time and resources have been dedicated to developing environmental and physiological monitors. To maximize the value of the data, equivalent care should be given to the evaluation of these devices' performance in an operationally relevant environment. Thus, given the differences in variety and sensing mechanisms in environmental and physiological monitors, having a standardized, repeatable, and applicable performance evaluation approach is crucial. Utilizing this cross-service, iterative, hierarchical approach will indicate preparedness for transition to airworthiness and flight testing, moving each device one step closer to fielding.

Learning Objectives

1. The audience will learn about the standardized approach used by United States Navy and Air Force researchers to transition environmental and physiological monitoring systems from unmanned benchtop to manned simulated flight testing.
2. The audience will learn about the qualifications required to transition environmental and physiological monitoring systems from verification and validation testing to flight testing.

[296] ACHIEVING AIRWORTHINESS APPROVAL FOR AN ENVIRONMENTAL AND PHYSIOLOGICAL SENSOR

Rachael Ryan
Department of the Navy, Patuxent River, MD, United States

(Education - Program/Process Review)

This presentation describes the requirements necessary to achieve airworthiness for a specific system to measure the gas and pressure within the oxygen masks, as part of the effort to understand a sub-set of physiological conditions of Naval Aviators in flight. A Cooperative Research And Development Agreement (CRADA) was established to collaborate with industry partners, in this case Draeger, to have a single piece of hardware (AviAir) containing an oxygen sensor, a carbon dioxide sensor, and a pressure sensor in fluid connection with the Navy's existing MBU-23 oxygen mask assembly, with the requirements of deploying the system for collection of data during all phases in flight in T-45 training aircraft. This presentation details how requirements documented in a Requirements Verification Trace Matrix (RVTM) specified which stage of testing performance would be verified as well as what would be needed to achieve approval of an Interim Flight Clearance (IFC) for flight testing, what tests were required for Fleet Data Collection, and what further level of qualification was needed to be considered fully Fleet fieldable. Verification methodologies along with documentation requirements from SMEs in the IFC approval chain were documented in an Engineering Data Requirements Agreement Plan (EDRAP) that was shared across the AviAir team to ensure all testing was being conducted and reported out in a manner that would result in approval for the IFCs. The following tests verified functionality of the AviAir system with the MBU-23/P and were necessary as part of the Airworthiness process:

1. Laboratory Testing: Altitude Chamber (unmanned at NAVAIR), ROBD, Gear Fit, Windblast, EMI, and Environmental.
2. Laboratory Testing (Brooks City Base and NAMRU-D): Altitude and Centrifuge chamber (manned).
3. Ground Testing: Fit check and flight control snag hazards test to be conducted on test articles to ensure the AviAir does not degrade the performance or usability of aircraft flight controls.
4. Flight Testing: Conducted in order to gather actual data during the flight of T-45 aircraft. This includes the use of an actual pilot

connected to the AviAir system. The system must be able to collect and measure O2, CO2, and mask pressure continuously during flight.
5. Fleet Data Collection: Manufacture a limited set of sensor units and conduct on-site data collection with T-45 Instructor Pilots at Kingsville and Meridian Naval Air Stations (NAS).

Learning Objectives
1. The audience will learn about Engineering Data Requirements Agreement Plan Process.
2. The participant will learn about the Airworthiness Process for NAVAIR/NAWCAD.

[297] INTEGRATED COCKPIT SENSING (ICS): CHALLENGES IN REAL-TIME DATA FUSION AND CONTEXTUAL INTERPRETATION

Chris Dooley
711th Human Performance Wing, Wright Patterson AFB, OH, United States

(Education - Program/Process Review)

BACKGROUND: Unexplained physiologic events (UPEs) in the high performance aircraft (HPA) environment stem from complex, multifactorial insults. The National Commission for Military Aviation Safety, in their report published in Dec 2020, identified the need for persistent physiologic and environmental monitoring of the HPA pilot. Multiple efforts across the US Department of Defense (DoD) and industry have taken on the challenge of addressing this need. **OVERVIEW:** The Integrated Cockpit Sensing (ICS) program is an ongoing effort led by the 711th HPW, in coordination with Ball Aerospace. The program aims to develop a modular capability, separate of the aircraft systems and power, which enables for real-time aggregation and analysis data pertaining to LSS performance, cockpit environmental conditions, and airmen physiology in high performance aircraft. The foreseen benefit of the system is two-fold. Firstly, providing actionable in-flight alerting for pilots, reducing physiological risk and ultimately preventing adverse physiologic events. Secondly, the system will be integral in creating a database of holistic aircraft-airmen performance in-flight data that will allow for mission performance improvement as well as detailed forensic analysis of future UPEs. The ICS system integrates high-TRL miniaturized and wearable sensors, integrated via the GOTS COG Pack open architecture, and applies data fusion and machine learning to generate accurate, actionable alerts to pilots. With the constant improvement of physiologic systems, the ICS system is modular and able to incorporate new/improved GOTS/COTS sensors as they become available due to its open architecture design and algorithms agnostic of specific sensing technologies. **DISCUSSION:** Ever more insightful work is ongoing in DoD and civilian labs for understanding the human-machine interactions that occur in the HPA cockpit environment. Transitioning, and expanding upon, that knowledge requires data collected in the cockpit environment, from multiple sensing elements, to be appropriately fused to ensure accurate context is conveyed. Successfully overcoming these challenges opens the aperture for what is possible in the HPA cockpit for improving human-machine interactions in the realms of both safety and performance.

Learning Objectives
1. Understand the value add of multiple data streams in the context of the high performance aircraft environment.
2. Learn about techniques for time synchronization of disparate sensing systems.

[298] PHYSIOLOGICAL MONITORING: WIRE-FREE INTEGRATION TO STREAM SENSOR DATA AND ASSESS PILOT STATE

Raisa Marshall[1], Bridget Rinkel[3], Maura Kilgore[4], Amanda Muller[2], Erin Benson[2], Sean Mahoney[2], Casey Boutwell[3], Nichola Lubold[4], Dan Ratcliff[5], Christine Wood[1]
[1]*Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States;* [2]*Athena GTX, Johnston, IA, United States;* [3]*NIRSense, Richmond, VA, United States;* [4]*Honeywell Aerospace, Phoenix, AZ, United States;* [5]*Naval Air Systems Command, Patuxent River, MD, United States*

(Education - Program/Process Review)

BACKGROUND: Physiological monitors measure human responses to detect and warn of degraded cognitive or physical performance. Numerous challenges are associated with adapting clinical monitoring concepts and integrating devices for use in a tactical air environment. The devices need to be evaluated against environmental extremes encountered in high-performance flight and identify changes in human physiology. The US Navy has mounted a considerable effort to evaluate physiologic and environmental sensors to develop an aircrew monitoring and warning system (AMWS). This involves a collaborative effort with the US Air Force that is partially funded through the Defense Innovation Unit. The physiological monitoring capability must track environmental and physiological systems to autonomously interpret aircrew status. Several prototype devices designed to operate independently were tested and evaluated, none of which were a complete AMWS. A proof of concept effort to create this unified wire-free system that provides aircrew state in real-time began in June 2021. **OVERVIEW:** The goal of the AMWS is to track oxygenation (cerebral tissue and blood), heart rate and variability, breathing rate and patterns, aviator mask gas and pressure, acceleration, and ambient pressure and temperature. The system uses these data to estimate aircrew physiologic state, workload, fatigue, and cognitive status. Wire-free Bluetooth Low Energy (BLE) protocol links the sensors. The challenge is to connect and time sync signals from different BLE transmitters, determine signal quality, derive measurements on a small processing unit, input them into status algorithms, determine aircrew status and alert aircrew. **DISCUSSION:** The system's core is the HsHub, derived from Athena GTX's Holistic Modular Aircrew Physiologic Status (HMAPS) monitoring system that has been successfully tested in-flight. It serves as the communications nexus and status arbiter. Athena GTX is demonstrating the prototype HsHub with its HMAPS peripheral devices (environmental sensor and ECG patch), Honeywell Biosensing Apparel (compression t-shirt or sports bra), and NIRSense cerebral tissue oximeter. Apps were developed and bench tested to display real-time data on smartwatch platforms with an alert function. HsHub function and life support equipment compatibility will be dynamically tested in the altitude chamber, centrifuge, and in-flight with the assistance of the Patuxent River Flight Test Squadron.

Learning Objectives
1. The audience will learn about the next step in the evolution of developing and validating an aircrew physiologic monitoring and warning system.
2. The audience will learn about the types of sensors considered core to an aircrew physiologic monitoring system.
3. The audience will learn about obstacles to overcome when integrating systems together into a wire-free platform.

[299] CONTINUED FAA MEDICAL CERTIFICATION OF FIRST AND SECOND CLASS PILOTS WITH INSULIN TREATED DIABETES USING CONTINUOUS GLUCOSE MONITORING TECHNOLOGY

James DeVoll[1], Lynn Stanwyck[2], Joyce Pastore[1], Richard Murphy[1], Bernice Batres[3], Petrolina Chilaka[4], Zykevise Gamble[5]
[1]*FAA, Washington, DC, United States;* [2]*Virginia Tech Carilion School of Medicine, Roanoke, VA, United States;* [3]*University of California Jonathan and Karin Fielding School of Public Health, Los Angeles, CA, United States;* [4]*University of Texas Health Science Center at Houston, Houston, TX, United States;* [5]*Howard University, Washington, DC, United States*

(Original Research)

INTRODUCTION: In November 2019, the FAA announced a new protocol to evaluate pilots with insulin treated diabetes mellitus (ITDM) for special issuance (SI) medical certification for first/second class pilots. This program leveraged the emergence of continuous glucose monitoring (CGM) technology in the treatment and of monitoring pilots with ITDM. A previous study examining two years of data showed pilots certified under this protocol meet or exceeded clinical standards for diabetes. The purpose of this study was to further evaluate the characteristics of pilots

with ITDM who were initially certificated, recertificated or denied medical certification. **METHODS:** Data was collected retrospectively from the FAA Document Imaging Workflow System (DIWS) for pilots considered for a first/second class SI under the ITDM program between November 2019 and September 2022. Inclusion criteria required a certification decision (SI vs. denial) under the ITDM program. We extracted de-identified data on demographics and CGM parameters including average glucose, coefficient of variance (CoV), time > 250mg/dl (%), and time less than 70-80 mg/dl (%). We compared these parameters between pilots issued a SI vs. denial with Mann-Whitney U-tests and Fisher exact tests using R. We also compared the pilots certified between October 2021 and September 2022 with those previously certified. **RESULTS:** 68 received SIs and 28 were denied. Of these, 13 of the pilots were granted SI after October 2021 and 9 were denied. 60 pilots renewed their SIs. Pilots granted an SI were older (45.5 versus 25.5 years old, p = <0.001), had a lower hemoglobin A1c (6.4% versus 7.1%, p<0.001), lower average glucose (140 mg/dl versus 156 mg/dl, <0.001), and lower CoV (26.8 versus 35.5, p<0.001), and spent less time with low (1% versus 3%, p<0.001) glucose levels. There were no statistically significant differences between pilots certified before versus after October 2021. **DISSCUSION:** This program has shown enduring and robust consistency in effectively differentiating between pilots for whom ITDM is safely mitigated for both initial and recurrent certification. This program will continue to evolve with the clinical and technological advances in the field of ITDM, and we expect many more pilots with the condition will be able to achieve safe certification.

Learning Objectives

1. The audience will learn about the continuation of the FAA's ITDM protocol for first/second class pilots.
2. The participant will be able to describe clinical characteristics of a successful applicant for a first or second class medical certificate under the ITDM protocol.

Wednesday, 05/24/2023 ***10:30 AM***
Napoleon Ballroom A1-B3

[S-57]: PANEL: IMPROVING THE FUTURE TODAY: AEROMEDICAL RESEARCH AND PILOT-PHYSICIANS

Sponsored by the International Association of Military Flight Surgeon Pilots

Chair: Thomas Powell
Co-Chair: Chris Bates

PANEL OVERVIEW: *The audience will learn about emerging technology currently being implemented in United States Air Force aviator training and future potential avenues for development. Through a series of presentations, the learners will become more educated on the roles Pilot-Physicians occupy to further the general Aerospace Enterprise by acting as clinicians, educators, and researchers to continue to expand the knowledge of Aerospace Medicine and their contributions to educating the next era of Aviators. Topics to be discussed will include aircrew screening, training, procurement of new equipment, safety, and human factors. This panel of Pilot-Physicians and their team members will discuss new developments, training insights, and point to the direction of their future endeavors. As new technologies continue to be incorporated within aviator training pipelines, this panel will explore the benefits and potential pitfalls of these technologies. With a foot in both the operations and medical world, these insights will be invaluable to guiding the path of inspiring the next generation of aviators and ensuring their safety and effectiveness for the years to come.*

[300] THE FUTURE OF U.S. AIR FORCE PILOT TRAINING AND IMPLICATIONS FOR FLIGHT SURGEONS

Andrew Pellegrin
U.S. Air Force, Joint Base San Antonio-Randolph, TX, United States

(Education - Program/Process Review)

BACKGROUND: Undergraduate pilot training (UPT) in the United States Air Force is undergoing a major shift as it transitions away from the legacy system of producing pilots, which has been largely unchanged for the past 50 years. This new system of producing pilots, termed "UPT 2.5" includes incorporation of virtual reality simulation as a new training modality, increased flexibility in the training syllabus to tailor training to the individual student, and incorporation of human performance training with athletic trainers, dieticians, and cognitive performance specialists embedded within flying training squadrons. Future changes include a phasing out of the T-1 Jayhawk aircraft that is currently used to train mobility pilots and incorporation of additional paths to pilot qualification that do not include the current primary pilot training platform, the T-6 Texan II. These additional paths include a helicopter only track and a civilian path to wings whereby civilian pilots who meet specific training and experience requirements may bypass primary pilot training in the T-6 and enter training at a later point in the training pipeline bound for mobility, special operations, or surveillance aircraft. **OVERVIEW:** This presentation will provide current data regarding UPT 2.5 graduates' performance as compared to graduates of legacy pilot training. The presenter will also discuss ongoing questions and opportunities for future research. Such opportunities include determining whether the data gathered in the human performance evaluations now included in the UPT 2.5 syllabus predict flying performance in the program and determining appropriate medical standards for pilots entering the civilian path to wings who will not fly high performance aircraft at any time during their career as Air Force pilots. **DISCUSSION:** These current and future changes provide both challenges and opportunities for Air Force flight surgeons who care for student pilots as well as flight surgeons who care for operational pilots whose training and experience as they arrive to their first operational flying units may be significantly different than in the past. Lessons learned from this ongoing process will be broadly applicable to other military services and to all those who provide medical care to aviators.

Learning Objectives

1. Participants will learn about ongoing changes in U.S. Air Force undergraduate pilot training (UPT 2.5) and how these changes may impact the medical needs of pilots during training and after arrival to their first operational flying units.
2. Participants will learn about human performance optimization programs that are incorporated into UPT 2.5 and the impact these programs have had on student pilot performance.

[301] SPATIAL DISORIENTATION TRAINING: MULTI-DISCIPLINARY DEVELOPMENT FOR THE ROTARY-WING SIMULATOR

Steven Gaydos[1], Alaistair Bushby[2], Ian Curry[3]
[1]*HQ Army Air Corps, Army Aviation Centre, United Kingdom;* [2]*RAF Centre of Aviation Medicine, RAF Henlow, United Kingdom;* [3]*U.S. Army Aeromedical Research Lab, Fort Rucker, AL, United States*

(Education - Program/Process Review)

BACKGROUND: Spatial Disorientation (SD) results from improper sense of aircraft position, motion, or attitude with respect to the fixed coordinate system of the earth's surface and the gravitational vertical. SD remains a significant cause of aviation mishaps including the military rotary-wing (RW) operational environment. Within the British RW community, SD remains a causal or contributory factor in about one-third of serious accidents and carries a disproportional penalty with respect to accident severity and fatalities. **OVERVIEW:** With the operational requirement to fly increasingly complex platforms within challenging environments, the threat of RW SD remains significant, particularly at times of high workload and deceptive visual cues. The British tri-Service Consultant Advisors in Aviation Medicine endorsed a multi-modal, layered approach for SD mitigation that now includes interactive synthetic training systems. For the AW159 Wildcat helicopter, training scenarios were jointly developed from a team including aerospace medicine physicians, qualified helicopter instructors, and simulation technicians. **DISCUSSION:** It was

recognized that multi-disciplinary input was highly advantageous with each specialty bringing differing experiences and diverse perspectives. This "whole-of-team" approach also served to encourage and empower non-medical stakeholders within the aviation community to take larger ownership of SD mitigation ensuring that the operator threats, safety issues, and mitigation measures are not viewed solely through the lens of a medical discipline.

Learning Objectives

1. Participants will broadly recognize inherent advantages of multi-disciplinary developmental approach to SD mitigation including involvement of a pilot-physicians.
2. Participants will appreciate a multi-modal approach to spatial disorientation training including the use of high-fidelity simulation and synthetic trainers.

[302] NORMOBARIC HYPOXIA EMERGENCY IN TACTICAL F/A-18 HORNET SIMULATOR AS TOOL IN CRM TRAINING FOR FIGHTER 4-SHIP AND GCI

Tuomo Leino[1], Heikki Paavilainen[2], Nikke Varis[3]
[1]*National Defence University Finland, Kuusa, Finland;* [2]*Finnish Defence Forces, Tampere, Finland;* [3]*University of Tampere, Tampere, Finland*

(Original Research)

INTRODUCTION: Physiological episodes are an issue in military aviation including 5th generation fighters. Already 2008 normobaric hypoxia training in F/A-18 Hornet simulator (WTSAT) was developed in Finland to allow pilots to recognize individual symptoms of hypoxia and to execute hypoxia emergency procedures (EPs) in 100% identical cockpit environment. Pilot-physicians have been instructors in this training and nowadays hypoxia training can be done with 4 simulators and fighter controller (GCI) in same network. This makes crew resource management (CRM) training also possible using hypoxia emergency in one pilot as tool for team training. **METHODS:** The simulator flight was DCA sortie as 4-ship formation lead with SKATE tactics in BVR air combat against hostile fighter formation. Seven pilots participated the study. 8% of oxygen in nitrogen was used to provide normobaric hypoxia for 4-ship lead pilot. AMRAAM missile shooting distance and brake distance were analyzed from WTSAT data and shown as percentage from optimal. Bold face hypoxia EPs included: 1) green ring pull (100% emergency oxygen) 2) OXY flow knobb off 3) emergency decent with 20 degrees nose-down attitude to MSA. **RESULTS:** With 8 % oxygen lead aircraft shooting distance was 30% too close and brake distance 31% too close. During brake, 6 pilots out of 7 ordered lead role change to 2-ship lead pilot. Rest of fighter formation had to cover lead aircraft out from enemy missile envelope. **DISCUSSION:** Team CRM included CGI help during emergency decent to safe sector and loose control information about threat. After 3 minutes empty emergency oxygen bottle was simulated by closing breathing valve. RTB was done at low altitude in radar trail formation and post-hypoxic pilot as number one in radar trail. Annual hypoxia training can also be used for CRM training in simulator network. Line Orientated Flight Training (LOFT) approach offers valuable and safe experience for pilots and GCIs about the effects of hypoxia in fighter environment. Wingman and another 2-ship have their roles in emergency situation and this method helps to achieve also their training goals.

Learning Objectives

1. Hypoxia, although treated with 100 % oxygen, have an effect on 4-ship air combat due to hypoxia hangover i.e. long lasting cognitive impairment.
2. Normobaric hypoxia in simulator network offers a CRM training tool for fighter pilots and fighter controller (GCI).

[303] THE GUINEA PIG EXPERIENCE- LESSONS LEARNED AS A HUMAN TEST SUBJECT

Thomas Powell
377 Operational Medical and Readiness Squadron, Albuquerque, NM, United States

(Education - Program/Process Review)

BACKGROUND: Spatial Disorientation remains a killer of aircrews and their passengers. Despite decades of knowledge on the subject and great automation to prevent its development, it remains a dangerous pathology for humans operating in the aerospace environment. Even still, there are questions that have yet to be answered about its development and prevention. Training programs must teach new aviators about its insidious dangers and how to recognize and prevent symptoms. With more sophisticated centrifuges and simulators, we are learning more about these unanswered questions and developing better ways to recognize it, but these endeavors require human volunteers to test these hypotheses. **OVERVIEW:** These new, more sophisticated simulators and centrifuges require both novice and experienced aviators to fully determine the differences in spatial disorientation development across a variety of factors such as workload and hypoxia. This presentation will describe my experiences as one of these human test subjects. **DISCUSSION:** By utilizing a centrifuge combined with a flight simulator, an experience very close to actual flight can be simulated to produce a high-quality, reproducible scenario which may induce spatial disorientation. Variables such as workload, body positioning, and breathing-gas mixture can be manipulated and their results measured. To adequately explore these variables, motivated test subjects are required to fully explore these new effects. Subjects with little to no aviation experience function as surrogates for untrained aviators, whereas experienced aviators can be placed as controls. The results of these experiments can then be applied to the training realm to allow planners to develop more effective training and equipment that reduces spatial disorientation as well as allowing novice aviators to recognize it more quickly with the effect being an overall safer aviation environment. It is the presenter's hope that by having others hear about these experiences as a human test subject, more individuals will volunteer for these cutting-edge studies to expand the envelope of knowledge and make for a safer aerospace environment for all.

Learning Objectives

1. Learn about recent research in spatial disorientation and its frontiers.
2. Learn about how spatial disorientation research improves our understanding of this dangerous phenominal and can help training programs save lives.
3. How important it is to have motivated and eager human test subjects for these studies.

[304] USAF PILOT PHYSICIAN PROGRAM 2023, WHERE ARE WE NOW?

Christopher Backus
55th Medical Group, Bellevue, NE, United States

(Education - Program/Process Review)

BACKGROUND: Pilot physicians meld two disciplines central to aerospace medicine and thus have been central to the Association. As we discuss the next generation of aerospace, it is easy to focus on scientific and technical education at earlier levels, but it is also important to see how established programs change to meet the demands of this next generation. **OVERVIEW:** The United States Air Force pilot physician program allows operators with expertise in aerospace medicine to use both areas to further research in human performance, human factors, and human system integration. Gaining credibility in operations and medicine is time intensive and requires rare candidates. In the current climate of decreased resources to support advanced technology, the program has changed to most efficiently bring these operational medical experts to bear on the highest priority operational problems. This discussion focuses less on aeromedical research and more on the program that develops and enables one advanced type of researcher. **DISCUSSION:** In the third decade of the 21st Century, unique challenges present to the aeromedical researcher. While fourth generation fighters typically had two seat variants, fifth generation fighters do not, meaning the only chance for a physician to fly in the F-22 or F-35 is in the case of the pilot physician. Other examples include the KC-46, an innovative new approach to air refueling that

required design changes after fielding to reach full capability and pilot physicians were essential to that effort. Increased striving for diversity in aircrew mean that crewmembers that were previously excluded from the aerospace environment are seeking full inclusion, bringing attention to risks that are not fully characterized. Pilot physicians who have been in that environment stand ready to better describe those risks. A strained pilot training pipeline could not afford delays just when a new oxygen system threatened to induce delay. Hard to describe subjective physiological symptoms that are difficult to objectively measure in the cockpit environment benefit from experts who can ethically expose themselves to the environment, informing their approach to resolving the root causes. These lessons apply across services and among international partners.

Learning Objectives

1. The audience will learn about the current United States Air Force pilot physician program.
2. The participant will understand some differences between the current USAF pilot physician program and the program 10 years ago.
3. Attendees will understand some of the drivers that led program change and how those changes serve to make an effective program in the current environment.

[305] OPERATIONAL IMPACT OF NECK AND BACK PAIN FOLLOWING IMPLEMENTATION OF A HUMAN PERFORMANCE PROGRAM FOR FIGHTER AIRCREW

Joe Zhang
U.S. Air Force, Langley AFB, VA, United States

(Education - Program/Process Review)

INTRODUCTION: Neck and back pains are common complaints in the fighter community. Historically, this population experiences higher rates of injury than the general population. The USAF conducted a survey modeled after the NATO HFM RTG 252 recommendations in 2020 for all fighter aircrew and established an embedded human performance program for the career field. A follow up survey was conducted in 2022 to gauge the effects of the program. This is the first time that the NATO style survey has been repeated for a population. **METHODS:** All USAF fighter aircrew received an on-line anonymous survey that utilized the core questions from the NATO Aircrew Neck Pain Prevention and Management Human Factors and medicine research task group 252 report. All aircrew with a designation of 11F (Fighter Pilot) or 12F (Fighter Weapons officer) positions were allowed to participate including instructors, students, active, reserve, and non-current flying personnel. **RESULTS:** 2029 responses were received from 6500 anonymous surveys sent electronically making it the largest of its type ever performed. This is an increase from the prior survey which had 1962 responses. Significant findings include 98.3% and 92.3% of aircrew reported flying related neck pain and back pain respectively. 74.8% report current pain. 70% reported difficulty moving their head while pulling G's. 96.0% reported that these pains affect their quality of life in off duty settings. 82.6% and 82.4% claim to have never reported their neck and back pains respectively to a medical authority. This is up significantly from the prior survey which reported 40% failure to report rate. 50.3% have also taken themselves off the flying schedule at least once due to pain. **DISCUSSION:** These results reaffirm musculoskeletal pain to be a significant issue affecting fighter aircrew. More interestingly however, is that there appears to be a significant difference in responses when there is a well-functioning human performance program in operation. Even after just a single year, the more fully established human performance bases showed a 2.1-6.7% improvement in various cockpit functional movements when compared to bases without a working program. This type of information will help to refine existing human performance programs and provide interim benchmarks for future endeavors.

Learning Objectives

1. Gain an understanding of prevalence of neck and back pain in USAF fighter aircrew.
2. Gain an understanding of the operational impact of chronic pains on USAF fighter aircrew.
3. Gain an understanding of impact of human performance programs.

Wednesday, 05/24/2023 ***10:30 AM***
Nottoway & Oak Alley

[S-58]: POSTERS: SPACE MEDICINE POSTERS 1

[306] A NOVEL MODEL PREDICTING THE RISK OF UROLITHIASIS DURING LONG-DURATION SPACEFLIGHTS

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(Original Research)

INTRODUCTION: Urolithiasis is the development of urinary calculi and is a potential complication of prolonged exposure to microgravity. Ureteric stones have many negative complications, which include incapacitating pain, sepsis, renal failure, and death. The aim of this study is to determine the theoretical risk of urolithiasis during long-duration space missions using a model derived from spinal cord injury (SCI) patients who are known to be physiologically similar to astronauts. **METHODS:** The prevalence of urolithiasis following a SCI and bone mineral density (BMD) loss at the great trochanter was determined in SCI patients through literature review. This was compared to BMD loss in astronauts to develop a linear model of the theoretical risk of urolithiasis in microgravity equivalent to $H(x) = (-16.39)x$, where $H(x)$ is the hazard risk of nephrolithiasis per 1,000 person years, -16.39 is the leading coefficient, and x is the rate of change of the percentage of BMD loss. **RESULTS:** At the greater trochanter, BMD loss following SCI is -7.7% at three months, -11.7% at six months, and -14.9% at a year. Correspondingly, the prevalence of urolithiasis after SCI is approximately 43 cases per 1,000 person-years at three months, 43 cases per 1,000 person-years at six months, and 15 cases per 1,000 person-years at one year. In microgravity, the BMD loss is also rapid at -1.4 ± 0.8 %/month, equating to -4.65% at three months and -9.3% at six months. Using an SCI model of BMD loss and urolithiasis prevalence, we project that the instant prevalence of urolithiasis in microgravity is 26.08 cases per 1,000 person-years per month with an R-squared (R^2) value of 0.6327. **DISCUSSION:** This is the first study that aims to determine the risk of urolithiasis during long-duration spaceflights. The projected rate of the prevalence of urolithiasis in microgravity is likely multiple times higher than in Earth's gravity, which is approximately 0.02 – 0.14 cases per 1,000 person-years. Until more non-theoretical data is available to better calculate the risk of urolithiasis, we recommend that space agencies use counter-measures during future missions to reduce this risk and have contingencies in place should astronauts develop renal colic.

Learning Objectives

1. Learn about the differing risk factors for urolithiasis between microgravity environments and Earth's environment.
2. Understand the theoretical risk of urolithiasis during long-duration spaceflight based on spinal cord injury patients and known bone mineral density loss.
3. The need to recommend space agencies to develop risk mitigation strategies based on the projected urolithiasis risk model.

[307] DELIVERING REMOTE CARE: USING THE MICROSOFT HOLOLENS 2 TO FACILITATE VIRTUAL MUSCULOSKELETAL EXAMS

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(Original Research)

INTRODUCTION: Musculoskeletal (MSK) injuries are among the most common injuries reported in space. Physical assessment of an injury is essential for diagnosis and treatment. Unfortunately, when MSK injuries

occur in space the flight surgeon is limited to 2D video conferencing and potentially, observations from the crew medical officer. We investigated the feasibility of using the Microsoft HoloLens 2 mixed reality headset to facilitate 3D physical MSK shoulder exams. **METHODS:** To evaluate the feasibility of using HoloConnect for physical MSK exams we conducted a simulated international holoportation event between Western University in London, Ontario, and Huntsville, Alabama. The exam was performed by a medical student, and a healthy adult male was used as a simulated patient. The physical exam of the shoulder was based upon the shoulder exam as described in Bates Guide to the Physical Examination and included inspection, palpation, and strength and range of motion (ROM) testing. **RESULTS:** Inspection of the shoulder was completed by having the simulated patient slowly turn so all parts of the joint could be visualized. Self-palpation of all bony architecture was completed with guidance. ROM testing was completed in three degrees of freedom. Strength testing that required the resistance of gravity was completed, while strength and ROM testing requiring resistance or joint manipulation supplied by the examining physician could not be performed. **DISCUSSION:** During inspection, the anatomically correct size of the hologram made examination of the joint realistic. However, improving graphics quality towards 1080p and above would make subtle changes in the joint, skin, and bones more recognizable. Self-palpation of the shoulder joint worked better on the anterior aspect of the joint. The posterior components of the joint, such as the scapula, were more difficult to self-palpate, and in a person with less flexibility, could be completely inaccessible. The weightless environment of space would require another person, or a machine, to be used when evaluating the strength of the joint. Finally, compared to 2D video conferencing, holoportation felt more 'human', and organic, and could help maintain the value of physician-patient relationship while administering care remotely. As durations of space flights become longer, more work needs to go into developing methods to provide high quality physical exams to astronauts.

Learning Objectives

1. Learners will learn that administering a MSK physical exam is feasible with holoportation and confers subtle advantages compared to traditional 2D video conferencing.
2. The weightless environment of space and physical separation of physician and patient limits some aspects of the physical exam. Moreover, new methods for examining the strength of a joint in space need to be developed.

[308] HEIGHT OF FALL NEEDED TO SUSTAIN TRAUMATIC INJURIES IN LUNAR AND MARTIAN ENVIRONMENTS

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(Original Research)

INTRODUCTION: Treatment of traumatic injuries sustained during space travel entails limitations not experienced on Earth. Conservative management is preferable, but prevention of injuries is key. To better understand space travel traumatic injuries and prevent possible injuries, we calculated the approximate height needed from a fall in Lunar and Martian environments to cause various injuries. **METHODS:** Velocity (v) required to cause various injuries was calculated as $v=F\Delta t/m$. F is an injury specific constant obtained from literature. Impact time (Δt) was estimated using data from velocities and heights of impacts consistent with values determined in gymnastics and motorcycle collisions on Earth. Mass (m) was assumed to be an 80kg astronaut + 48kg primary life support system (PLSS). The height from fall (h) needed to cause trauma was calculated in Lunar and Martian gravity wells. Height was determined using $(v^2)/2g$, where g was individualized gravity. **RESULTS:** F for concussion=3800N, rib fracture=148N, splenic injury= 1120N, and femur fracture=4300N. v for concussion=6.09m/s, rib fracture=6.7m/s, splenic injury= 11.2m/s, and femur fracture=8.7m/s. In a Lunar gravity environment: h for concussion=11.4m, rib fracture=13.9m, splenic injury= 38.5m, and femur fracture=23.5m. In a Martian gravity environment: h for concussion=5.0m, rib fracture=6.04m, splenic injury=16.8m, and femur fracture=10.3m. LD50 for fall on the moon = 88m and on Mars =38.5m compared to 14.5m on Earth. **DISCUSSION:** Despite the multiple assumptions involved in this study, we found that a significant fall would be required on the moon and Mars to cause any major injury, likely in excess of the height of any currently planned lander or building. Further, the speed of travel of the lunar rover is unlikely to have velocity high enough to cause major injury should an astronaut be thrown from it in a collision. However, given the lack of a compression zone and other safety features of a future lunar rover, speed of travel should be kept to less than 4.5 m/s to minimize risks of major injury.

Learning Objectives

1. The audience will understand the likelihood of major traumatic injury in a Lunar and Martian environment.
2. The audience will understand the falls from differing heights necessary to cause major injuries in a Lunar and Martian environment.

[309] OPPORTUNITIES FOR PRECISION HEALTH UTILIZATION TO SUPPORT ASTRONAUT HEALTH AND PERFORMANCE AT NASA

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(Original Research)

INTRODUCTION: The field of precision health (PH) offers novel approaches to personalized health and medical care, from diagnostics and treatment to tools for the maintenance and support of health. These PH approaches hold great potential to support astronaut health and performance, addressing individual variability in responses to the unique environment of spaceflight. At present, various PH tools and techniques are available terrestrially and many more are in development, stemming from both research and clinical settings. In this new and evolving landscape, opportunities to utilize PH for spaceflight risk mitigation and health support must be actively sought, matching needs with potential solutions. **METHODS:** As a first step in the utilization of PH solutions at NASA, an assessment of PH-relevant opportunities was performed using the Human Systems Risk Board (HSRB) risk categories, each of which represent a health outcome or exposure of concern in the spaceflight environment. Risks were identified with individual variation recognized as a significant contributor in causal mapping. This list was then further narrowed to include risks with existing PH-relevant needs as top risk targets, which were paired with known or future PH solutions. **RESULTS:** Six risks were identified as top risk targets for PH solutions: Immune, Microhost, Pharm, Spaceflight-Associated Neuro-Ocular Syndrome (SANS), Sleep, and Muscle. For each of the top risks, information was catalogued regarding the risk's PH-relevant needs, relevant currently available terrestrial PH solutions as identified from a market search, as well as potential future PH solutions. Other risks of interest identified with potential PH relevance included Food & Nutrition, Cardiovascular, Radiation Carcinogenesis, Behavioral Med., Sensorimotor, and Medical. **DISCUSSION:** The identification of human spaceflight risk targets that pair to PH solutions represents a key step in the development of PH-powered mitigation approaches to reduce risk and improve crew health and performance at NASA. Periodic review of the PH landscape will allow for the incorporation of new PH solutions as they become available, providing valuable insights to inform future risk mitigation strategies.

Learning Objectives

1. This poster will summarize efforts in identification of precision health opportunities at NASA and match them to current and future precision health technologies.
2. The audience will learn about areas of individual variability in response to spaceflight conditions, and the relevant precision health solutions that could reduce risk and improve crew health.

[310] PRECISION HEALTH SOLUTIONS TO IMPROVE SLEEP DURING SPACEFLIGHT USING NUTRACEUTICALS

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(Original Research)

INTRODUCTION: Several differences in astronauts' sleep performance during spaceflight compared to the surface of Earth have been well-documented, including decreased sleep duration, decreased slow-wave sleep and circadian desynchrony. These findings are likely the reason that sleep-promoting and stimulant medications are among the most frequently used by astronauts during spaceflight missions. Current remedies have lacked a precision health approach in their implementation as well as the desired efficacy. Prescribed medications also have the potential for undesirable side effects, dependence, tolerance, and withdrawal. In addition, long-duration exploration class missions will present new challenges that may render current countermeasures more difficult to implement, such as insufficient drug shelf life and restrictions on mass and volume with the inability to replenish supplies. Nutraceuticals provide a possible solution to these problems. **METHODS:** A literature review was conducted on the effects of spaceflight on sleep, the consequences of these effects, and sleep-promoting nutraceuticals. Online database searches included PubMed and Google Scholar. Investigations were selected by targeted searches of primary literature as well as review articles describing the effect of various plant-derived compounds on sleep performance. Available literature was reviewed, and nutraceuticals were assessed for their suitability for use in exploration class spaceflight missions, with an emphasis on a precision health approach. **RESULTS:** Various compounds that have a proven or presumed positive effect on sleep were identified and assessed for efficacy and ease of implementation. Humulone, contained in hops, and L-theanine, contained in the tea plant, were identified as promising nutraceutical solutions that can replace or supplement current pharmaceutical countermeasures. Genetic polymorphisms influencing either circadian rhythm or metabolism of neurotransmitters and their receptors could be a great tool for individualizing sleep solutions in the future. **DISCUSSION:** The alpha acids in hops, particularly humulone, and the amino acid L-theanine in tea are compounds with proven efficacy based on multiple studies that could easily be implemented using a precision health approach in long-duration exploration class missions. Identified polymorphisms provide potential targets for precision health individualization in addition to currently available phenotypic approaches.

Learning Objectives

1. The audience will learn about the effects of spaceflight on sleep.
2. The audience will learn about the biochemical pathways involved in promoting or hindering sleep as well as differences in genotype and phenotype between individuals that can guide a precision health approach to improving sleep.
3. The audience will learn about nutraceuticals that have the potential to provide precision health solutions to improving sleep during spaceflight, the mechanisms by which they exert their effects, and advantages over currently employed strategies.

[311] SPACEFLIGHT ASSOCIATED NEURO-OCULAR SYNDROME: A BRIEF FOR ASTRONAUT CANDIDATES

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(Education - Tutorial/Review)

INTRODUCTION: Spaceflight Associated Neuro-ocular Syndrome (SANS) was first described in 2011 as a clinical process involving degradation of visual acuity and structural changes of the eye when exposed to microgravity. This syndrome poses a risk to astronaut vision, safety, and mission performance, especially during extended-duration missions. The modern astronaut cohort is a diverse group of men and women including scientists, engineers, teachers, pilots, business professionals, and artists. Given their diverse backgrounds, it is imperative all crews are educated on SANS risks and potential countermeasures. This education must be comprehensive and easily understood, regardless of academic background or specific expertise. **TOPIC:** A PowerPoint was created to serve as a presentation and stand-alone educational aid for all astronaut candidates (ASCANS). This medium was chosen as it can be updated dynamically as new information emerges. The brief was split into sections to facilitate organized delivery of complex content in easy-to-understand components. Sections included descriptive statistics, signs and symptoms, outcomes, myths and ongoing research, countermeasures, ongoing surveillance, and unknown and future directions. More research is necessary in order to understand this syndrome, and without continued ASCAN participation in research, acquisition of data will not be possible. These efforts will become increasingly critical with deep space and exploration missions. **APPLICATION:** We recommend regular use of this brief for all ASCANS, and potentially veteran crewmembers, given the high risks and potentially poor outcomes associated with SANS. For ASCANS, recommendations include that this brief be provided at the start of their training, with a bi-annual refresher course for all astronauts. This ensures they are current on SANS information, given the dynamic nature of this syndrome. Additionally, this brief will be made available to all as a self-study aid, utilized as a refresher immediately prior to launch. It is anticipated that this brief will promote the health, safety, and wellbeing of professional and private crews alike, during and after long-duration spaceflight.

Learning Objectives

1. The audience will be able to describe current Spaceflight Associated Neuro-ocular Syndrome (SANS) findings, significance, and countermeasures.
2. The audience will understand the importance of astronauts' familiarity with SANS prior to flying and the large risks associated with this syndrome.

[312] USE OF CALCULATED RISKS BASED ON DIRECT ACYCLIC GRAPH PATH ANALYSIS TO REDUCE NASA'S HUMAN SYSTEM RISK BOARD OF RENAL STONE RISK FROM RED TO YELLOW

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(Original Research)

INTRODUCTION: NASA's Human System Risk Board (HSRB) categorizes the Renal Stone Risk (RSR) as Red for a Mars mission, defined by the likelihood and consequence (LxC) score assigned based on the best evidence for a mission. The HSRB uses directed acyclic graphs (DAGs) to visualize the relationships between factors that contribute to each risk. The RSR DAG shows the chain of events that link physiologic changes in spaceflight to nephrolithiasis and delineates the events that must occur to impact mission outcomes that can change the LxC score. Recent updates assigned an LxC score for RSR as 4x4 (Red) for Mars. Medical PRA modeling provides estimates of the probability of occurrence of nephrolithiasis for a given mission duration. However, there is often confusion about whether nephrolithiasis is an outcome or a contributing risk factor. This study evaluates the use of the DAG as a communication tool for aligning subject matter expertise of the definitions and relationships between factors that contribute to risk and

those that are outcomes that inform LxC assignment. **METHODS:** Using data from NASA's Integrated Medical Model risk of nephrolithiasis in a 2-year Mars mission and available evidence from medical literature, we use the Renal Stone DAG to assign probabilities to nodes and identify the relevant probability chains that inform outcomes. 'What if?' scenarios are explored to demonstrate the value of the DAG structure in helping to inform LxC scoring approaches. **RESULTS:** Using the HSRB board configuration managed Renal Stone DAG, a 'What if?' walkthrough using conservative estimates for the probability of occurrence demonstrates the value of this back-of-the-envelope technique for assessing LxC scores. An example scenario is presented that estimates the chance of Loss of Mission Objectives due to renal stone at 0.85% for a 2-year Mars mission. **DISCUSSION:** This study discusses a quick assessment technique for LxC scoring using publicly available DAGs from the HSRB and evidence from the medical literature. This example 'What if?' case uses conservative estimates to inform likelihood and consequence values that can then be assigned a score. While this is not a complete probabilistic model, the rapidity with which this technique can provide a defensible estimate for scoring is valuable for SMEs responsible for working risk assessment, and the association with visualization provides an easily communicated and understood walkthrough for LxC assessments.

Learning Objectives

1. The audience will learn about how DAG's can be used to diagram causal network pathways for human spaceflight risks.
2. The audience will learn a rapid analysis technique using DAGs to assess mission-level outcomes and LxC assignments.
3. The audience will be able to describe the currently understood factors that contribute to the development of symptomatic renal stones in spaceflight and the likelihood that the condition will lead to negative mission-level outcomes.

[313] PRINCIPLES FOR TERMINATION OF MEDICAL CARE IN AUSTERE ANALOG ENVIRONMENTS FOR DEVELOPMENT OF SPACEFLIGHT PROTOCOLS

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(Original Research)

INTRODUCTION: When compared to operations in low Earth orbit, exploration class missions will have substantially limited resources and ground medical support while the risk of a significant medical event is projected to be higher. There may be medical conditions which require termination of care (TOC) to minimize the total risk to crew life and to ensure mission success. NASA has identified TOC as a necessary requirement for deep space missions and are currently developing the framework for these protocols. We aim to utilize data from earth-based analogs to identify common principles that can help develop future guidelines to this complex medical and ethical challenge. **METHODS:** A comprehensive literature review was conducted in Medline, nasa.gov, Defense Technical Information Center (DTIC) and google scholar. Key search terms including "withdrawal of care, termination of care, termination of CPR, military medicine, wilderness medicine, futility, potentially inappropriate" and others were used to identify analog studies of relevance. These were qualitatively evaluated for recurring principles or themes that were reviewed and structured. **RESULTS:** Mission planning termination of care principles: definitions of clear medical goals, separate protocols for each relevant condition, protocols developed using best available evidence, crew involvement in development, protocols rehearsal pre-launch, and inclusion of palliative capabilities. In-mission termination of care principles: 1. Crew Medical Officer directed stabilization of the patient 2. Consultation with mission control with standardized information exchange 3. Multidisciplinary medical and ethical conference among the mission directors, flight surgeons and relevant specialist experts. 4. Multidisciplinary risk review examining both medical and mission risks for relevant options 5. Provide a transparent explanation of the process and decision to crew. 6. Allow crew feedback and inquiry to review board 7. Support the crew in the enacted decision. **DISCUSSION:** By utilizing the best available evidence in conjunction with expert opinion we have identified common principles from earth-based analogs that could be used to help design future TOC protocols.

Learning Objectives

1. Common Earth analog termination of care principles and protocols in austere and extreme environments.
2. The utility of termination of care contingency plans prior to flight.
3. A sample protocol emphasizing common principles for flight.

[314] A REVIEW OF VENOUS THROMBOEMBOLISM DURING HUMAN SPACEFLIGHT

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(Original Research)

INTRODUCTION: Recent evidence following the finding of a deep venous thrombosis (DVT) during spaceflight has prompted the need to clarify mechanisms and risk of venous thromboembolism (VTE). In turn, mitigation countermeasures, diagnostic modalities, and treatment options must be explored. The objective of this literature review was to provide a current synopsis of the evidence and knowledge gaps of VTE during human spaceflight. **METHODS:** A literature review was performed from inception to October 2022 pertaining to VTE in the context of spaceflight or ground-based analogues with human participants. PubMed was searched for papers written in English using the terms "spaceflight" or "weightlessness" and "thrombotic" or "embolism" or "thromboembolism" in "venous" or "veins". Papers using cellular or animal models were excluded. **RESULTS:** 60 papers were captured; 8 original scientific, 4 narrative reviews, 2 systematic reviews and 3 commentaries discussed VTE in spaceflight. Reference lists were screened. Important themes included: 1 paper described a VTE occurrence during spaceflight and a partially occlusive thrombus in a second astronaut. 11 studies demonstrated increased venous distension and pressure with decreased flow. 3 studies reported increased fibrinogen levels, 3 studies reported hypoalbuminemia or increased coagulation markers, and 2 papers reported increased pro-inflammatory cytokines or decreased cytotoxic T-lymphocyte function. Additional risk factors may be seen in females in spaceflight, including those ingesting oral contraceptives (OCPs) resulting in increased viscosity. **DISCUSSION:** Venous stasis and decreased shear stress secondary to headward fluid shifts may induce inflammatory changes in the venous system, resulting in endothelial damage and upregulation of the coagulation cascade. Additionally, women in space are subject to physiological factors increasing their VTE risk, such as oral contraceptive use, inducing increased blood viscosity and hypoalbuminemia. Our recommendations include instating thrombophilia screening where appropriate and including oral anticoagulants with reversal agents in the onboard medical kit. Efforts should also be placed in optimizing sensitivity and specificity of imaging markers, payload and training ability, notably the use of vector flow imaging, and improving point-of-testing biomarkers, such as albumin and p-selectin.

Learning Objectives

1. The audience will learn about the effects of spaceflight on Virchow's Triad and the gaps in current literature regarding spaceflight-associated venous thromboembolism.
2. The audience will learn about various screening, diagnostic, and treatment approaches for VTE that should be considered for exploration class missions.

[315] CHANGES IN PERIVASCULAR SPACE FOLLOWING LONG DURATION SPACEFLIGHT: A SYSTEMATIC REVIEW AND FUTURE DIRECTIONS

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(Original Research)

INTRODUCTION: Some astronauts returning from long duration spaceflight suffer from symptoms related to alterations in brain structure and intracranial fluid shifts. A possibly related condition is spaceflight-associated neuro-ocular syndrome (SANS). Although initially, increased intracranial pressure (ICP) due to cephalad fluid shift in zero-gravity was hypothesized to be a major factor in the development of SANS, recent findings have brought this theory into question. The glymphatic system, a novel-defined brain-wide pathway of connecting perivascular spaces (PVS) responsible for glial-dependent waste clearance in the CNS, may play a role in the development of SANS and other neurologic conditions associated with prolonged exposure to zero-gravity. The goal of this study is to review emerging literature characterizing changes in PVS following long duration spaceflight. **METHODS:** A systematic review was performed to assess the current understanding of PVS fluid shifts following long duration spaceflight following PRISMA guidelines. PubMed, OVID, and Scopus were searched by independent researchers using the terms: perivascular space, glymphatic system, and spaceflight. Inclusion and exclusion criteria were determined a priori by authors. **RESULTS:** 24 studies were identified in the initial search and 3 were included for review. The included studies utilized T1-weighted MRI for visualization of the PVS of astronauts before and after spaceflight. Barisano et al. found an increase in PVS volumes in all astronauts returning from long but not short duration spaceflight. Hupfeld et al. found an increase in PVS volumes in novice astronauts returning from long duration spaceflight missions on the ISS but not experienced astronauts (>1 previous spaceflight mission). Interestingly, experienced astronauts had larger PVS and lateral ventricular volumes at baseline. Barisano et al. found a correlation between increased pre- and post-flight and PVS volumes and development of SANS, but Hupfeld et al. did not. **DISCUSSION:** The role of the glymphatic system in neuropathology is still emerging. However, the increased PVS volume documented following long duration spaceflight may reflect its function as a major component of fluid homeostasis in the CNS. Further characterization of the PVS changes seen in the zero-gravity setting is necessary to elucidate its relationship with the development of SANS and may contribute to a deeper understanding of the glymphatic system overall.

Learning Objectives

1. The participant will gain an understanding of recently documented changes seen in perivascular space following long duration spaceflight.
2. The participant will be introduced to an emerging topic in neuroscience: the glymphatic system.

[316] MARS MEDICAL SYSTEM MEDICAL HARDWARE CAPABILITIES SURVEY

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(Original Research)

INTRODUCTION: Mars missions will be significantly longer than current mission operations and challenges us to explore what will be needed to continue to optimize crew health. Medical hardware allows for health monitoring and treatment of many possible emergent, urgent, ambulatory, and chronic conditions. There is not currently an understanding of medical hardware capability priorities for Mars missions. This study analyzes the perceived importance of medical capabilities for a Mars mission from survey data collected by XMIPT. **METHODS:** Thirty-six operational flight surgeons and physicians involved in exploration or operational activities were contacted to complete a survey on medical hardware capability needs for a Mars mission. Seventeen physicians completed the survey rating each of 43 medical hardware capabilities on a Likert scale of importance. Responses were converted to an importance score and ranked. Importance score averages were compared across subcategories of medical hardware capabilities and NASA-STD-3001 level of care definitions. **RESULTS:** No medical hardware capability was uniformly rated. Medical communications and basic monitoring were the highest rated subcategories. The medical hardware capabilities with the highest importance scores fell within medical capabilities of Level I or Level II per the NASA level of care definitions documented in NASA-STD 3001. **DISCUSSION:** Past experiences with current operational capabilities and past events may have informed physician responses. Respondents favored capabilities required for high likelihood, low consequence events over those required for low likelihood, high consequence events. The most highly rated capabilities are currently available on the ISS (International space station). Vision and ocular evaluation capabilities were highly rated potentially due to concerns regarding SANS (space associated neuro-ocular syndrome) as was ultrasound imaging capability. Importance score ratings serve to inform prioritization of capabilities and device development.

Learning Objectives

1. Understand the perceived importance of medical hardware capabilities for a Mars mission.
2. Analyze perceived medical hardware capability importance based upon type of capability and level of care of capability.

[317] SELECTION OF NEXT PRIORITY IMPACT MEDICAL CONDITIONS BASED ON AVAILABLE TERRESTRIAL AND SPACEFLIGHT DATA

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(Education - Program/Process Review)

BACKGROUND: As the era of exploration class missions begins, identification of medical conditions that may occur and require management becomes essential for the modeling of medical risk. To this end, NASA has developed IMPACT (Informing Mission Planning via Analysis of Complex Tradespaces), a suite of tools to assist in assessment of medical risk analysis. It has incorporated an initial list of the 120 conditions of highest concern, labeled the IMPACT condition list (ICL). This abstract describes a method for prioritizing the 92 conditions included on the Proposed Future Conditions List (PFCL) for inclusion in future iterations of the ICL. **OVERVIEW:** To construct the Prioritized Proposed Future Conditions List (P-PFCL), each condition on the PFCL was scored as "low," "medium," or "high" on each of four variables: incidence, likelihood of significant task impairment, diagnostic and treatment complexity, and treatment futility. Qualitative assessment using clinical judgement was utilized to score complexity, futility, and likelihood of impairment. Incidence was assessed quantitatively using spaceflight data and/or analog populations where available then assigned a score using established cutoffs. Logarithmic numerical values were assigned to each category label. A Prioritization Score was generated for each condition by taking the product of incidence and likelihood of task impairment (risk) divided by the product of complexity and futility (difficulty of care), with higher values corresponding to higher priority for future inclusion in the ICL. **DISCUSSION:** The described methods allow for the generation of a ranked P-PFCL to act as a decision support tool for selection of the next generation of modeled medical conditions. Some of the conditions

ranked highly on the P-PFCL include EVA-related upper and lower extremity sprain/strain, delirium, and hypertension, among others. While this effort does not attempt to quantify the absolute risk associated with each condition, it does attempt to semi-quantitatively estimate the risk of each condition relative to the other possible conditions. This tool in concert with subject matter expert opinion could optimize the future use of limited resources thereby producing a more accurate medical risk model, which will be essential to the upcoming exploration class missions.

Learning Objectives

1. Understand NASA's current approach to medical risk modeling for exploration class missions.
2. Learn a proposed method for prioritizing medical conditions for inclusion in medical risk models.

[318] BUILDING A ONE COUNTRY ONE LICENSURE FRAMEWORK: APPLICATIONS FOR THE FUTURE OF CANADIAN SPACE PHYSICIANS

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(Original Research)

Space medicine combines various medical specialties through providing care in the most extreme and resource-depleted environment known to humankind. With increased access and interest of the private sector, the space economy is forecasted to be a $1 trillion industry by 2040. Increased access and utilization will require additional healthcare support and legal frameworks. We reviewed the current Canadian medicolegal framework for the capability to adapt to this new demand. Currently, Canadian physicians are required to hold a license in each province they practice. As space medicine encompasses multiple medical specialities and its practice is beyond Canadian provincial jurisdictions, we identified a medicolegal gap in Canadian physicians' ability to legally provide healthcare in space. COVID-19 has demonstrated the challenges of the current Canadian paradigm of geographical licensing restrictions. These obstacles have caused detriment to healthcare provision more traditionally in remote communities, military medicine, and cross-jurisdictional telemedicine. By examining similarities and solutions deployed in these terrestrial situations, bi-directional translational licensing solutions may be found. Recommendations for an improved Canadian licensing framework targeting the provision of space medicine may also lead to improving the universality and access to healthcare for Canadians nationwide. These include, in brief, the development of a pan-jurisdictional medical license for clinicians certified in the RCPSC competency portfolio of aerospace medicine with all Canadian provinces and space as jurisdictional boundaries, and fast-track or portable licenses for space or ground-based physicians supporting aerospace missions.

Learning Objectives

1. Participants will learn about the current model of physician licensure in Canadian territories and provinces and its medicolegal gap in addressing Canadian physician licensing in space.
2. Participants will learn about challenges in the Canadian healthcare system presented by the provincial and territorial model of physician licensing and past solutions and proposals aimed at overcoming these challenges.
3. Participants will learn about how past Canadian medicolegal licensing solutions at addressing access to physicians can be applied to space medicine, including the proposal for a pan-jurisdictional competency-based license for space medicine.

[319] COMPREHENSIVE TRIALING OF MEDICATIONS PRIOR TO LONG DURATION SPACEFLIGHT

Haig Aintablian
University of California-Los Angeles, Glendale, CA, United States

(Education - Program/Process Review)

BACKGROUND: Medication selection and integration for next generation exploration-class missions is of the utmost importance in ensuring humanity's ability to reach distant planetary bodies. Each medication's breadth of use, dosing concentrations, adverse effects, and shelf-life must be heavily researched and scrutinized in order to provide the optimal, weight-efficient, and all encompassing medication architecture for long-duration interplanetary expeditions. Even with a robust medication infrastructure in place, the possibility of a medication complication is not addressed. The scenario of a crew-member requiring a medication during their expedition that they had not been exposed to terrestrially is almost certain to happen. What if they were subsequently found to have an adverse effect or allergic reaction to this medication millions of miles away from earth? **OVERVIEW:** We propose the following comprehensive, tiered, medication trial regimen implemented prior to long duration exploration-class missions in order to prevent this scenario.

1. Stimulant and Space Motion Sickness Combinations: Used to determine the most favored medication combination per crewmember for the prevention of space motion sickness as well as medication induced drowsiness, including 6 combinations of: promethazine, scopolamine, and meclizine with dextroamphetamine, or modafinil.
2. Common Allergen Exposures: Used to determine allergies to common medication classes that are of higher likelihood to cause allergic reactions and that are likely to be flown and used in long-duration spaceflight, including medications from each major class including: amoxicillin-clavulanate as a penicillin-class drug, Trimethoprim-Sulfamethoxazole as a sulfa-class drug, Doxycycline as a Tetracycline-class drug, Levetiracetam as an anticonvulsant category drug, and Aspirin as a NSAID category drug.
3. Procedural Exposures: A regimen used to determine adverse reactions to commonly used procedural components and medications, including exposure to latex, medical glue (cyanoacrylate-derivatives), medical tape (acrylate and methacrylate-derivatives), amide local anesthetic (Lidocaine) and ester local anesthetic (Tetracaine).

DISCUSSION: The goal of our proposed medication trial is to ensure an expected and safe response to medication classes and procedural materials that will be flown and used on these exploration class missions - an important aspect for successful long-duration space endeavors.

Learning Objectives

1. Understand the terrestrial epidemiology of medication reactions and their implications in long duration spaceflight.
2. Understand the clinically relevant medication-classes, including antibiotic and anesthetic classes, most attributed to adverse reactions.
3. Understand the current limitations in ground testing of medications prior to long duration spaceflight and the potential importance for terrestrial ground testing.

[320] FEASIBILITY OF TERRAFORMING MARS

Stephen Hobson
University of Vermont, Burling, VT, United States

(Education - Tutorial/Review)

INTRODUCTION: For decades, science fiction books have envisioned terraforming planets into new worlds for humans to inhabit. More recently, space enthusiasts have begun to seriously advocate for humanity becoming a "multiplanetary species" by terraforming Mars. **TOPIC:** Terraforming Mars is not possible using present-day or near-future technology. Fully terraforming Mars would require the creation of a thicker atmosphere, warmer temperature, and breathable air. Mars is more than 100 degrees Fahrenheit colder on average than Earth, has less than 1% of the atmosphere of Earth, and the atmosphere that it *does* contain is 95% carbon dioxide, making it fatal for humans to breathe. Warming the planet and creating a thicker atmosphere would require releasing greenhouse gases like carbon dioxide from polar ice caps, surface regolith, and minerals in the crust. Even if all the available CO2 were released, it would only make up about 3% of Earth's atmospheric pressure and still be toxic to breathe. If we accomplished the creation of an atmosphere and oceans

of liquid water on Mars, this would still not solve the lack of a magnetic field, weaker gravity, or the many health risks for humans traveling and surviving on the planet for long periods of time. None of the options for fully terraforming Mars are possible in the foreseeable future. Even if they were, the resources needed to dedicate to such projects would be better used to address environmental problems on Earth, our home planet that humanity evolved to live on. NASA and commercial space companies should focus their efforts in space on exploration, scientific discovery, and even commercial enterprise – *not* on terraforming Mars into Earth 2.0. **APPLICATION:** It is possible for humans to maintain a long-term presence on Mars, but challenges to reproduction, growth, and development will exist if humans plan to "colonize" Mars for generations. Human space exploration of Mars should focus on first establishing permanent research stations with protective habitats and full life support systems. Next, humans can move toward "paraterraforming" with habitats, like domes, that are sealed and create livable conditions with pressure, temperature, and a breathable atmosphere. Paraterraforming may eventually lead to permanent human settlements on Mars, however, plans to fully terraform Mars should be abandoned until these more reasonable milestones are achieved or technological breakthroughs put the impossible within reach.

Learning Objectives

1. The audience will learn about current theories on how to terraform Mars to be more Earth-like.
2. The audience will learn why terraforming Mars is not possible using present-day or near-future technology.
3. The audience will learn about a more achievable vision for permanent research stations on Mars and paraterraforming.

[321] A LONG WAY TO MARS: A MULTIDIMENSIONAL ANALYSIS OF A 520-DAY SIMULATED MISSION

Galymzhan Issabekov
Kumagaya General Hospital, Kumagaya, Japan

(Original Research)

INTRODUCTION: Long-duration missions to Mars are being planned by public and private organizations in the 2030s, yet challenges to human health and performance remain. One major challenge is prolonged isolation and confinement. To this end, a comprehensive simulation was attempted to evaluate the potential impact of isolation and confinement stress on human health and performance, called the Mars500 project. The first Earth-based experiment investigated long-term health by isolating in a 550 m chamber healthy multinational crew for 520 days. As a result, there have been 25 publications associated with the Mars500 project. However, there has been a considerable lack of multidimensional analysis of these works. Thus, the objective of this study was to identify possible group- and individual-level correlations between data collected from various publications regarding the Mars500 project. **METHODS:** From June 3rd, 2010, to November 4th, 2011, six male subjects (three Russians, two Europeans, and one Chinese) with a median age of 31 years (range 27–38 years) lived under totally isolated and confined conditions in the Mars500 habitat located in Moscow, Russia. Physiological, psychological, proteomic, metabonomic, immune, microbiome, cardiovascular, and cognitive data were collected over 520 days. **RESULTS:** A total of 25 publication results came from the Mars500 project in the areas of physiology (n=8), psychology (n=9), biochemistry, immunology (n=4), and microbiology (n=4). Some biological functions were not significantly affected by isolation and confinement. However, significant changes in multiple data types were observed in association with the "landing period". Specifically, a correlation between psychological and biochemical data were identified that included changes in plasma hormone level, sleep-wake alterations, body weight, skeletal muscle alternations, the circadian rhythm of cardiovascular control, cortical activity, gut microbiome composition, and serum metabolites. **DISCUSSION:** Given that most of the biological and human health variables remained stable or returned to baseline after a 520-day simulated mission, these data suggest that human health can be mostly sustained over this time of isolation and confinement. These results highlight the importance of identifying biomarkers of characteristics predisposing prospective crewmembers during prolonged spaceflight confinement to inform crew selection, training, and individualized countermeasures.

Learning Objectives

1. The impact of chronic stress burden of 520-d isolation and confinement on the physiological, psychological, proteomic, metabonomic, immune, microbiome, cardiovascular, and cognitive response during the Mars500 simulated mission to Mars.
2. Identify possible group- and individual-level correlations between data and results collected from various 25 publications regarding the Mars500 project, which is the longest controlled human confinement study conducted to date.

Wednesday, 05/24/2023 ***2:00 PM***
Grand Ballroom D-E

[S-59]: PANEL: A MOMENT OF FOCUS ON ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)

Chair: Ryan Peirson

PANEL OVERVIEW: *This panel presents an update on the clinical aspects of ADHD and related aeromedical concerns. The panel will discuss various aspects including neuropsychological testing, clinical interview techniques, specific concerns in the aerospace environment, and new concepts in the natural history of the disorder. Members of the Neuropsychiatry branch of the USAF School of Aerospace Medicine's Aeromedical Consultation Service will highlight clinical experience as it relates to pilot applicants and trained air crew. Occupational and aeromedical assessments require a number considerations and the panel's aim is a practical discussion.*

[322] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER: CLINICAL AND AEROMEDICAL PRACTICE GUIDELINES

Kevin Heacock
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Attention-deficit/hyperactivity disorder (ADHD) is characterized by a lifelong disturbance in the ability to marshal and sustain attention, modulate activity level, and moderate impulsive actions. The classic triad of ADHD symptoms includes inattention/distractibility, impulsivity, and hyperactivity. ADHD is common is society, USAF Airmen, and USAF flyers. How do we decide if ADHD will have an operational impact? **TOPIC:** When is psychostimulant use allowed in USAF aviators? Under what conditions? When is it forbidden? Can non-stimulant treatments be utilized to treat ADHD? Since ADHD is so common in our world and our aviation community, how do we undergo proper risk assessment, management, and mitigation strategies? **APPLICATION:** When evaluating ADHD in USAF flyers, under what conditions is it medically-qualifying (requiring no waiver), require a waiver, and when is it disqualifying? How do accommodations and treatment of ADHD impact aeromedical decisions? A discussion of problems noted with aeromedical summaries and waiver packages will be addressed. Although specific for Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations. **RESOURCES:** 1. American Psychiatric Association (Ed.). (2022). Diagnostic and statistical manual of mental disorders: DSM-5-TR (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives

1. The participant will be able to understand the evaluation of ADHD in USAF flyers.
2. The audience will learn about how accommodations and treatment of ADHD impacts aeromedical decisions.

[323] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD)-CLINICAL VARIABILITY AND NEW CONCEPTS FOR AN OLD FRIEND.

Ryan Peirson
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: Although the diagnosis of ADHD is not particularly controversial in the mental health community, it continues to engender controversy and disagreement among clinicians more broadly. As the diagnosis increased in the past three decades, a larger number of individuals with a history of and treatment for ADHD are coming of age and seeking aeromedical waivers. With societal pressures and expectations changing, regulatory authorities face difficult challenges in addressing risk mitigation for a disorder with a broad spectrum of severity and clinical presentations. **TOPIC:** A neurodevelopmental disorder, ADHD is, by definition, a disorder that manifests in the developmental period and alters the remaining developmental trajectory. Older concepts estimated that perhaps half of individuals with known ADHD in childhood "grow out" of the disorder in adulthood. Newer data suggest a waxing/waning presentation for many. Further, the severity is also variable which may be attenuated by a number of factors including family support and intellectual capacity or made worse by comorbid conditions or the consequences of the very behaviors for which individuals are known to have greater risk—especially substance use and social issues. This makes aeromedical risk assessment particularly challenging especially when there is incentive to minimize or simply cope with symptoms due to the generally strict proscription against medical qualification. **APPLICATION:** ADHD is a prevalent condition among flying applicants and is potentially waiver-eligible in USAF aircrew. Notoriously difficult to evaluate, and difficult to monitor and mitigate, excellent evaluation and management have the potential acceptably mitigate for some, but not for others. This presentation will highlight these concepts and is primarily relevant to USAF flight surgeons but it also has utility for other military services and civilian flight medicine. **RESOURCES:** 1. *American Psychiatric Association. Diagnostic and statistical manual of mental disorders*, 5th edition. Arlington (VA): American Psychiatric Association; 2013:265-290. 2. Sibley M, Arnold L, Swanson J, et al.. Variable patterns of remission from ADHD in the multimodal treatment study of ADHD. Am J Psychiatry 2022; 179:142-151. 3. Viscera S, Danielson M, Bitsko R, et al. Teens in the parent-report of health care provider diagnosed and medicated ADHD: United States, 2003-2011. J Am Acad Child Adolesc Psychiatry 2014; 53:34-46.

Learning Objectives

1. Participants will understand the data behind suggesting a waxing and waning presentation for many with ADHD.
2. Participants will understand the variability in the presentation of ADHD--especially how some are able to cope more than others.

[324] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD) – CONTRIBUTIONS OF NEUROPSYCHOLOGICAL ASSESSMENT IN THE AVIATION POPULATION

Monica Malcein
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: ADHD is a neurodevelopmental disorder characterized by a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning. There is percentage of individuals who had symptoms of ADHD in childhood that have symptoms persist into adulthood. Characteristics of the disorder, to include impaired attention, cognitive inefficiency and impulsivity, can impact functioning and make it unsafe to perform aviation duties. Comprehensive assessment, to include a careful history and assessment of neurocognitive functioning, is important for diagnostic clarification and identification of functional limitations as they relate to flying. **TOPIC:** Neuropsychological assessment of individuals with a history of or concern for ADHD can provide useful information regarding current cognitive functioning as part of the overall clinical assessment. In general, neuropsychological profiles of adults with ADHD shows weaknesses on measures of attention, information processing speed, executive functioning, and memory. More specifically, research has documented deficits that are most evident in attention, response inhibition, word generation, and memory. Such findings from neuropsychological evaluation can be helpful in the diagnostic process or in characterizing cognitive deficits associated with the diagnosis in the general population. It is well-established that aviators are a unique population with superior intellectual and cognitive abilities, and it is unclear whether those with a history of ADHD have a similar presentation on neuropsychological testing as those in the general population. There is concern that ADHD-related cognitive deficits may be easily overlooked in the those with higher levels of intellectual ability. A review of neuropsychological evaluation findings in those with a history of ADHD seen at the Aeromedical Consultation Service will explore the usefulness of neuropsychological testing data in this population. **APPLICATION:** ADHD is disqualifying for flying duties in the USAF, but a waiver may be considered for flying if stability can be documented. Neuropsychological features associated with ADHD have the potential to negatively impact functioning in the aviation environment and should be thoroughly assessed. This presentation will focus on the usefulness of neuropsychological assessment in aviators and will discuss findings from a series of evaluations conducted with pilots and other aircrew.

Learning Objectives

1. The audience will gain knowledge about the neuropsychological findings associated with adult ADHD.
2. Findings from neuropsychological assessment in aviators with a history of ADHD will contribute to understanding of this population.

[325] ATTENTION-DEFICIT/HYPERACTIVITY DISORDER (ADHD) – HOW IS THIS RELEVANT IN AVIATION?

Terry Correll
USAFSAM, Wright-Patterson AFB, OH, United States

(Education - Tutorial/Review)

INTRODUCTION: The essential feature of attention-deficit/hyperactivity disorder (ADHD) is a persistent pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development.[1] **TOPIC:** Population surveys suggest that ADHD occurs worldwide in about 7.2% of children. In a cross-national meta-analysis, ADHD occurred in 2.5% of adults. Adults with ADHD show poorer occupational performance, attainment, attendance, and higher probability of unemployment, as well as elevated interpersonal conflict.[1] Many of these symptoms are common, but the diagnosis of ADHD is made when the symptoms interfere with school/work/relationships and activities of daily living. On average, individuals with ADHD obtain less schooling, have poorer vocational achievement, and have reduced intellectual scores than their peers, although there is great variability. In its severe form, the disorder is markedly impairing, affecting social, familial, and scholastic/occupational adjustment.[1] ADHD also commonly overlaps or coexists with other mental health conditions. **APPLICATION:** Features associated with ADHD in adults could have a negative impact in the aviation environment and could cause one to be found unfit for flying duties. This presentation will focus on the selection and retention of aviators as it relates to ADHD. A discussion of problems noted with aeromedical summaries and waiver packages will be addressed. Although specific for US Air Force pilots and aircrew evaluated at the Aeromedical Consultation Service, the underlying issues are common to aviators and waiver processes in all the military services and civilian organizations. **RESOURCES:** 1. American Psychiatric Association (Ed.). (2022). *Diagnostic and statistical manual of mental disorders:* DSM-5-TR (Fifth edition, text revision). American Psychiatric Association Publishing.

Learning Objectives

1. To understand the impact that ADHD has in the aviation community.
2. To discuss risk assessment, management, and mitigation for Air Force aviators and aircrew with ADHD.

Wednesday, 05/24/2023 ***2:00 PM***
Grand Chenier

[S-60]: PANEL: SAFETY CENTERS YEAR-IN-REVIEW

Chair: Ajiri Ikede

PANEL OVERVIEW*: This panel presents a review of recent aerospace safety data. Representatives from military and civil aerospace organizations will present summaries and analyses of recently collected safety data. Topics may include: cause factors including mechanical and human factors, identifiable safety trends, and updates on mitigation strategies for current risks. With certain types of accidents becoming rare events, the panel discussion is a unique opportunity to review the collective experiences of multiple safety programs and consider a variety of risk mitigation solutions.*

[326] TRANSPORT CANADA: YEAR-IN-REVIEW

Tyler Brooks
Transport Canada, Ottawa, Ontario, Canada

(Original Research)

BACKGROUND: Transport Canada is the federal regulator responsible for policies and programs which promote safe, secure, efficient, and environmentally responsible transportation in Canada. This presentation will familiarize participants with the mission of the Civil Aviation Medicine (CAM) Branch of Transport Canada, and highlight topics of interest arising in over the past year. **OVERVIEW:** The mission of the CAM Branch of Transport Canada is to ensure aircrew and air traffic controllers are medically fit, to close gaps in scientific knowledge of Canadian aviation medicine, to promote health and safety in the field of aviation, and to prevent aircraft accidents due to medically related human factors. The CAM Branch will present an overview of notable civil aviation medicine issues encountered over the past year. **DISCUSSION:** Aviation medicine practices and policy respond not only to changes in medicine, but also to changes in society, politics, and global events. The CAM Branch of Transport Canada shares its experience responding to a variety of issues.

Learning Objectives

1. Understand the mission of the Civil Aviation Medicine Branch of Transport Canada
2. Understand Transport Canada's experience in responding to specific issues related to aviation medicine

[327] NAVAL AVIATION SAFETY: 2022 YEAR IN REVIEW

Robert Krause
Naval Safety Command, Norfolk, VA, United States

(Education - Program/Process Review)

BACKGROUND: The Naval Safety Command analyzes Navy and Marine Corps aviation safety investigation reports in order to identify mishap causal factors and recommend corrective actions. **OVERVIEW/METHODS:** All Class A flight mishaps involving US Navy and Marine Corps aircraft during fiscal year 2022 (FY 2022) were reviewed using the Human Factors Analysis and Classification System (HFACS). **RESULTS:** During FY 2022 there were multiple Class A Flight mishaps in the U.S. Navy and US Marine Corps. A review of Class A flight mishaps over the past 10 years demonstrated that human factors were the predominant causal factors. A review of current Physiological Episodes and Events in Naval Aviation will also be presented. **DISCUSSION:** HFACS is a useful tool in safety investigation analysis and assists in identifying causal factors to focus mitigation strategies to prevent future mishaps. Its standardization across the Department of Defense facilitates cross-analysis and shared efforts to prevent future mishaps.

Learning Objectives

1. Review the overall trend in US Navy and Marine Corps flight mishaps and the most common human factors identified as causal factors.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for Naval Aviation mishaps and review the trends of mishap HFACS causal factors over the last decade.
3. Become familiar with emerging topics of discussion at the Naval Safety Command related to aviation, including physiologic events.

[328] AIR FORCE AVIATION AND SPACE SAFETY: 2022 YEAR IN REVIEW

Andrew Metelko, Kevin Alford, Geoffrey Ewing, Denise Zona, Michael Armstrong
U.S. Air Force, Kirtland AFB, NM, United States

(Education - Program/Process Review)

BACKGROUND: The United States Air Force Safety Center's Human Factors experts support commanders and safety professionals Air Force wide by applying human factors (HF) expertise to identify, anticipate, analyze, manage and prevent human factors risk in Air Force operations and safety culture. **OVERVIEW/METHODS:** The Human Factors Division analyzed All Class A mishaps, manned/unmanned aviation mishaps, fatalities, CFIT/GLOC events, and the predominate HF identified in fiscal year 2022 mishap investigations. **RESULTS:** Overall USAF mishap trends were mixed in 2022 but supported a continued downward trajectory for fatal aviation mishaps. Commonly identified HFs stayed consistent across most categories. **DISCUSSION:** HF continues to contribute significantly to aviation mishaps representing a pivotal area for improvement in the goal to reduce mishaps. Future efforts should focus on improving consistency in identification and categorization of HFs in Air Force mishaps to support trend analysis and recommendations for improvement.

Learning Objectives

1. Review the overall trends in US Air Force aviation and space mishaps.
2. Identify the most common Human Factors Analysis and Classification System (HFACS) categories for USAF US Air Force mishaps.
3. Understand limitations human factors trend analysis and consider methods to improve human factors mishap recommendations to instill behavior changes that reduces mishap frequency and severity.

[329] UK MILITARY AVIATION SAFETY AND AIRCRAFT ACCIDENT INVESTIGATION: YEAR IN REVIEW

Matthew Lewis
RAF Centre of Aviation Medicine, Baldock, United Kingdom

(Education - Program/Process Review)

BACKGROUND: The purpose of this presentation is to identify the primary causal factors, survival and injury outcomes, and crew escape system performance findings from UK military aviation accidents. The analysis centred on both human and technical causal factors. Hazard trends were identified and compared with previous years' data. **OVERVIEW:** Aircraft accident data were obtained from military aircraft accident databases and the casual factors and injury outcomes were analysed. For the RAF the all-aircraft accident rate was 0.07 per 10,000 flying hours (FH), with one Class A (Category 5) mishap and no fatalities. The rates for RN accidents rate were 1.99 per 10000FH, with a rolling 10-year rate of 1.25 per 10000 FH. However, these data are skewed by ground incidences which dd not involved aircraft losses. The injuries sustained by the aircrew ranged from minor cuts and abrasions through to major skeletal injuries. Where escape systems had been used these worked satisfactorily, although there were failures of the survival equipment which could have caused different outcomes had the aircraft losses occurred over water. These shortcomings were common to a number of aircraft platforms and also occurred on sea survival training as identified by Defence Air Safety Occurrence reporting and trend analyses. **CONCLUSION:** UK military accident rates have shown a gradual reduction over the past ten years with the largest reduction being

shown by fast jets. Human factors persist in being the major cause of aircraft accidents and in particular were responsible for the loss of an F35 Lightning II aircraft.

Learning Objectives

1. The audience will learn about the UK military's efforts to utilise aviation accident data to develop proactive intervention strategies to prevent future accidents in an effort to preserve human life and aircraft losses.
2. Understand the importance of how aircrew equipment design and function is critical to aircraft accident survival.

[330] ROYAL CANADIAN AIR FORCE FLIGHT SAFETY: YEAR IN REVIEW 2022

Ajiri Ikede
Canadian Armed Forces, Ottawa, Ontario, Canada

(Education - Program/Process Review)

MOTIVATION: The Commander of the Royal Canadian Air Force (RCAF) is appointed as the Airworthiness Authority for all aviation in the Canadian Armed Forces (CAF). The Director of Flight Safety (DFS) is appointed as the Airworthiness Investigative Authority for all flight safety occurrences with the goal of preventing accidental loss of aircraft and personnel. Contributory or causal human factors are identified using the Canadian Forces Human Factors Analysis and Classification System (CF- HFACS). Statistics and analysis from 2022 are discussed. **OVERVIEW:** Accidents and incidents from 2022 were reviewed to identify human factors which may have caused or contributed to these occurrences. The Self-Administered Interview (SAI) was adopted as the standard operating procedure for collecting witness statements in 2021 and continues to be of great utility. **SIGNIFICANCE:** Fatigue, culture and substances hazardous to aviation continue to be relevant hazards in the RCAF. DFS has helped to propel several risk mitigation initiatives specifically aimed these factors, including the implementation of the RCAF Fatigue Risk Management System, while facilitating the international distribution and use of SAI for accident investigations.

Learning Objectives

1. Understand the overall trends in RCAF flight occurrences in 2022.
2. Understand the effectiveness of the SAI in the collection of information from witnesses, especially when timely face-to-face interviewing is not possible.

[331] US ARMY AVIATION SAFETY: FY 2022 YEAR IN REVIEW

Luis Rivero, Sean O'Connell
U.S. Army, Fort Rucker, AL, United States

(Original Research)

INTRODUCTION: Discuss (FY) 2022 statistics and analysis for USA Class A aviation mishaps including Human Factors Analysis. **METHODS:** FY2022 data was obtained from the USA Combat Readiness Center database (ASMIS2.0) for Class A thru C manned aviation mishaps and reviewed for human factors as determined by the Safety Investigation Boards. **RESULTS:** In the manned aircraft category, Army aviation experienced 57 Class A - C manned aircraft Flight mishaps in FY22. This was a decrease from the 59 Class A-C Flight mishaps reported in FY21. The US Army experienced 4 Class A manned aviation Flight mishaps during FY22, 57% below the 7 Flight mishaps reported for FY21. The accident rate for Class A Flight mishaps (per 100,000 flying hours) was 0.50 in FY22, a 37% decrease from the 0.87 Class A record rate recorded in FY21. There were only two aviation mishap fatalities in FY22 compared to 13 in FY21. **DISCUSSION:** For the third year in a row, Army Aviation has remained below a rate of one mishap per 100,000 flying hours. This overall rate is the result of three years in a row of single digit Class A Mishaps (FY20 = 6, FY21 = 8, and FY22 = 8). The Army continued to maintain a Class A mishap rate below established norms during FY22. FY22's manned Class A flight mishap rate was 0.50 per 100K flying hours, the sixth time in the last ten years the rate has been below the 1.0 mark and lower than the ten-year rate of 1.10. There were eight Class A mishaps (4 Flight; 1 Flight Related; 3 Aircraft Ground) reported in FY22 with approximately 803,683 hours flown. Human error continues to be the leading cause factor in Army Class A Flight mishaps.

Learning Objectives

1. With historically low Class A mishap rates, the Aviation Division at the USACRC has shifted its focus to Class C and below mishaps that account for 88% of the flight and flight related mishaps. We will discuss leading categories for Class A-C mishaps between FY16 and FY22.
2. We will discuss other areas of focus to reduce Class C and below mishaps, such as aviation ground events such as ground handling and servicing.
3. Discuss the primary cause factor in manned and unmanned aircraft mishaps.

Wednesday, 05/24/2023 ***2:00 PM***
Napoleon Ballroom C1-C2

[S-61]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS III

Chair: Jonathan Elliot
Co-Chair: Albert Lee

PANEL OVERVIEW: *Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.*

[332] DOC, MY URINE IS BROWN

Jason Gordon
Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case describes novel exertional rhabdomyolysis provoked in the upper extremities of a man following an 18 minute series of concentric and eccentric upper body exercises. **BACKGROUND:** Exertional rhabdomyolysis is a potentially life threatening condition with high morbidity if left untreated. Exertion may be short and extreme muscle damage may still occur. Aviators and maintainers with limited time to exercise may opt for high intensity, short exercise sessions without an adequate adjustment or warm up period or adequate baseline hydration. Education of our aviation personnel on the risks associated with burst workouts is warranted to ensure adequate personnel availability and limit personal harm. **CASE PRESENTATION:** A 32-year-old right hand dominant man with unremarkable past medical history performed a workout of 120 pull ups and 120 dips in 18 minutes. His serum creatine kinase [CK] peaked at 238,000 units/liter (U/L) with gross edema of only his right forearm. He never experienced acute kidney injury and was able to maintain a glomerular filtration rate greater than 100 milliliters/minute following 10 liters of intravenous [IV] crystalloid therapy over 2 inpatient hospital days. One week after the initial workout his follow-up CK was 25,000 U/L and he had no evidence of morbidity at the end of one month. **DISCUSSION:** First described in war zones from crush injuries, rhabdomyolysis is a syndrome resulting from damage to the muscle sarcolemma. It may also occur from non-traumatic exertion in a healthy, fit person who has the mental drive and physical ability to push themself

beyond a pain threshold normally signifying muscle fatigue. The triad of myoglobinuria, myalgias and fatigue may be present but is rarely seen. Treatment of exertional rhabdomyolysis via multiple crystalloid boluses alone without dialysis, alkalinization of urine, or complex monitoring techniques is an acceptable first line treatment. Theoretical hyperchloremic metabolic acidosis does not appear to occur in previously healthy patients. With rapid evaluation and treatment of a previously healthy patient with no underlying risk factors who presents with elevated CK secondary to exertion, the prognosis is good and the diagnosis should not necessarily be cause for alarm.

Learning Objectives

1. The audience will learn about the potential risks associated with short burst exercise regimens common in aviation personnel.
2. The audience will learn about the treatment of exertional rhabdomyolysis and expected lab abnormalities.

[333] CORNEAL DEGENERATION IN A PILOT APPLICANT

Joelle Thorgrimson[1], David Hessert[2]
[1]*Royal Canadian Air Force, Pensacola, FL, United States;* [2]*Naval Aerospace Medicine Institute, Pensacola, FL, United States*

(Education - Case Study)

INTRODUCTION: Corneal degeneration in a pilot applicant was eventually diagnosed in a complex ocular case resulting in disqualification. **BACKGROUND:** This unique case report illustrates the importance of ocular history disclosure and photo documentation of ophthalmologic pathology when waivers are granted. **CASE PRESENTATION:** Gelatinous drop like corneal dystrophy was initially diagnosed in a pilot applicant who previously had an approved waiver for a corneal scar. Following further information disclosure, this pathology was determined to be post-operative changes from previous Salzmann's nodule removal. **DISCUSSION:** Corneal dystrophy and degeneration are disqualifying conditions for military pilot applicants. Ocular history must be shared by applicants for appropriate diagnosis. Photo documentation should be completed and reviewed when waivers are granted.

Learning Objectives

1. The participant will be able to understand the decision-making process of ophthalmologic medical waivers.
2. The audience will learn about the pathophysiology for corneal dystrophy and degeneration as it relates to compatibility with flight crew operations.

[334] SEVERE ALTITUDE ILLNESS AT 12,000 FT IN MILITARY SERVICE MEMBER

John Solak, Yiwei Jiao
U.S. Army Department of Aviation Medicine, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a military service member who experienced severe altitude illness at 12,000 ft while participating as a research volunteer. **BACKGROUND:** The U.S. military conducts operations in diverse geographical locations across the globe, thus altitude illness can pose significant operational challenges. Acute mountain sickness (AMS) is the most common form, and its symptoms can be debilitating, while the less common high altitude pulmonary edema (HAPE) and high-altitude cerebral edema (HACE) can be life threatening. Currently, there are no reliable methods to predict likelihood of severe altitude illness. Therefore, early recognition of its signs and symptoms and prompt interventions are paramount in preventing sequelae. **CASE PRESENTATION:** A 19-yr old healthy, physically fit with no significant medical history volunteered in an altitude illness related research. He had no prior high-altitude experience. He and his cohort of volunteers ascended from 3,981 ft (1,213 m) to 9,321 ft (2,841 m) over seven hours by vehicle, then ascended to 12,000 ft (3,657 m) over two hours by hiking while carrying 15% of body weight. He started experiencing symptoms of headache, tachycardia, shortness of breath, within several hours of arriving at 12,000 ft that gradually worsened over the next day. On the morning of the third day at altitude, he started exhibiting dry cough, chest tightness, and neurological symptoms including ataxia, mild confusion, and mild slur in speech. Exam showed crackles in the lungs. He was immediately treated with supplemental oxygen and descended by vehicle to approximately 7,000 ft to be evaluated at an emergency department. Chest x-ray confirmed presence of pulmonary edema and brain CT was inconclusive. He successfully recovered without significant long-term sequelae. **DISCUSSION:** This case highlights the acute and unpredictable nature of severe altitude illness in a healthy individual without prior high-altitude experience as well as the importance of early recognition and intervention to prevent long term sequelae or death. Proper logistical and operational planning in preparation for the treatment of severe altitude illness in austere environments and possible hostile enemy territory is also a major consideration in this case.

Learning Objectives

1. Recognition of the signs and symptoms of severe altitude illness.
2. Operational considerations of severe acute mountain sickness in austere and possible hostile environments.
3. Treatment options of severe acute mountain sickness.

[335] A CASE OF ACUTE MYOCARDITIS MIMICKING MYOCARDIAL INFARCTION WITH NORMAL CORONARIES

Andrew Glenn, Heung Noh
Department of Aviation Medicine, Fort Rucker, AL, United States

(Education - Case Study)

INTRODUCTION: This is a case of a viral myocarditis mimicking a myocardial infarction in an Army flight student. **BACKGROUND:** Myocarditis is the inflammation of the heart muscle with variable clinical presentations that require close attention of a flight surgeon. While most commonly caused by a viral illness, myocarditis is known to have other etiologies such as bacterial infection, sarcoidosis, and systemic lupus erythematosus among others. Roughly half of the cases are due to undetermined etiology. The onset can be acute versus chronic, or focal versus diffuse. For aviation safety, myocarditis must be carefully evaluated, and risk stratified after resolution prior to performing flying duties. **CASE PRESENTATION:** A 25-year-old National Guardsman in Army flight school presented to an emergency department (ED) with complaint of severe chest pain, left arm pain, diaphoresis and shortness of breath. The symptoms woke him up from sleep at 4 a.m. but resolved without intervention. Same symptoms arose again while driving home from work but this time persistent, prompting him to report to an ED. Patient reported congestion and flu-like symptoms for the past month and two nights with night sweats prior to the ED presentation. Serial troponin level per ED chest pain protocol showed rise from 11,000 ng/mL to greater than 25,000 ng/mL without EKG changes. Cath lab evaluation for suspected NSTEMI demonstrated normal coronary vessels with some apical akinesia. Stress test was unremarkable, and the echocardiogram showed borderline but normal cardiac motion. His symptoms in hospital improved with Imdur and morphine, and post-discharge Holter monitor and cardiac MRI were both unremarkable. Upon review of the cardiac tests, viral myocarditis was determined to be the leading diagnosis. With a favorable prognosis, the patient later graduated from flight school with his duties were limited to simulator only. Final month of flight training is exclusively done on simulators for all flight students. Meanwhile he completed his further cardiology follow up. **DISCUSSION:** Viral Myocarditis is a temporary medical condition that is not compatible with flight but has a favorable prognosis for recovery and return to flight duties. Flight duties usually resume 6 months after the initial episode of Viral Myocarditis with no residual symptoms and negative follow up testing to include EKG, stress test, echo and cardiac MRI.

Learning Objectives

1. The audience will learn about the presentation and diagnosis of Viral Myocarditis.
2. The audience will learn about the aeromedical implications and flight considerations of patients with Viral Myocarditis.

[336] IT ISN'T A DOLPHIN, IT'S A ZEBRA

Katherine Cortez
U.S. Navy, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: A 26-year-old male presented to his annual flight physical reporting recent worsening of chronic folliculitis. This case study reviews the relevant workup as well as the ultimate relevant diagnosis and findings. **BACKGROUND:** Primary Cutaneous Follicular Center Lymphoma (PCFCL) is a rare B-cell form of Non-Hodgkin's Lymphomas, with an incidence rate at around 1 per 1,000,000 per year in Western countries. A diagnosis of middle age, the disease is exceedingly rare in the youthful military-aged population. PCFCL follows an indolent course, sometimes present for decades before diagnosis, and has an extracutaneous dissemination rate of approximately 10%. For overall prognosis, PCFCL is considered treatable but not curable. With treatment the 5-year survival rate is excellent, at >95%. The recurrence varies based on treatment; the lowest recurrence is seen with radiation, approximately 30% at 10 year. PCFCL and other indolent lymphomas present a complex aeromedical decision pathway, taking into account considerations of complications of treatment, frequent specialist follow ups, high likelihood of recurrence, and overall general lack of robust data on this rare disease. **CASE PRESENTATION:** This student naval aviator had a 6-year diagnosis of recurrent folliculitis on his anterior trapezius that was historically treated conservatively. On his most recent flight physical, he reported several 'red spots' on his torso and face that had been waxing and waning for several years and had recently been worsening. After biopsy, he was diagnosed and treated for Primary Cutaneous Follicle Center Lymphoma. **DISCUSSION:** This case will discuss medical issues in line with this diagnosis as well as the pertinent aeromedical considerations surrounding the case. It is intended for Aerospace Medicine Residents and Flight Surgeons to aid in determination of flight duty eligibility as well as general military duty eligibility.

Learning Objectives

1. Participants will be able to develop a cursory differential list and initial evaluation plan for chronic folliculitis-like skin complaints.
2. Participants will gain knowledge of the aeromedical implications of indolent cutaneous lymphomas.

[337] HYPOCAPNIA WITHOUT PANIC RESULTING IN PHYSIOLOGIC SYMPTOMS

Christopher Rock[1], Evan Knock[2]
[1]*Naval Aerospace Medical Institute, Pensacola, FL, United States;* [2]*Naval Training Air Wing 6, Pensacola, FL, United States*

(Education - Case Study)

INTRODUCTION: We present a case involving aircrew aboard a T-6A training aircraft who experienced a suspected acapnic physiologic event which we believe was caused by oscillating oxygen concentrations from the on-board oxygen generation system (OBOGS) resulting in a physiologic response of hyper, then hypoventilation. **BACKGROUND:** The Navy's definition of a physiological episode (PE) is when a pilot experiences a loss in performance related to insufficient oxygen, depressurization, or other factors during flight. Hypocapnia (hypocarbia) is a recognized, less common etiology associated with hyperventilation conventionally correlated to episodes of panic, severe anxiety, or stress. **CASE PRESENTATION:** Instructor Pilot (IP) and Student NFO (SNFO) were on a day instrument flight from NAS Pensacola. The aircraft departed at 0824. There was a steady and continuous climb, during which all advisory/caution/warning lights were consistent with normal operations. At approximately 0837, the aircraft reached 23,000 feet. Two minutes later (0839), the OBOGS FAIL warning light illuminated. The IP silenced the warning light and, within 5 seconds, began to experience symptoms of lethargy, and dizziness. At this time, the SNFO was not experiencing symptoms. While the IP and SNFO initiated procedures for physiological symptoms, the OBOGS FAIL light illuminated a second time at 0840, and SNFO noted symptoms. Both aircrew switched to emergency bottled oxygen and began immediate descent. Once below 10,000, MSL, both aircrew dropped their masks and noted an immediate reduction in symptoms. **DISCUSSION:** OBOGS data analyzed from this flight showed that the oxygen composition control algorithm was delivering wide concentration swings at the outlet of the concentrator. Even with the oscillations, OBOGS oxygen concentration remained above physiological minimums, making classic hypoxic hypoxia unlikely. A maintenance investigation ruled out the possibility of contamination resulting in histotoxic hypoxia. The patients had no factors to suspect anemic hypoxia. We propose the most likely explanation to be hypocapnia.

Learning Objectives

1. Define what constitutes a physiologic event in the context of aerospace medicine, and the various causal factors known to contribute to physiologic events.
2. Describe the pathophysiology of hyperventilation-induced hypocapnia, and how the proposed oscillating oxygen concentration mechanism could lead to hypocapnia.

Wednesday, 05/24/2023 ***2:00 PM***
Napoleon Ballroom D1-D2

[S-62]: PANEL: ADVANCES IN AEROSPACE MEDICINE IN IBEROAMERICA

Sponsored by Iberoamerican Association of Aerospace Medicine

Chair: Rocio Garzon
Co-Chair: Angela Gomez

PANEL OVERVIEW: *This session is given in Spanish language with English slides. This session offers a space to share the advances made in Iberoamerica in different aspects of aerospace medicine. On this occasion, accident investigation topics, from Spain, will be followed by physiology research (Colombia), and clinical aspects will be presented (Venezuela).*

[338] HUMAN FACTORS INVOLVED IN THE FIRST A400M AIRCRAFT ACCIDENT

Beatriz Puente
Spanish Air Force Institute of Aviation Medicine, Madrid, Spain

(Education - Case Study)

INTRODUCTION: The A400M is a European cutting-edge transport aircraft for military use designed as a tactical airlifter with strategic capabilities to replace older transport aircraft. **BACKGROUND:** The A400M is equipped with four turboprop engines, manufactured by Airbus Military S.L. and operated by seven European Armed Forces and three other countries. The mishap aircraft was undergoing its final industrial operational tests, which are conducted prior to the aircraft's delivery to the end customer. **CASE PRESENTATION:** The flight took place on 9 May 2015. The accident occurred during the first production acceptance flight. The crew consisted of six ADS employees, four of them were killed, and the other two were seriously injured. All the procedures carried out on the day of the accident until the moment of take-off were conducted within the usual parameters associated with this type of flight. During the take-off phase and shortly after rotation, the crew received various warnings pertaining to the degraded operation of engines 1, 2, and 3. This degraded operation froze the power of engines 1, 2, and 3 at take-off (maximum) thrust. The crew was unable to change engine power and had no engine information in the cockpit. The crew's subsequent actions to adjust the speed and altitude parameters ended up leaving the aircraft with the thrust for engines 1, 2, and 3 frozen at flight idle. The operation of engine 4 was not affected. Due to the loss of power, the aircraft was unable to maintain altitude; as a result, three and a half minutes after initiating the take-off run, it impacted the ground. The aircraft was destroyed. **DISCUSSION:** Human Factors were

analyzed during the investigation and will be discussed during the presentation. These include not only medical and pathological information but also situational awareness, complexity, automation, stress and performance, crew resource management, decision-making, man-machine interface, and training. Some of these factors were considered probable causes and some contributing factors, leading to several recommendations. The analysis was based on the taxonomy of the Human Factors Analysis and Classification System (HFACS).

Learning Objectives

1. The participant will be able to understand the capital importance of human factors analysis in aircraft accident investigation.
2. The audience will learn about the results of a thorough investigation of the accident of a modern aircraft.

[339] ALTITUDE-HIKING PHYSIOLOGICAL EFFECTS IN AEROSPACE MEDICINE RESIDENTS AT THE CHINGAZA NATIONAL PARK, BOGOTA, COLOMBIA

Adriana Zuluaga Serna[1], Laura Maria Pineda Jimenez[1], Diego Malpica[2], Diego Manuel Garcia Morales[3], Gustavo Adolfo Celis-Ceballos[1]

[1]*Universidad Nacional de Colombia, Bogota, Colombia;* [2]*Colombian Air Force, Bogota, Colombia;* [3]*Embry-Riddle Aeronautical University, Daytona, FL, United States*

(Original Research)

INTRODUCTION: Physiology training is key for crews, also for aerospace medicine specialists. Aerospace Medicine Residents (RAMS) take advantage from physiology training campaigns both as subjects and researchers. A group of RAMS based at 2640 meters above sea level (MASL) were exposed to a high-altitude hiking exercise, while recording various physiological variables in order to understand their own reactions to high altitude exercise. **METHODS:** Eight healthy RAMS were exposed to a hike of 1.62 km with a total change of altitude of 360 m up to 3700 MASL. They wore a Polar V800 and a H7 chest band to record RR. Data was exported to Kubios® standard free version 3.5 to analyze heart rate variability. Records were exported to Microsoft Excel® 2016. Descriptive, repeated measurements ANOVA were used to examine within-subjects differences. **RESULTS:** Age range was 27-40 (mean: 31 years old, SD 4.46) and 6 (75%) were females. Most RAMS (75%) had a normal body mass index, 1 (12.5%) was underweight and an equal portion was overweight. Lifestyle was reported as sedentary, for 50% of participants. The average time for ascent was 100min, the group spent 70min at the top of the mountain, and 80min for descent. Stress-related physiological variables such as mean heart rate and mean interval RR (MeanHR, MeanRR) showed mirrored behavior throughout the ascent, summit and descent, respectively, as recorded means with their 95% confidence interval indicate: MeanHR: 149.7 (139.6-159.8); 112.1 (96.8-127.4); 129.6 (117.4-141.7). MeanRR was 403 ms (373.8-432.2), 547 ms (472.8 to 622.6), 468 ms (422.9-513.2). Also, calculated stress index and Sympathetic Nervous System (SNS) showed similar behavior throughout the ascent, summit and descent, respectively: Calculated stress index recorded 21.4 (12.8-30.0); 15.1 (6.8-23.3); 18.9 (9.9-27.9) and, SNS 8.7 (6.7-10.7); 4.2 (1.5-7.0); 6.4 (4.1-8.7). **DISCUSSION:** A middle aged, female-predominant population of healthy RAMs were exposed to a high-altitude hike, showing expected physiological traits of acclimatization to hypobaric hypoxia. This acute exposure to altitude during a physically demanding activity was a successful approach to extreme physiology assessment both from study-subject and researcher perspective.

Learning Objectives

1. The participant will be able to undestand the importance of conducting real-world scenarios to perform research as part of the residency program in aerospace medicine.
2. The participants will learn about the integration between the theoretical foundations of high-altitude physiology and the practical implications for residents in-training

[340] PREVALENCE OF DECOMPRESSION SICKNESS DURING HYPOBARIC CHAMBER TRAINING AT THE COLOMBIAN AIR FORCE, 2010-2020

Gustavo Adolfo Celis[1], Sonia Jaimes[1], Diego Malpica[1], Laura Maria Pineda Jimenez[2], Adriana Zuluaga S[2], Diego Manuel Garcia Morales[3]

[1]*Colombian Air Force, Bogota, Colombia;* [2]*Universidad Nacional de Colombia, Bogota, Colombia;* [3]*Embry-Riddle Aeronautical University, Daytona, FL, United States*

(Original Research)

INTRODUCTION: The hypobaric chamber is a simulator of the physical and physiological phenomena that occur due to the decrease in barometric pressure. The present study aimed to investigate the frequency of decompression sickness during hypobaric chamber training in the Colombian Air Force (COLAF) from 2010 to 2020. **METHODS:** Retrospective observational study on aircrews undergoing hypobaric chamber training at the Aerospace Medicine Center COLAF in Bogota D.C, Colombia, who were diagnosed with decompression sickness type I or II by the Aerospace Medicine service and the hypobaric chamber medical director. **RESULTS:** 6,745 crewmembers underwent hypobaric chamber training, 54 cases were included in the study due to signs and symptoms of decompression sickness (DCS), mostly men 35 (64.81%), ages from 21 to 44 years (median 30 years), the main specialties were nurses 19 (35.18%), pilots 14 (25.92%), flight technicians 7 (12.96%) and physicians 5 (9.25%); 34 (62.96%) were instructors or internal observers, the rest were students. 45 aircrews (83.33%) presented type I DCS, the main symptoms were joint pain in the upper limbs 19 (35.18%), joint pain in the lower limbs 18 (33.33%) and headache 6 (11.11%). Finally, the aircrews with type II DCS were 9 (16.66%). Regarding treatment, all patients required management with oxygen 100% and, all crewmembers with type II DCS and also three crewmembers with type I DCS, required hyperbaric oxygen treatment. The total prevalence of decompression sickness was 0.8%. **DISCUSSION:** The prevalence of decompression sickness during and after hypobaric chamber training is similar to what is reported in the literature, suggesting that a pre-chamber medical check and the period of denitrogenation, can help to reduce the risk.

Learning Objectives

1. The participants will be able to compare the frequency of decompression sickness during hypobaric hypoxia training in the Colombian Air Force with the published literature.
2. The audience will be able to go over the most frequent symptoms of sub-atmospheric decompression sickness during or after hypobaric hypoxia training in the Colombian Air Force aircrews.

[341] USE OF PCSK-9 INHIBITORS IN THE MANAGEMENT OF HOMOZYGOUS HYPERCHOLESTEROLEMIA IN COMMERCIAL PILOTS IN LATIN AMERICA. ¿ IS ALLOWED ?

Jean Duenes[1]

[1]*Cardiocountry Medical Center, Bogota, Colombia*

(Original Research)

The objective of the study is to know the number of commercial pilots diagnosed with familial dyslipidemia, determining the number of homozygous familial hypercholesterolemia in commercial pilots and identify possible aeromedical restrictions in this special population. Since studies have shown that patients with spontaneous functional PCSK9 deficiency have reduced LDL-cholesterol (LDL-C) concentration and increased long-term cardiovascular risk, PCSK9 (proprotein convertase subtilisin/kexin type 9), which is an enzyme that intervenes in the degradation of LDL receptors in the hepatocyte, in such a way that its blockade reduces said degradation, which ensures that the receptors are in continuous activity, allowing to increase the uptake and removal of LDL particles from the liver. plasma with consequent reduction in its plasma concentrations. **MATERIALS AND METHODS:** This is a retrospective

descriptive study, carried out in the period from June 2020 to June 2022 with a population from Argentina, Chile, Brazil, Colombia, the United States, Guatemala, Mexico, Panama and Venezuela. It was carried out through the analysis of the results of levels of Total Cholesterol, LDL, HDL of the selected population. The total population was 1,080, with an average age between 39 and 63 years of age. **CONCLUSIONS:** Using the data obtained, the prevalence of familial dyslipidemia between commercial pilots with established coronary disease and those in which it has not been diagnosed is established. Obesity and hypertension were identified as risk factors, although they are not enough to predict the risk. 110 users started PCSK9 inhibitors, improving LDL levels for 2 to 3 months, A total of 11 people from the initial population decided not to continue with this research ICAO and FAA in their medical regulations still do not mention the use of these inhibitors.

Learning Objectives

1. The objective of the study is to know the number of commercial pilots diagnosed with familial dyslipidemia.
2. Calculate people who started treatment with statins • Know how much these PCSK9.

[342] MEDICAL LEAVES OF AEROMEDICAL CERTIFICATE HOLDERS IN COLOMBIA: 2017 – 2022

Johana Giraldo[1], Brian Andres Ramirez[2], Maria Angelita Salamanca[1], Alexandra Mejia[1], Patricia Barrientos[1], Diego Garcia[2]
[1]*Aerocivil - Civil Aviation Authority of Colombia, Bogota, Colombia;* [2]*National University of Colombia, Bogota, Colombia*

(Original Research)

INTRODUCTION: Health affectations to aeromedical certificate holders is a key element for aviation safety given their safety-critical role. This study aims to describe medical leaves in this population, for gaining a general perspective of recurrent diagnosis, and for estimating associations between change of aeromedical certificate status and type of diagnosis. **METHODS:** This is an observational, cross-sectional study design gathering reports of sick leaves between 2017 and 2022, from certificate holders to the Colombia Civil Authority (CAA). Cumulative frequency distribution informed relations between the nature of the sick leave and its impact on the status of the medical certificate. **RESULTS:** 2331 result were processed, median age of the reporting personnel was 38 (IQR: 32 - 44), 56% were male. Most of them (49%) hold a 2nd class certificate, 42% hold a 1st class and 8.2% hold a 3rd class. Half (50.1%) of the medical leaves lasted less than 20 days. Major diagnostic categories reported during this period were respiratory diseases (47,4%), and musculoskeletal disorders (27,1%). Status of aeromedical certificate was affected by diagnoses in 406 cases (17% of reported total cases), 218 certificate holders went back to normal flight operations without restrictions on their certificate (9,3%), 123 are still deferred (5,2%), 17 of them (0,7%) received a special issuance certification, and 48 (2,05%) certificate holders were declared unfit. An observation by diagnostic-related groups revealed that 100% of psychiatric conditions reported derived in affected certificate status, while 72.9% of cardiovascular diagnosis, 71.4% of nervous system, 29.2% of urinary/reproductive, and 27,2 % of eye/ear-nose-throat conditions ended up affecting certificate status. **DISCUSSION:** Our observations demonstrate that most medical leaves reports In Colombia did not affect the status of the aeromedical certificate of those reporting, this mostly since aeromedical decision are made on an individual basis. Nonetheless, certain diagnoses are more prone to affect safety-critical human performance, thus more certificate holders with those conditions saw they medical certificate affected while individual assessment was performed. There was an evident surge of respiratory diagnosis reports after the 2020 period, findings easily relatable to the COVID-19 pandemic.

Learning Objectives

1. The audience will be informed about the distribution of medical leaves in Colombian certificate holders during the last six years.
2. Attendants will learn about how aeromedical certificate status was impacted by different major diagnostic categories of reported medical leaves.

Wednesday, 05/24/2023 ***2:00 PM***
Napoleon C3

[S-63]: SLIDES: SPACE MEDICINE TO SCALE

Chair: John Allen

[343] EFFECT OF DEEP-SPACE TIME DELAY AND TEXT COMMUNICATIONS ON TELE-SURGICAL GUIDANCE

Chelsea Spencer[1], Scott Stegeman[1], Margaret Sui[1], Kristina Kramer[1], Dana Levin[2], Kathleen Mosier[3], Ute Fischer[4], Tovy Kamine[1]
[1]*Baystate Medical Center, Springfield, MA, United States;* [2]*Columbia University Irving Medical Center, New York, NY, United States;* [3]*San Francisco State University, San Francisco, CA, United States;* [4]*Georgia Institute of Technology, Atlanta, GA, United States*

(Original Research)

INTRODUCTION: It is possible that an astronaut on a long duration space flight will suffer a surgical emergency. As current plans do not involve sending someone with significant surgical training on long duration spaceflight, any surgical procedure will likely require remote telementoring. Space flight beyond the Earth-Moon system will involve significant time delay and text-only communication. Using simulation, we assessed feasibility of textual communications with significant time delay to guide remote appendectomy. **METHODS:** A laparoscopic simulator (Simbionix LAP Mentor III) was used to simulate a patient presenting with appendicitis, equipped to perform all necessary steps of laparoscopic appendectomy. Emergency medicine physicians (EMP) were guided by a board-certified general surgeon (GS) through an appendectomy both bedside and remotely using delayed textual communications. Each text message was sent with a 3.5 minute one way delay. Procedural efficiencycharacteristics were obtained and compared. Each EMP and GS completed the NASA Task Load Index (TLX) following appendectomy. GS also completed simulated appendectomy as a control. **RESULTS:** Twelve EMPs underwent bedside and remotely guided appendectomy, 6 in each group. Average appendectomy time by EMPs with bedside guidance vs. GS control was 10:25 min vs. 04:44 min (p=0.012). Remotely guided appendectomy averaged 40:44 min (p=0.003 compared to bedside). For right hand economy of motion, bedside vs. remote guidance was 2.78 cm/sec vs. 04.72 cm/sec (p=0.002). Average number of texts sent for remote guidance was 6.67, contributing an average of 23:20 min of wait time. Analysis of TLX data reveal no difference in demand between bedside and remote guidance. **DISCUSSION:** Bedside guided appendectomy required less time and was more efficient compared to remotely guided. Remote guidance of appendectomy is possible, however time delay associated with each text using a 03:30 delay resulted in an average 23:20 difference, which may translate to 02:44:08, or approximately 35 times longer than the GS control if using the 22:00 delay in communication to Mars. This increase in time requirement will require significantly increased amounts of disposables such as IVF and anesthesia supplies in a weight limited environment. Additional study is needed to assess other components of operative intervention and patient outcome.

Learning Objectives

1. The listener will understand the feasibility of remote procedural guidance with a significant time delay.
2. The listener will understand the where the task load burden falls with telementoring with significant time delay.

[344] TRANSCRIPTOMIC RESPONSE OF BIOENGINEERED HUMAN CARTILAGE TO PARABOLIC FLIGHT MICROGRAVITY IS SEX-DEPENDENT

Shankar Jha[1], Amira Aissiou[1], Kirtan Dhunnoo[1], Hilda Ma[2], David Li[1], Rahul Ravin[1], Melanie Kunze[1], Kinston Wong[1], Adetola Adesida[1]
[1]*University of Alberta, Edmonton, AB, Canada;* [2]*University of Toronto, Toronto, ON, Canada*

(Original Research)

INTRODUCTION: Microgravity induces osteoarthritic-like alterations at the transcriptomic levels in meniscal cartilages of rodents. However, little is known about the effects of microgravity on the transcriptome of tissue-engineered human cartilage cells. Furthermore, woman have a worse prognosis with osteoarthritis then men and this is not well understood. We assessed the transcriptome response of engineered human cartilage tissue to short exposure to microgravity. We also assessed for sex specific molecular changes in the cartilage tissue after exposure to microgravity. We hypothesize that the transcriptome profile of engineered human cartilage will respond to short-term microgravity via parabolic flight and these changes will be sex specific. **METHODS:** Human bone marrow aspirates from 3 male and 3 female age matched donors were collected from the University of Alberta (U of A) Hospital. The U of A Health Research Ethics Board waived the need for consent of donors, as specimens were intended for discard post-surgery. Mesenchymal stem cells were isolated from these aspirates and expanded in an incubator for 7 days. Next, these cells underwent in vitro chondrogenic differentiation in collagen scaffolds for 21 days. The parabolic flight was conducted in the Falcon 20 at the National Research Council of Canada. Our samples cycled through 11 parabolas on the flight, exposing them to approximately 140 seconds of microgravity. After levelling-off, the cartilage was terminated in RNAlater. Post experiment analysis included RT-qPCR and whole transcriptome next generation sequencing. **RESULTS:** We observed 30 differentially expressed genes of human cartilage tissue in response to short term exposure to microgravity *($p < 0.05$)*. Furthermore, 94 male specific genes and 74 female specific genes were expressed in response to microgravity. **DISCUSSION:** Our research shows microgravity specific molecular changes in human bioengineered cartilage are sex specific. This has important implications including in the identification of drug targetable pathways and development of countermeasure technologies for long duration spaceflight. This research also helps elucidate the sex specific differences in the pathology of human cartilage tissue.

Learning Objectives

1. Understand the molecular changes that occur in bioengineered cartilage tissue exposed to short term microgravity.
2. Appreciate the clinical and long term space travel implications of this research.

[345] ESTABLISHMENT OF THE DEPARTMENT OF DEFENSE CLINICAL AND OPERATIONAL SPACE MEDICINE INNOVATION CONSORTIUM (COSMIC)

Craig Nowadly[1], David Burch[2], James McEachen[3]
[1]*U.S. Air Force, 59th Medical Wing, San Antonio, TX, United States;* [2]*Air Force Research Lab, Dayton, OH, United States;* [3]*711th Human Performance Wing, Dayton, OH, United States*

(Education - Program/Process Review)

BACKGROUND: Vertical take-off and vertical landing (VTVL) commercial spacecraft may provide the Department of Defense (DOD) rapid, global, point-to-point transit capability with unprecedented speed and ability to overfly contested airspace. The DOD is actively cultivating commercial spaceflight partnerships with US Transportation Command. Furthermore, the United States Air Force (USAF) has already established the Vanguard Rocket Cargo Program, assessing the feasibility of using commercial launch platforms for rapid movement of military cargo. The National Aeronautics and Space Administration (NASA) is the global leader in space medicine, with extensive space medicine research and operational capability. However, DOD spaceflight will have a fundamentally different mission than NASA, utilizing kinetic, unregulated, suborbital, short-duration, VTVL flights. DOD personnel require different training, health screening, qualifications and mission risks than NASA. It is clear that the DOD will have different space medicine research objectives compared to NASA. **OVERVIEW:** In order to customize a DOD-specific space medicine research program in a systemic and logical fashion, we established the Clinical and Operational Space Medicine Innovation Consortium (COSMIC), a dedicated, clinically focused, space research presence within the 59th Medical Wing (MDW) En-route Care Research Center (ECRC) in close partnership with the 711th Human Performance Wing (HPW). **DISCUSSION:** With rapid advancements in engineering capability in commercial spaceflight, the goal of COSMIC is to advance DOD-specific space medicine research priorities that may not directly overlap with NASA or civilian spaceflight research gaps. By building a consortium led by the 59th MDW and 711th HPW, we will be able to leverage engineering capability, animal research laboratories, and human clinical research at both institutions. In the coming years, COSMIC will focus on feasibility studies involving engineering, animal, and human research. The long-term objective of COSMIC is to curate a permanent DOD-specific space medicine research capability, in partnership with other DOD, civilian, and international partners, to help inform DOD operational decision makers in the space medicine environment.

Learning Objectives

1. Introduce the purpose and vision of the DOD Clinical and Operational Space Medicine Innovation Consortium.
2. Outline and describe key players, roles, collaborative federal opportunities in relation to DOD space medicine research.
3. Understand the clinical relevance associated with DOD space medicine research projects.

[346] THE IMPACT OF LONG-DISTANCE SPACEFLIGHT ON THE HUMAN EXPOSOME

Amelia Garner Shrader[1,2], Aubrey Florom-Smith[3]
[1]*University of Alabama, Tuscaloosa, AL, United States;* [2]*University of Alabama-Huntsville, Huntsville, AL, United States;* [3]*Stanford University, Stanford, CA, United States*

(Education - Program/Process Review)

BACKGROUND: On Earth, human health is strongly influenced by environmental exposures. The concept of long-distance space exploration is quickly becoming a reality, and astronauts will truly travel "where no man has gone before". This novel experience poses a new, unprecedented level of risk to the health of these astronauts. Space travel has well-documented risks. NASA's Human Research Program (HRP) has categorized the greatest risks to human health into five priorities: alterations in gravity, radiation, distance, hostile environments, and psychological impacts of isolation. Increased understanding of the exposome, which encompasses all environmental exposures that have the potential to affect human health, is crucial for optimizing astronaut health during long-duration missions. **DESCRIPTION:** The exposome causes changes in human DNA that is unrelated to the individual's genetics. Beyond individual priority risks, there is a high likelihood of DNA changes related to the cumulative exposomic exposures associated with space travel, including exposure to new pathogens, novel stress and psychological challenges, space radiation, and dust. Astronauts will be immersed in the whole environment of space, experiencing all of the exposure risks that entails. Therefore, a comprehensive understanding of the exposomic impact of space travel is important to inform and develop holistic mitigation strategies for associated health risks. **DISCUSSION:** The purpose of this presentation is to discuss the "big picture" of the potential effects to human health associated with exposomic exposures during prolonged space travels. It is important to consider a holistic approach when creating mitigation strategies for human health risks. The cumulative effect of multiple exposomic exposures can all have their own impact on human DNA. While small changes from one exposure may not be significant enough to lead to disease, the long-term effects and combination of the

multitude of risks may ultimately lead to devastating outcomes in exploration class astronauts. An interprofessional approach to understanding the impact of exposomic factors on astronaut health, and subsequent collaborative countermeasures and intervention design is needed to address the challenging risks of the exposome during exploration-class missions. Would like to be considered for a poster presentation if an oral presentation is not available for this topic.

Learning Objectives

1. After completion of this presentation, learners will be able to identify the exposomic risks from environmental exposures to the NASA priority risks to human health.
2. After completion of this presentation, learners will be able to describe how the exposome may be impacted by cumulative risks associated with long-distance space exploration.

Wednesday, 05/24/2023 ***2:00 PM***
Napoleon Ballroom A1-B3

[S-64]: PANEL: TAMING VIRTUAL REALITY FOR THE NEXT GENERATION

Sponsored by the Aerospace Physiology Society

Chair: John French

PANEL OVERVIEW: *At the request of the Aerospace Physiology Society, this panel was designed to contribute to the understanding and reduction of the physiological limitations for new training techniques available through Virtual Reality (VR) technologies. There are bold steps being made to educate and train the next generation in what has been called the approaching metaverse. For example, the use of VR environments can dramatically increase understanding of medical or biological phenomenon through the ability to traverse from the macroscopic to the microscopic. VR environments can follow cells and substrates as they course throughout the organism. VR also promises to dramatically reduce the costs and dangers associated with real world training for military preparedness. These VR environments, however, also present a use-limiting factor in the form of a visually induced motion sickness (VIMS) called cybersickness. The first two presentations of this panel explore the theoretical basis for VIMS and cybersickness and provide an idea of the scope of the issues. The third and fourth panel papers focus on the incidence and severity of symptoms in new students using VR environments and ways to determine who is at risk with the aim of beginning mitigation early in training. Finally, the fifth and sixth presentations explain the Navy's use of eXtended Reality (XR) in training aviators and remotely piloted aircraft operators by the USAF with realistic countermeasure strategies. The panel extends from theory to practice with the idea of reducing cybersickness events so that the promises of a metaverse might be realized. The potential impact of VR technologies for the future of training the next generation is sufficient enough for us to request a slightly greater number of presentations allowed for a typical panel.*

[347] IS A VISUALLY INDUCED ILLUSION OF SELF-MOTION (VECTION) NECESSARY OR SUFFICIENT FOR VISUALLY INDUCED MOTION SICKNESS (VIMS)?

Ben Lawson[1], John Christopher Brill[2]
[1]*Naval Submarine Medical Research Lab, Naval Submarine Base New London, Groton, CT, United States;* [2]*711th Human Performance Wing, U.S. Air Force Aeromedical Research Lab, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: Next-generation virtual environments (VE) will not support fully realistic training simulations until experiences beyond visual and auditory are incorporated, such as the perception one is moving through an immersive world. However, it is common to read publications asserting that visual vection (the compelling illusion of self-motion elicited by a moving visual frame of reference) is one of the main causes of visually-induced motion sickness (VIMS). It is important to evaluate this assertion, as VIMS has challenged training among military users of visual vehicle simulators, advanced head-mounted flight displays, and unmounted VE training systems. **METHODS:** A systematic review employed Google Scholar searches and Semantic Scholar feeds to locate publications with terms such as "vection" and "sickness." Publications relevant to strong causal inference were defined as those that directly, empirically confirmed that vection could not occur without VIMS (supporting vection is necessary to VIMS), AND VIMS could not occur without vection (supporting vection is sufficient). **RESULTS:** Fifteen studies met the selection criteria, NONE of which established that vection is both necessary AND sufficient for VIMS. Five of 15 studies examined whether vection could occur without VIMS, ALL of which found this to be true. Six of 15 studies examined whether VIMS could occur without vection, four of which (67%) found this to true. **DISCUSSION:** Vection is neither necessary nor sufficient for VIMS to occur. In fact, vection might prove beneficial for making inexpensive next-generation NATO training simulations more realistic when real field training or full motion simulator training is not feasible, e.g., via VE rehearsal of the mission during space transit of astronauts/space forces or undersea/air transit of special forces. We will discuss why a causal VIMS role for vection could be challenged on theoretical grounds, posit other causes of VIMS, and introduce preliminary findings from an ongoing review addressing the less stringent question of whether the literature supports a compelling non-causal association (i.e., a strong and significant correlation) between vection and VIMS.

Learning Objectives

1. The audience will learn about the visually-induced illusion of self motion, called vection.
2. The audience will learn that vection is not strongly causal of sickness, which is good news, and should be explored for its potential benefit to the realism of future military training simulations (in cases where it is desirable to elicit the feeling one is actually moving through the virtual world).

[348] VIRTUAL AIN'T REAL – CONSEQUENCES FOR USING VR WITH A FOCUS ON CYBERSICKNESS.

Jelte Bos
Netherlands Organization for Applied Scientific Research, Soesterberg, Netherlands

(Education - Tutorial/Review)

INTRODUCTION: New technologies often follow Gartner's hype cycle. Several, however, fail, some even repeatedly. 3D films, for example, have vanished from the scene already eight times since their introduction in 1914. The last cycle coincided with the introduction of 3D TVs, which are not manufactured anymore already since 2019. What can we learn from these failures regarding VR in general? **TOPIC:** The failures can partly be explained as followings. First, 5-20% of all people cannot "see" 3D. Second, all 3D technologies are (still) affected by the unnatural condition of a required fixed accommodation of our eye lenses, while both eyes should move to keep a sharp image on the center of both retina's. Third, only one viewpoint for each eye allows a correct view of 3D images. And last but not least, self-motion as seen by the eyes and as felt by the organs of balance in our inner ears often are in conflict. Virtual therefore differs from real, which causes visual discomfort and/or cybersickness in most VR users. Although these facts are long known, they are still often ignored. This ignorance partly concerns our basic understanding of these side-effects, which also hamper truly effective solutions that act on the core of the problem. This holds in particular for those who believe that all problems can be solved by (better) technology, while the opposite can even be true. This also holds for VR and VR goggles in particular, typically causing over three times more sickness than computer monitors do. **APPLICATION:** Consumers use VR voluntarily and can just quit when getting sick, whereas in defense applications like training and design evaluations, its use is generally involuntary. Moreover, sickness affects pleasure *and* performance. Mitigating

cybersickness is therefore of particular interest to defense organizations, typically being large-scale VR users. To facilitate adequate solutions, a NATO Specialist Team (Proietti et al., 2022, NATO STO-TR-HFM-MSG-323) recently finalized a review including guidelines for the mitigation of cybersickness, also listing knowledge gaps. A current Research Task Group (HFM-MSG-346) will elaborate on the latter, aiming at a better future for VR.

Learning Objectives

1. Virtual reality is still affected by limitations causing a different perception of the images as compared to the actual reality causing side-effects like eyestrain and cybersickness.
2. Countermeasures that act on the core of the problem should be pursued, which, however, still lacks sufficient knowledge.

[349] CYBERSICKNESS RESEARCH AND OPERATIONAL EXPERIENCES IN NAVAL AVIATION

Brennan Cox[1], Alexandra Kaplan[1], Todd Seech[2]
[1]*Naval Medical Research Unit-Dayton, Wright-Patterson Air Force Base, OH, United States;* [2]*U.S. Navy, San Diego, CA, United States*

(Education - Program/Process Review)

BACKGROUND: The U.S. Navy is developing and applying new training methodologies to produce pilots faster and with stronger skill-sets, a program referred to as Naval Aviation Training Next (NATN). One of the key enablers of NATN is the use of eXtended Reality (XR) training systems. Graduates to date have demonstrated that the program works, reaching key training milestones faster and with fewer flights than their traditionally trained counterparts. However, reports from participants of NATN indicate widespread experiences with cybersickness, leading to research and operational evaluations to characterize the extent and nature of the problem and determine how best to mitigate its effects. **OVERVIEW:** Naval Aviation Training Command (NATRACOM) has included the Simulator Sickness Questionnaire as part of all students' anonymous end-of-training feedback survey since 2021. These data help inform the prevalence and severity of cybersickness experiences associated with XR use. Naval Medical Research Unit-Dayton (NAMRU-D) has further established a research program to systematically evaluate cybersickness experiences and mitigation strategies. **DISCUSSION:** Discussion will summarize results and recommendations from NATRACOM, whose data inform the operational use of XR in support of naval aviation training, and from the studies coming out of NAMRU-D, which provide a more detailed investigation of cybersickness assessments and prevention techniques. With an improved understanding of the prevalence, severity, symptoms, and associated countermeasures of cybersickness among naval flight students, attendees will be better able to evaluate the overall impact of XR training on human performance and be more knowledgeable of the current and future state of aeromedical research in this area.

Learning Objectives

1. Participants will learn about the prevalence, severity, and experience of cybersickness among users of extended reality training devices.
2. Participants will learn about specific mitigation strategies to reduce or avoid the experience of cybersickness.

[350] SHOULD WE VR THE NEXT RPA? LESSONS LEARNED IN AVOIDANCE OF VISUALLY-INDUCED MOTION SICKNESS (VIMS) IN TRADITIONAL RPA OPERATIONS

Cherie Richards
U.S. Air Force, Las Vegas, NV, United States

(Education - Tutorial/Review)

INTRODUCTION: When considering which aircraft operational platforms would benefit the most from virtual reality (VR) and augmented reality (AR) integration, Unmanned Airman Systems (UAS) operations, and specifically Remotely Piloted Aircraft (RPA), continue to present an appealing choice, but may introduce increased visually induced motion-sickness compared to current operations. **TOPIC:** VIMS is a significant human factor limiting widespread adoption of VR and AR in flight training and operations. Having both a current technological limitation with real-time tactile feedback and increased sensory and cognitive workload, real-world use of VR in flying operations has led to frequent reports of motion sickness and rapid loss of spatial orientation in flight training settings. A fully realized VR flight environment, to include corresponding somatosensory references, potentially allows for increased visual-vestibular congruence, such that the pilot could fly virtually inside the fighter cockpit with better resistance from motion sickness. In contrast to the frontiers of the VR flight training world, RPA ground control stations would seem predisposed for VIMS, allowing for a very limited sight picture either in front of the aircraft, or a radial picture directly below, neither of which is controlled by the pilot themself. Adapting to this limitation, RPA pilots in the now-retired MQ-1 and current MQ-9 variants fly "by numbers," ignoring the traditional environmental visual picture during transit in favor of heads-up and down display readings of aircraft state and flight indicators. This method helps to dispel many of the highest-risk visual sensory pre-conditions for VIMS, but is not without its unique challenges during manual landing and strike conditions, where the environmental picture becomes the primary display. **APPLICATION:** Using a descriptive study of pilot experience into the unique visual sight picture of the RPA platform and experiences with VR during pilot training, potential VIMS issues can be identified in operational use of VR in flight. This may provide opportunities for incorporation of lessons learned from the contemporary RPA field to next generation RPA and UAS operations. 1. Understand the difference in USAF VR flight training technology and operational RPA flight control.1. Understand the difference in USAF VR flight training technology and operational RPA flight control.

Learning Objectives

1. The participant will be able to understand the difference in USAF VR flight training technology and operational RPA flight control.
2. The participant should be able to identify inherent risk factors for visually-induced motion sickness in operational RPA flight.
3. The audience will learn about adaptive remote flight motion sickness avoidance strategies either improved upon, or worsened by, the integration of VR technologies.

[351] MOTION SICKNESS IN VISUAL DISPLAYS: PREDICTING ONE'S SUSCEPTIBILITY VIA QUESTIONNAIRE

Behrang Keshavarz[1], John Golding[2]
[1]*University Health Network, Toronto, Ontario, Canada;* [2]*University of Westminster, London, United Kingdom*

(Education - Tutorial/Review)

INTRODUCTION: The use of visual technologies such as Virtual Reality or driving/flight simulators can cause unpleasant side-effects associated with visually induced motion sickness (VIMS), jeopardizing the success of these technologies. Although most users get accustomed to VIMS with repeated exposure, it is crucial to understand who is at increased risk of experiencing VIMS. **TOPIC:** A variety of factors determines one's susceptibility to VIMS, including technological (screen size, resolution), situational (motion type, optic flow), and individual (age, stress) factors, making it challenging to estimate whether a user will experience VIMS or not. To date, a tool that can reliably predict VIMS susceptibility does not exist. **APPLICATION:** To improve our ability to predict VIMS, we have developed the Visually Induced Motion Sickness Susceptibility Questionnaire (VIMSSQ). A long (67-item) and a short (6-item) version of the VIMSSQ have been introduced. In both cases, the VIMSSQ tries to predict the likelihood of VIMS based on past experiences; individuals report the frequency of nausea, headache, dizziness, fatigue, or eye strain when using visual displays or devices such as smartphones, simulators, or large public displays. We conducted two experimental studies with different VIMS-inducing stimulation (rotating panoramic visual scenes) in healthy populations. Both the VIMSSQ long (R^2=.36)

and short version (R^2=.34) explained a considerable amount of variance in VIMS as measured by the Simulator Sickness Questionnaire that increased to 59% (VIMSSQ-long) and 56% (VIMSSQ-short) when other variables (susceptibility to traditional motion sickness, migraine, syncope) were added to the respective statistical models. In two large online surveys, we also collected first data from large samples that provide first insights into the general distribution of VIMS susceptibility. Overall, our results suggest that the VIMSSQ can be a useful tool for estimating one's susceptibility to VIMS, especially when used in combination with other metrics. **RESOURCES:** Golding, J.F., Rafiq, A., & Keshavarz, B. (2021). Predicting Individual Susceptibility to Visually Induced Motion Sickness by Questionnaire. *Frontiers in Virtual Reality*, *2*, 3. https://doi.org/10.3389/frvir.2021.576871

Learning Objectives

1. The participants will learn about factors contributing to individual susceptibility to visually induced motion sickness.
2. The participants will be introduced to a novel tool predicting individual susceptibility to visually induced motion sickness.

Wednesday, 05/24/2023 ***2:00 PM***
Nottoway & Oak Alley

[S-65]: POSTERS: HUMAN PERFORMANCE POSTERS 1

[352] DOES FREQUENT HIGH-GZ FAST JET FLYING AFFECT THE MECHANICAL PROPERTIES OF THE NECK MUSCLES? EUROFIGHTER PILOTS VERSUS MATCHED NON-PILOTS

Rene Lingscheid[1,2], Fabian Goell[2], Roland Nuesse[1], Albracht Kirsten[2,3], Braunstein Bjoern[2,4]
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(Original Research)

INTRODUCTION: Fast jet pilots (e.g. Eurofighter) are exposed to accelerations of up to 9 Gz during high-performance flight maneuvers. The pilots' need to observe the airspace, requires preparation of the musculoskeletal system of the cervical spine for those loadings. Although the cervical spine has been identified as vulnerable, there is little research on the mechanical characteristics of the involved muscles. Therefore, the aim of the study was to compare pilots to non-pilots in terms of mechanical properties of the muscles involved in pilots' head movements (e.g. check-six). **METHODS:** Twenty male Eurofighter-Pilots (in possession of a valid and current flight medical) and twenty anthropometric matched non-pilots took part in the approved study (Ethics 33/2019). Exclusion criteria for pilots and non-pilots were the presence of musculoskeletal impairments in the neck region and a neck disability index score higher than 20%. To estimate the mechanical characteristics (stiffness, elasticity, frequency, relaxation, creep) of the left and right Mm. splenius capitis, upper trapezius, and sternocleidomastoids, the MyotonPRO device (Myoton, Estonia) has been used according to Myotons' current guidelines. Three repetitions of five mechanical impulses each were applied by the MyotonPRO device to defined anatomical landmarks of the laying subject. Normality distribution was assessed using Shapiro–Wilk (R, Ver. 4.2). The level of significance was set to α=0.05 and the thresholds for Cohen's d were defined as small (0.2), medium (0.5), and large (0.8) effects between groups. **RESULTS:** Pilots showed significantly higher elasticity of the left splenius capitis (p<.025,d=medium), the upper trapezius left (p<.007,d=large) and the upper trapezius right (p<.008,d=large). For the relaxation pilots also showed a faster recovery of their muscle shape from deformation after applying an external force (p<.037,d=medium). For the creep of the muscle, left (p<.029,d=medium) and right (p<.005,d=large) sternocleidomastoids showed higher values for the pilots. **DISCUSSION:** Due to numerous head movements during each high-Gz flight multiple times a week, differences in muscle mechanical properties were expected for pilots compared to non-pilots. It can be confirmed that the sensitivity of the method was sufficient to detect the expected changes in the mechanical properties of the muscles and therefore enables the use of such a method to long-term monitor pilot muscular (health) status.

Learning Objectives

1. Understand that high frequent, high-Gz exposure over years (fast jet pilots) lead to changed muscle mechanical properties in the head and neck region in comparison to non-pilots.
2. Understand that monitoring mechanical properties of the head and neck muscles of fast jet pilots is beneficial for their long-term health status.

[353] G-INDUCED LOSS OF CONSCIOUSNESS (G-LOC) PREDICTION USING SUPPORT VECTOR MACHINE

Takahiro Imamura[1], Nobuhiro Ohrui[1], Yuji Iino[2], Koichiro Kuramoto[1], Azusa Kikukawa[1], Koji Okano[1], Satoshi Maruyama[1], Kunio Takada[1], Tetsuya Tsujimoto[1]
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(Original Research)

INTRODUCTION: High +Gz (head-to-foot direction) acceleration force induces cerebral blood loss and results in Gravity-induced loss of consciousness (G-LOC). G-LOC is a major threat to fighter pilots and may result in fatal accidents. The brain has an ability that allows transient ischemia to be tolerated without loss of consciousness during high +Gz exposure. This has been described as the functional buffer period. The functional buffer period has a duration of approximately 4-6 seconds for any +Gz exposure. Support vector machine (SVM) is one of the most popular classification methods in the machine learning. We tried to establish ten classifiers at 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5 and 5.0 sec (Classifier 0.5-5.0) to predict G-LOC within the functional buffer period by liner SVM and nonlinear SVM with Gaussian and polynomial kernels using age, height, weight, with / without anti-G suit, +Gz values, cerebral oxyhemoglobin (oxyHb) concentration and cerebral deoxyhemoglobin (deoxyHb) concentration. **METHODS:** Subjects were 124 flight course students trained with centrifuge device between 2008 and 2012. The subjects were classified into G-LOC and Non-G-LOC group. Each group had the same number of subjects. We measured trainee's cerebral oxyHb and deoxyHb concentration using near infrared spectroscopy (NIRS). The cerebral oxyHb and deoxyHb concentration were measured before +Gz load as the baseline, and during five seconds from the onset of high +Gz. The sampling rate was set at 2 Hz. **RESULTS:** Nonlinear SVM with Gaussian kernel performed better than liner SVM and nonlinear SVM with polynomial kernel. The accuracy of each classifier is as follows: Classifier 0.5, 58.1 %; 1.0, 54.8 %; 1.5, 57.3 %; 2.0, 58.1 %; 2.5, 64.5 %; 3.0, 63.7 %; 3.5, 65.3 %; 4.0, 64.5 %; 4.5, 64.5 %; 5.0, 64.5 %. **DISCUSSION:** These results demonstrate that nonlinear SVM with Gaussian kernel using age, height, weight, with / without anti-G suit, +Gz values, cerebral oxyHb concentration and cerebral deoxyHb concentration could predicted G-LOC at approximately 65% after 2.5 second. Further number of cases and factors to enhance accuracy may be needed to apply those classifiers in centrifuge training and actual flight.

Learning Objectives

1. The participant will learn about the G-LOC predication potential using Support vector machine.
2. The participant will be able to understand that G-LOC prediction requires development of various in-flight monitoring devices.

[354] PREDICTIVE MODEL OF G TOLERANCE AND EFFECTIVENESS OF ANTI-G STRAINING MANEUVER BY USING THE PARAMETERS OF BODY COMPOSITION

Chung-Yu Lai[1], You-Jin Lin[1], Yi-Hsiang Hsin[2], Kwo-Tsao Chiang[3], Min-Yu Tu[4], Hung-Wei Huang[5], Chao-Chien Cheng[2]
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(Original Research)

INTRODUCTION: Humans can generally tolerate 4.5G to 6G induced by inertial force. In the high G flight, fighter pilots must execute the proper anti-G straining maneuver (AGSM) to increase the G tolerance. The AGSM operation will maintain brain perfusion and prevent G-induced loss of consciousness. Anaerobic fitness is always emphasized to optimize the AGSM effectiveness and G tolerance among the military pilot population. Therefore, the goal was to assess body composition and whether it could predict anti-G ability. **METHODS:** This was a cross-sectional study organized and conducted in the Aviation Physiology Research Laboratory, Taiwan. Subjects were the flight cadets recruited from the Air Force Academy and qualified by Flying Class I. Before the high G training, they were monitored by the parameters of the body composition by using a body composition machine (TANITA-BC-545N, Tokyo, Japan). Based on the loss of visual light, relaxed G tolerance, and straining G tolerance (RGT, SGT) were examined during the gradual-onset-run profile (onset rate: 0.1G/second). AGSM effectiveness was defined as the difference between the RGT and SGT. All data were managed and analyzed by the SPSS 24.0 software. **RESULTS:** There were 88 male subjects with the mean age of 25.57 in this study. Values of RGT, SGT, and AGSM effectiveness were 5.11, 7.95, and 2.84G, respectively. Body mass index (BMI) was a positive factor associated with RGT and SGT. Each unit increment of BMI would be enhanced by 37% probability at the RGT of more than 5G, and 31% probability at the SGT more than 8G. Subjects with the higher muscle mass of their left leg had better AGSM performance (≧2.5G VS. <2.5G: aOR=1.47, 95%CI: 1.03-2.11). **DISCUSSION:** These findings noted that BMI and the mass muscle of the legs were the positive factors so as to enhance the G tolerance and AGSM effectiveness. The potential explanation was mainly that the training elements of the physical condition for the high-G pilots should critically focus on the trunk and lower body muscles against the blood pooling. It would cause the significant alteration of body weight, mass, and shape. Therefore, body composition monitoring could potentially be developed as an initial screening tool to G tolerance and AGSM effectiveness.

Learning Objectives

1. To understand the effect of G force on the human body.
2. To realize the increment of G tolerance by AGSM operation
3. To observe the body composition related to G tolerance and AGSM effectiveness.

[355] LIGHT-EMITTING DIODES FOR AIRFIELD LIGHTING APPLICATIONS

Kelene Fercho[1], Peter Hu[2], Theodore Mofle[2], Bryan Watson[2]
[1]*FAA CAMI, Oklahoma City, OK, United States;* [2]*Cherokee Nation 3-S, Oklahoma City, OK, United States*

(Original Research)

INTRODUCTION. Airfield lighting (e.g., runway, approach, taxi) provide visual cues on the ground to guide a pilot to a safe takeoff, landing, or ground maneuvering operation, and are particularly useful during reduced visibility conditions. Since the 1930s, incandescent lamps have been the most common type of light source used in the United States National Airspace System (NAS). However, in response to the Energy Independence and Security Act of 2007, widespread integration of light-emitting diode (LED) lamps in the NAS has started. This research was intended to identify human factors, operations, and safety-related considerations for using LEDs in airfield lighting. **METHOD.** Aviation transportation authority databases, Google Scholar, and conference proceedings were searched for studies evaluating the use of LEDs in airfield lighting (through August 2021). English language articles, including both published and unpublished research, were reviewed. **RESULTS.** Thirty-nine studies were identified. Ten studies on chromaticity perception found that LEDs have higher color saturation, which may provide an opportunity to better separate color boundaries and improve discriminability of airfield lights, especially in fog or haze. However, individuals with color-vision deficiencies may perform worse at color identification with certain LED colors (e.g., yellow). Eleven studies on brightness perception showed that LEDs may appear brighter than incandescent lights. Adjusting LED output could result in an undesired stroboscopic effect that may be experienced by pilots in single propeller aircraft. Additionally, LEDs may not be compatible with some flight deck vision technologies (e.g., Night Vision Imaging Systems, Enhanced Vision Systems). Eighteen studies on LED airfield hardware showed that LEDs have a longer lifespan, but may dim to unacceptably low levels over time. Additionally, LEDs may not emit enough heat to melt snow and ice in colder climates. **DISCUSSION.** The findings suggest that the use of LEDs for airfield lighting have advantages and disadvantages. FAA guidance has already addressed many of the identified concerns (e.g., LED brightness). Future research should focus on the evaluation of additional environmental factors related to weather, and include operationally relevant contexts (e.g., perception of LEDs under time pressure and within a cluttered airfield, effects of aging LEDs on color perception).

Learning Objectives

1. The audience will learn about the introduction of light-emitting diodes into airfield lighting systems in the United States National Airspace System.
2. The audience will understand the human factors, operations, and safety-related considerations for using LEDs in airfield lighting.
3. The audience will learn that LEDs are incompatible with some flight deck vision systems (e.g., Night Vision Imaging Systems, Enhanced Vision Systems).

[356] THE EFFECT OF HYPOHYDRATION ON AVIATION RELEVANT COGNITIVE PERFORMANCE

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Florida Institute for Human and Machine Cognition, Pensacola, FL, United States

(Original Research)

INTRODUCTION: It has been documented that dehydration affects cognitive performance and can lead tactical aviators susceptible to common aeromedical stressors including gravitational force induced loss of consciousness (G-LOC) and spatial disorientation. Research suggests that cognitive performance is significantly affected at 2% dehydration. Conversely, an equal number of studies show dehydration does not significantly affect cognitive performance. Pilots may be especially susceptible to dehydration due to the cited practice of tactical dehydration. This study seeks to determine if passive dehydration significantly affect aspects of cognitive performance relevant to military aviation. For this evaluation, dehydration is operationally defined as a percentage deficit of body weight resulting from water loss. The current study aims to investigate cognitive performance effects across 1%, 2%, and 3% dehydration by examining participant loss of body weight. **METHOD:** Sixteen active-duty naval aviator students (M = 25.5 years, SD = ±3.52 years) for aviation duty participated in the study. Participants executed series of PAT and SWAY tasks across a six-hour Dehydration protocol on two separate days. Dehydration was induced by the administration of either a placebo pill or diuretic (Lasix) on one of the two testing days. To ensure fluid loss, participants were instructed not to consume any food or fluids for the duration of the six-hour protocol on each of the data collection

days. **RESULTS:** PAT and SWAY performance was analyzed through a series of repeated measures ANOVAS, which revealed no statistically significant interaction between dehydration levels and workload in either of the conditions. However, strong trends were present, suggesting that some effect on SWAY balance scores began to emerge at 3% dehydration. **CONCLUSION:** This study suggests that passive dehydration alone is not associated with significant cognitive performance impairment; moreover, heat stress and exercise related fatigue moderate the relationship between dehydration and cognitive performance. Although not significantly, the results suggest that dehydration does begin to affect balance at as low as 3%. Results must be interpreted with caution and more investigation is needed to examine the relationship between specific cognitive and perceptual performance domains and hydration across environmental exposures associated with specific military aviation mission sets.

Learning Objectives

1. The audience will learn the difference between passive and active dehydration.
2. The audience will develop a better understanding of the relationship between dehydration and psychomotor performance.
3. The audience will learn about the possible mitigation or moderation effects between dehydration and active methods to dehydrate participants.

[357] RAPID DETECTION OF HYPOXIA-RELATED IMPAIRMENT USING NON-INVASIVE NEURAL RECORDING

Cammi Borden[1], Daniel McHail[2], Kara Blacker[2]
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(Original Research)

INTRODUCTION: Exposure to hypoxia remains a relevant threat to aviators. Aviation safety training includes a controlled hypoxia exposure to learn symptom recognition. Prior research has shown that acute hypoxia exposure impairs sensory processing and associated neural activity. Here we advance this work closer to the training environment by assessing whether the neural markers, mismatch negativity (MMN) and P3a, are sensitive to a mask-on exposure that resembles a hypoxia training profile. **METHOD:** In this repeated-measures, single-blind design, 34 healthy adults completed two 30-min sessions that included a normoxic (21% O_2) or gradual hypoxic (14.3% - 8.1% O_2) exposure. For each session participants performed a cognitive assessment and reported hypoxia symptoms while EEG was recorded in response to auditory stimuli. After a 10-min baseline period where an on-demand hypoxia trainer (ODHT) delivered normoxic air, the gas mixture either continued to deliver normoxic or hypoxic air that increased in altitude every 5 min to 10-, 15-, 20-, and then 25-thousand-foot equivalents. Participants reported symptoms of hypoxia in real time during the session and afterwards via questionnaire. All human subjects testing was completed in accordance with NAMRU-D IRB guidelines. **RESULTS:** For the performance task, the Advanced Stoop component did reveal a time × condition interaction, whereby participants did perform progressively worse when exposed to hypoxic air. Declaration of the first noticed hypoxia symptom was evenly distributed across all altitude bins, suggesting high inter-individual variability of recognition of symptoms. MMN/P3a amplitude decreased over time in both conditions, suggesting habituation of the neural response to the auditory stimuli. However, this decrement was greater in the hypoxia condition during more extreme altitudes, suggesting a dose-dependent impact of hypoxia. **DISCUSSION:** The results suggest that an altitude profile resembling training conditions and using a relatively novel device, the ODHT, can impact neural mechanisms of sensory processing consistent with prior work. The milder effects on the MMN/P3a seen here compared with previous studies are consistent with this study's less severe and more gradual exposure profile. Furthermore, the time course of hypoxia-induced changes in neural activity revealed here, combined with self-report and other physiological data, may help inform future aviation safety training efforts.

Learning Objectives

1. Objective 1: The audience will learn how emerging technologies in hypoxia training can be paired with physiological, behavioral, and neural recording.
2. Objective 2: The audience will learn about the time course of how the brain responds to a gradual hypoxia exposure.

[358] EVALUATING OPERATOR STATE USING EYE TRACKING AND PUPILLOMETRY IN ROTARY-WING PILOTS DURING SIMULATED FLIGHT

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(Original Research)

Flight operations in degraded visual environments (DVE) pose significant risks to the aviators completing those operations. DVE occurs when an aviator is exposed to partial or total loss of visibility due to environmental factors, such as airborne dust, sand, or snow, as well as clouds, haze, fog, and starless nights. The implementation of advanced flight controls, sensors, and cueing delivered via the visual, auditory, and tactile senses has promise to mitigate the risk of accidents and mishaps in such conditions. This is accomplished by assisting the aviator in maintaining situational awareness and reducing workload. Such technologies are already available in commercial vehicles via blind spot detectors, lane drift indicators, and back-up sensors. These use a combination of cameras and displays, audio alerts, and seat and steering wheel shakers to compensate for drivers' known limitations. These same technologies are being developed for military applications. U.S. Army Aeromedical Research Laboratory (USAARL) researchers recently completed a study evaluating the Integrated Cuing Environment (ICE) developed by U.S. Army Combat Capabilities Development Command researchers. Fourteen U.S. Army rated helicopter pilots flew 12 flight routes in a UH-60 Black Hawk flight simulator using ICE, each with a unique combination of cueing parameters, mission profiles, and injected events designed to manipulate workload. Multiple measures were collected from these pilots to give insight into their physical condition, cognitive state, and autonomic tone. As part of the operator state monitoring toolkit, a head-mounted eye tracking system was used to capture pupil diameter throughout each flight. We conducted a repeated measures analysis of variance (ANOVA) on the pupil diameter data, averaged across the duration of each flight, with the intensity of the aural and tactile cueing configurations of ICE as the within-subject factors. Tactile cueing intensity had a statistically significant effect on right eye pupil diameter at the 0.05 level ($F = 6.579$, $dfn = 1$, $dfd = 164$, $p = 0.011$). Aural cueing intensity had a statistically significant effect on left eye pupil diameter at the 0.05 level ($F = 4.670$, $dfn = 1$, $dfd = 164$, $p = 0.032$). These results suggest that more intense cueing is associated with a larger average pupil diameter, suggesting an increase in cognitive workload or heightened level of arousal.

Learning Objectives

1. How can prevent or mitigate a loss of situational awareness?
2. How does the integrated cueing environment work to support situational awareness?
3. How is pupil diameter collected in a flight simulator?

[359] CYBERSICKNESS COMPARISON IN A VIRTUAL REALITY AND TWO MIXED REALITY HEAD-MOUNTED DISPLAY CONDITIONS FOR SHORE-BASED NAVAL APPLICATIONS

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(Original Research)

INTRODUCTION: Defence Research and Development Canada is developing guidance on the use of Mixed Reality (MR) head-mounted displays (HMD) for naval operations for the Royal Canadian Navy (RCN). Virtual reality (VR) HMDs display 3-dimensional (3D) graphics to the user and completely occlude the user's view of the real world. MR HMDs overlay and integrate graphics onto the real world allowing the viewer to perceive the real world and rich 3D graphic elements simultaneously. Nausea and other debilitating symptoms caused by use of extended reality HMDs known as 'cybersickness' (CS) is well documented during VR HMD use and can be severe. However, it is not yet clear if CS is the same, more severe, or less severe when using MR HMDs. The objective of this study was to determine the impact of MR HMDs on CS. We modulated the quantity of graphics in the display and hypothesized that CS severity would increase with the quantity of graphics. **METHOD:** We compared CS scores using the simulator sickness questionnaire while participants viewed similar scenes in VR and MR in three conditions. One MR condition graphically rendered foreground objects only (called 'MR' condition) in an MR HMD. The second MR condition graphically rendered the entire scene (called 'MR+' condition) in an MR HMD. These conditions employed the Microsoft Hololens 2 HMD. The VR condition simulated the MR+ condition in a VR HMD and employed the Oculus Rift S HMD. **RESULTS:** Findings indicated CS was significantly greater in the MR+ condition compared to the MR and VR conditions. Moreover, CS increased significantly over the 25-min session in the MR+ condition but not in the MR and VR conditions. **DISCUSSION:** We concluded that MR with low graphic quantity as in the 'MR' condition can be used over extended periods of up to 25-min with negligible CS. These findings indicate safe use of MR HMDs by the RCN for shore-based applications provided quantity of graphics is limited in the MR HMDs. In an upcoming study, the MR condition will be tested aboard an RCN vessel to determine if CS remains negligible at sea.

Learning Objectives

1. Provide an overview of the current state of cybersickness research using extended reality head-mounted displays.
2. Demonstrate that cybersickness is more severe in mixed reality head-mounted displays when the visual scene is entirely saturated with graphical elements compared to the limited cybersickness experienced with few graphical elements displayed in a mixed reality head-mounted display.

[360] THE COGNITIVE ASSESSMENT OF AVIATION PERFORMANCE STATE (CA2PES) RELIABILITY AND WORKLOAD

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(Original Research)

INTRODUCTION: Development of a valid and reliable psychometric tool for tactical aviation has been of operational interest by the United States Air Force School of Aerospace Medicine (USAFSAM), which led to their recent development of the Cognitive Assessment of Aviation Performance State (CA^2PES). CA^2PES is a psychometric evaluation and an optimal tool for detecting the effects of common operational stressors on human performance. CA^2PES was developed to allow researchers to examine performance effects in high and low cognitive workload settings. The inclusion of a high workload setting may detect changes not detected in common, overlearned aviation tasks. The current study is conducted in two phases. Phase 1 focused on the CA^2PES test-retest reliability and subjective workload, and Phase 2 focused demonstrating the cognitive workload effect on tracking performance. **METHODS:** In Phase 1, Ten participants ($M = 26.8$, $SD = 4.6$) were recruited from The Florida Institute for Human and Machine Cognition (IHMC) to participate in the study. All subjects completed each of the CA^2PES subtasks individually, task combinations, 10 iterations of full CA^2PES, and filled out the NASA-TLX after every combination of tracking and the three secondary tasks. In Phase 2, fourteen participants performed CA^2PES in low and high workload mode across 4 iterations. **RESULTS:** A series of inter-class correlation coefficients (ICCs) were calculated across PCOLA Composite 1, PCOLA Composite 2, Tracking 1, and Tracking 2 as a measure of test-retest reliability. The NASA-TLX scores showed a 16.4 increase in subjective mental workload between tracking only and the full CA^2PES. The repeated measures ANOVA revealed a significant effect of workload on tracking performance $f(1, 13) = 58.05$, $p = 0.000$, *partial eta square* = 0.817. **CONCLUSION:** The results of the current study suggest that CA^2PES provides the ability to accurately and reliably measure psychometric tracking performance under at least two distinct levels of cognitive workload. The importance of these specific measures permits the ability for investigators to address the effects of stress at varying levels of cognitive workload to determine if there are cognitive workload by stressor interaction effects.

Learning Objectives

1. The audience will learn the importance of test-retest reliability in psychomotor research.
2. The audience will learn about the importance of testing particiapants under varrying levels of cognitive workload.
3. The audience will learn about the potential for the use of computer adaptive psychometric tools in human performance research.

[361] IDENTIFICATION OF HYPERCAPNIA THROUGH VOICE ANALYSIS ASSOCIATED NEUROLOGICAL AND PERFORMANCE EFFECTS

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(Original Research)

INTRODUCTION: Due to unidentified physiologic episodes (UPEs) experienced in tactical aviation, a need exists for early detection of these occurrences in flight to ensure operator safety. Hypercapnia is believed to be a significant contributor to UPEs as operators encounter breathing resistance from oxygen mask valves, breathing hoses, and regulators, which can lead to hypoventilation and CO_2 retention. While current methods to detect hypercapnia exist, the ability to use this technology in the cockpit remains difficult due to environmental issues and interference from and with flight equipment. This investigation seeks to develop a non-invasive method to identify hypercapnia using a machine learning algorithm to detect changes in speech and breath features specific to an individual with excess arterial CO_2. **METHOD:** Thirty-five active-duty student naval aviators ($M = 24.11$ years, $SD = 2.14$) performed two iterations of the Performance Assessment Tool (PAT) and two reading tasks while breathing four normobaric CO_2 concentrations, 1.0%, 2.5%, 4.0%, 5.5%, delivered via an MBU-20/P flight mask, for 15-minutes each. **RESULTS:** Transcutaneous arterial partial pressures of CO_2 ($PaCO_2$) increased in participants across the four CO_2 exposures with an average increase of 15.30 mmHg from baseline $PaCO_2$. A repeated measures ANOVA conducted on tracking performance during PAT revealed significant differences between conditions, $f(1.69, 28.78) = 4.39$, $p = 0.027$, *partial eta square* = 0.21. Pairwise comparisons revealed significantly better tracking performance in the 2.5% and 4.0% exposure conditions when compared to the 1.0% exposure condition. Both the speech and breath machine learning approaches accurately identified the CO_2 that participants were being exposed to. The approaches based on modeling each individual's speech and breath features performed best with accuracy at 89% and 84.5% respectively. The speech and breath machine learning approaches also resulted in AUROC values in the 80s and 90s indicating that they

are excellent as diagnostic instruments to identify CO_2 concentrations. **CONCLUSION:** The results of the current investigation show proof of concept that speech and breath acoustic features can be used to identify physiological stress states. Machine learning approaches should be further pursued to identify changes in physiological status and mitigate performance issues in mask worn life support breathing systems.

Learning Objectives

1. The audience will learn about the effect of carbon dioxide on human perrformance at high levels.
2. The Audience will learn about the potential use of machine learning to model breath whenever there is a microphone present.

[362] WIRE STRIKES AND IN-AIR OBSTACLE AVOIDANCE DURING PART 137 AGRICULTURAL OPERATIONS

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(Original Research)

INTRODUCTION: Wire strikes and in-air collisions with obstacles are a leading cause of accidents in the aerial application industry. While some of these collisions occur due to previously unseen obstacles, some pilots report being previously aware of the obstacles that they collide with. Whether or not pilots are aware of obstacles pre-collision is an important factor to inform methods of accident prevention. **METHODS:** Final accident reports from the National Transportation Safety Board were retrieved for all U.S. Part 137 Agricultural Operation accidents that occurred between Jan. 2020 and Sep. 2022. Narratives, demographics, probable cause, and findings were evaluated for overall trends. A deeper analysis of cases that involved an in-air collision with an obstacle was performed, excluding cases that were attributable to an external cause (e.g., aerodynamic stall, mechanical or computer failure). For cases that involved an in-air collision with an obstacle as the primary cause of accident, the pilot's awareness of the obstacle pre-accident was inferred from narratives if available. **RESULTS:** A total of 80 final accident reports were analyzed. Ten accidents included fatal injuries, 11 included serious injury, and 14 included minor injuries. Nearly half of all accidents (n = 34) involved an in-air collision with an obstacle (e.g., wire, tree, pole), that was not attributable to another immediate cause such as an aerodynamic stall or computer/mechanical failure. In cases where pilot awareness of the obstacle was determinable through the accident report, 44% of pilots (n = 11 of 25 accidents) had previously seen this obstacle yet still made contact with it. These pilots provided recommendations in accident reports that included: turning down high-risk jobs or careful route planning when close calls with in-air obstacles are unavoidable. **DISCUSSION:** Wire strikes and in-air collisions with obstacles make up a substantial portion of accidents within the Part 137 Agricultural Aviation industry. Nearly half of pilots in these cases report that they were aware of the obstacle pre-collision, indicating that inadequate preparation in scoping the field are not to blame. Instead, these findings suggest that other factors including distractions, task difficulty, and errors in decision-making may contribute to these cases. Factors that lead to wire strikes and object collisions in aerial application are important to understand to prevent future accidents.

Learning Objectives

1. Understand factors that lead to wire strikes and in-air object collisions in aerial application operations.
2. Learn recommendations regarding decision making from pilots that survive wire strikes and in-air obstacle collisions in aerial application operations.

[363] PREVALENCE OF SKIN DISCOMFORT AND PATHOLOGY IN DEPLOYED AIRCREW USING THE ATTENUATING CUSTOM COMMUNICATIONS EARPIECE SYSTEM HEARING PROTECTION SYSTEM

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(Original Research)

INTRODUCTION: During a deployment of a fighter unit, aircrew began to exhibit ear discomfort and episodes of auricular irritation and ulceration. All affected were using the Attenuating Custom Communications Earpiece System (ACCES). Discomfort was previously discussed in the literature, but prevalence and skin ulceration had not been previously described. **METHODS:** An anonymous paper questionnaire was used with three fighter squadrons while deployed in 2019. A total of 59 aircrew in the F-15C/E and F-16 airframes participated while aircrew not using ACCES were excluded. **RESULTS:** Response rate was 57.3% spread evenly among airframes, with 78% being pilots; 79.7% of respondents stated they had ACCES problems in the deployed setting. Among those noting problems in the deployed setting, 89% reported ear discomfort, with smaller numbers reporting skin redness, erosion, and bleeding. **DISCUSSION:** This study provided a small sample estimate of the prevalence of ear problems among fighter aircrew ACCES users while deployed. This small sample exhibited an increase in prevalence of ear discomfort during the deployment. It also showed pathological features absent in home station flying such as skin redness and erosion. The small sample and study design prevented risk factor characterization, confounder control, or causal inference. While ACCES may contribute to these problems, other confounders such as desert air characteristics, recall bias, aircrew motivation to report problems, and baseline dermatologic pathology could not be excluded. These data should serve as a baseline for larger studies better powered for confounder control and assessment of other potential risk factors. **DISCLAIMER:** The views expressed are those of the authors and do not reflect the official guidance or position of the U.S. Government, the Department of Defense, or the U.S. Air Force.

Learning Objectives

1. Anticipate aviator complaints emanating from molded communication system wear in a deployed setting with high-frequency, long-duration sorties.
2. Characterize the prevalence of discomfort and dermatologic pathology in a small sample of ACCES wearers in the deployed environment.
3. Stimulate future research into comfort and pathology of molded communication systems.

[364] COMPARISON OF THE PREVALENCE OF NECK AND BACK PAIN IN UK TYPHOON AND HAWK PILOTS

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(Original Research)

INTRODUCTION: Neck and back pain is known to be a potential consequence of military flying associated with exposure to high G, the use of head mounted equipment and the need to achieve unfavorable postures. The prevalence and factors associated with neck and back pain needs to be understood in order to tailor musculoskeletal injury mitigating strategies. **METHODS:** Aircrew across all UK military aircraft platforms were surveyed on MSI in 2019. The survey's core questions were based on NATO RTG Aircrew Neck Pain recommendations to determine: the prevalence of neck, upper-back and lower-back of pain in the previous 12 months; the perceived causal factors; the impact of pain in terms of flight safety. Summary statistics for Typhoon and Hawk pilots are contrasted. **RESULTS:** 172 of fast-jet and trainer aircraft pilots responded to the survey, of which 41 flew Typhoon and 32 flew Hawk. The 12-month prevalence of neck, upper-back and lower-back pain was 71 %, 39 % and 24 %, respectively, for Typhoon pilots and 33 %, 26 % and 26 %, respectively for Hawk pilots. Typhoon pilots considered high-G, night-vision goggles and helmet use with their operational tasks as the main cause of neck pain and high-G, mission type, posture with frequency of flying the main causes of upper-back pain. Hawk considered high-G, posture and equipment worn as a cause of neck pain, and seating depending on the body region. Typhoon pilots reported some impact to flight safety due to neck pain in 19 % of typical and 60 % of worst-case occurrences, compared to 0 % and 30 %, respectively, for Hawk pilots. Typhoon respondents reported a total of 295 days unfit-to-fly in a 12-month period due to neck, upper-back and lower-back pain. **DISCUSSION:** The prevalence of neck and upper-back

pain and the perceived impact to safety was greater for Typhoon pilots relative to Hawk pilots. The difference in prevalence of neck and upper back pain for Typhoon and Hawk appears to be related to the more extreme physical experience of flying high performance jets and the type of equipment used by Typhoon compared to Hawk pilots

Learning Objectives

1. The reader will understand there can be differences in neck and back pain prevalence in pilots of front-line and trainer fast-jet aircraft.
2. The reader will understand the perceived factors causing of neck and back pain in the two pilot groups and it impact on performance.

[365] A PRELIMINARY ASSESSMENT OF COGNITION AND FATIGUE DURING SIMULATED LUNAR SURFACE EXTRAVEHICULAR ACTIVITIES

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(Original Research)

INTRODUCTION: Exploration Extravehicular Activity (xEVA), or spacewalks, during NASA's future Lunar (Artemis) missions are expected to be more physically and cognitively demanding than any previous missions. Characterizing the effects of xEVA tasks and timelines on cognition and fatigue will be valuable, and perhaps essential to the preservation of crew health and performance during xEVA. **METHODS:** Two subjects each completed two ~5-hour simulated Lunar xEVAs in a pressurized Mark III spacesuit with one day of rest between each EVA, carrying out simulated lander operations, cable routing, crew rescue, geology, payload relocation, and traverses. Lunar gravity was simulated using NASA's Active Response Gravity Offload System (ARGOS). Subjects completed two cognitive assessments (Digit-Symbol Substitution Task (DSST) and Psychomotor Vigilance Task (PVT)) before the first and after the second simulated EVA to assess effects of xEVA tasks on processing speed (DSST) and vigilant attention (PVT). Sleep quality, duration, and efficiency was monitored (Oura Ring) for ≥7 days prior to the simulated EVAs, as well as between each EVA, to account for possible effects of sleep decrements on cognition metrics. **RESULTS:** Cognitive performance changed minimally from pre to post EVA for both DSST (response time (RT): S1 Δ129.1ms, S2 Δ40.7ms; Accuracy: S1 preEVA = 1.0, S1 postEVA = 0.98, S2 preEVA = 1.0, S2 postEVA = 1.0) and PVT (S1 PVT RT Δ17.7 ms, S2 PVT RT Δ-2.7 ms). Subjects' sleep duration immediately prior to EVA showed minimal deviation from baseline (Δhrs; S1 preEVA1= + 0.67, S1 preEVA2 = -.03, S2 preEVA1 = - 1.1, S2 preEVA2 = -1.39) and efficiency (Δ%; S1 preEVA1 = 0.09, S1 preEVA2 = 9.54, S2 preEVA1 = 0, S2 preEVA2= 12). Notably, sleep waketime shifted earlier for one subject by ~1 hr which may have impacted performance. **CONCLUSION:** Understanding the impacts of xEVA workloads on cognitive performance and fatigue will be instrumental to future exploration mission planning and success. Characterizing these metrics will inform modeling and prediction capabilities for planning of xEVA workload, duration, and frequency. Future work will expand the subject pool to include the full spectrum of body types, sizes, and genders represented in the astronaut population, as well as test new spacesuit designs to better simulate and evaluate performance in the xEVA suited working environment of Artemis missions.

Learning Objectives

1. The audience will learn about the impacts of simulated Lunar Exploration Exavehicular Activity (xEVA), or spacewalk, in a pressurized spacesuit on cognitive performance.
2. The audience will learn about the impacts of sleep quality, duration, and efficiency and fatigue on performance during simulated Lunar Exploration Exavehicular Activity (xEVA), or spacewalk, in a pressurized spacesuit.

[366] CAFFEINE COUNTERMEASURE AND FATIGUE MODELING OF AIRCREW IN WARGAMING SIMULATIONS

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(Original Research)

INTRODUCTION: Wargaming simulations often lack realism in regard to fatigue effects on the aircrew who are critical to mission success. In wartime, combating fatigue with sleep is difficult given operational tempo, circadian desynchrony, and stressful environments. Consequently, caffeine is commonly used as a stimulant to maintain alertness. However, caffeine's effects on subsequent sleep is not often considered. The current effort integrates caffeine effects into a wargaming fatigue modeling application to examine performance outcomes on aircrew. **METHODS:** A realistic 30-day mockup of aircrew mission schedules from the Integrated Sustainment Wargaming and Analysis Toolkit was fed into an in-house wargaming fatigue modeling application that utilizes the Sleep, Activity, Fatigue, and Task Effectiveness biomathematical model to produce fatigue estimates based on realistic sleep periods. Caffeine effects, specifically ingesting 200 mg of caffeine 1 – 3 hours before bedtime if sortie end times were within 3 hours of bedtime, were then integrated to examine primary and secondary effects on fatigue. Analyses were conducted to compare fatigue estimates without and with caffeine. **RESULTS:** Aircrew sorties without and (with) caffeine had an average of 82.94% (79.81%) and average minimum performance effectiveness of 69.54% (64.49%), with 70.45% (54.28%), 18.38% (19%), and 11.17% (26.72%) of time in the Green, Yellow, and Red bands, respectively across 110 sorties. A repeated measures ANOVA with caffeine and sortie start hour as independent measures suggested that caffeine significantly increased fatigue estimates for aircrew $F(1, 6) = 6.43$, $p < .05$. There was also a significant effect of sortie start hour, $F(4, 6) = 32.58$, $p < .001$. **DISCUSSION:** This initial integration of caffeine in a wargaming simulation showed that consistent use of a caffeine countermeasure close to sleep periods significantly increased average fatigue estimates. This suggests that the timing of caffeine ingestion needs to be taken into account if used during wartime as a fatigue countermeasure. Future work will focus on validating and extending the model with flexible caffeine addition in terms of time and amount within missions.

Learning Objectives

1. Learn about the incorporation of caffeine in a wargaming fatigue modeling application.
2. Understand the implications of consistent caffeine usage as a countermeasure close to major sleep periods on subsequent fatigue estimates and performance.

[367] ASTRONAUT SLEEP DURATION VARIES BY TIMING OF SCHEDULED SLEEP

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(Original Research)

INTRODUCTION: Studies find that humans average approximately six hours of sleep per night in space, which is less than they sleep on Earth. Such short sleep duration has been associated with reduced alertness and performance in space. It is unclear whether this sleep loss is related to modifiable factors, such as irregular scheduling, poor sleep environment, and excessive workload or due to features of spaceflight that alter physiology (e.g., microgravity). Recent missions have afforded crew better, more stable sleep and work schedules, and an improved sleep environment. Despite these improvements, schedules do still vary enough to cause decrements in sleep duration. **METHODS:** Crewmembers (n = 19) who volunteered for the NASA Standard Measures protocol between January 2019 and March 2022 were provided with actiwatches (Phillips, Respironics, Bend OR) that they wore for two bouts of data collection lasting two weeks each before flight (at approximately L-270 and L-180), either continuously (n = 9) or for two weeks every two months while in

space (n = 10), and for seven days postflight, immediately upon return to Earth (R+0). A regularly scheduled (or "nominal") sleep episode would take place between the hours of 9:30pm and 6:00am. We looked at sleep outcomes (sleep duration, wake after sleep onset [WASO], sleep efficiency) depending on the distance from nominal sleep offset to see whether scheduled sleep period affected sleep durations and other metrics of sleep quality. **RESULTS:** Crewmembers provided data from 402 nights preflight, 2,137 nights inflight, and 275 nights postflight. They averaged 7.33 hours of sleep per night (± 1.16, SD) in space. Though this was significantly less sleep than they achieved preflight (7.87 ± 1.10) or postflight (7.75 ± 1.43, $p < .01$), this duration of sleep meets the recommended amount for optimal human health and well-being. For every hour after the nominal sleep period a crewmember woke up (up to 5 hours), their total sleep increased by 0.33, or 20 minutes. **CONCLUSIONS:** We conclude that humans are capable of achieving sufficient sleep in space, especially when their schedules afford adequate sleep (namely, schedules that phase delay rather than advance). Future studies are needed to determine whether microgravity impacts sleep architecture and sleep quality. Going forward, it is imperative that crewmembers are provided with stable schedules, with moderate workload, and environments that are conducive to sleep.

Learning Objectives

1. The audience will learn that astronauts are achieving sufficient sleep in space, likely due to modifiable factors such as regularly timed sleep schedules, optimized sleep environment, and moderate workload.
2. The audience will learn that there are still other factors yet to be explored, such as how microgravity may impact sleep architecture and sleep quality.

[368] HOW TO CREATE IMPACTFUL IMMERSIVE SIMULATION FOR AEROSPACE MEDICINE TRAINING AND EDUCATION

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(Education - Tutorial/Review)

INTRODUCTION: Immersive simulation is a valuable platform for training and education in aerospace medicine. We will describe best practices and innovative strategies to create high yield experiences optimizing individual and team performance. **TOPIC:** Hands-on, experiential learning is crucial to aerospace medicine training programs and high-performance teams. The intent of immersive learning experiences ranges widely from technical skill development/train-to-mastery, non-technical skill development (CRM/TEM), to individual and group stress response, and gauging process reliability and failure points. We will discuss best practices in creating educational objectives, optimizing critical components of simulation, and selecting debriefing strategies. Clear definition of objectives is essential to successful simulation and guides degree of fidelity and implementation strategies (i.e., live-actor versus manikin, utilization of real cases, and 4-D realism with motion, vibration, noise, and smell.) Intentional, focused pre-briefing of participants is essential. Debrief organization, such as staged debriefing or coalescing groups, and debriefing techniques such as advocacy-inquiry, plus-delta, and the After-Action Report may be employed contingent upon the objectives. Novel simulation modalities such as virtual reality, gamification, inversion, and embedded participants can be utilized to achieve unique educational goals in aerospace medicine and beyond. Finally, we will share pearls, pitfalls, and the top 5 tips for success: 1. Know the audience; 2. Understand the objectives; 3. Tailor the experience to goals; 4. Make it engaging; 5. Take it to the next level (meta-cognition.) **APPLICATION:** Delivery of high-quality, impactful training is valuable to both novices and professionals in aerospace medicine. These best practices and innovative tools may be employed by aerospace medicine educators in academic settings, as well as professional civilian or military medical teams. Themes discussed are applicable to in-situ and simulation-center based experiences.

Learning Objectives

1. The participant will be able to discern meaningful Learning Objectives best achieved by immersive simulation.
2. The participant will understand innovative experiential learning techniques and their potential benefits as well as limitations.
3. The participant will be able to construct debriefing strategies optimized for the scenario.

[369] INVESTIGATING DEBRIEFING OF ADVERSE PHYSIOLOGICAL CONDITIONS TRAINING

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NAWCTSD, Orlando, FL, United States

(Original Research)

INTRODUCTION: To address challenges associated with Physiological Episodes (PEs), efforts were initiated to research and develop technology solutions that will prepare aviators to respect the breathing threat through training exposures to multiple adverse physiological conditions and symptoms. While part of this research and development effort focused on expanding Mask On Breathing Device training capabilities, exploring ways to expand the instructional quality of the training was a secondary focus. **METHODS:** The instructional capabilities developed were integrated within the Aviation Reconfigurable Cockpit for Hypoxia & Hazard Exposure and Recognition (ARCH2ER) system, which offers realistic flight tasking during profile exposure and an instructor station to aid with the run time and debrief dialog associated with training. **RESULTS:** Specific instructional enhancements developed under this effort included runtime annotations and alerts, as well as data synchronization of system and instructor inputs for debriefing. During the individual profiles, instructors are provided with opportunities to track extant physiological measures and subjective measures of adverse physiological conditions and symptoms. However, exploration is underway to investigate methods for integrating eye tracking capabilities to enhance instructor tracking of performance and aviator understanding of performance degradation through enhanced diagnostic debriefing solutions. Specifically, on-going research and analysis is developing debrief systems concepts that would at a minimum include heat map displays to assist with understanding variations in scan patterns throughout the training profile. More exploratory in nature, the research team is conceptualizing hypotheses associated with fixations and erratic eye movement that might align with other symptoms (e.g., tunnel vision). **DISCUSSION:** These efforts seek to expand the training and debrief quality of dynamic breathing threat training going forward to address current training requirements. As a result, increased training efficiency offers an opportunity to increase aviator awareness of associated dynamic altitude threats, thereby increasing aviator safety and survivability.

Learning Objectives

1. Understand emerging debrief capabilities for dynamic breathing threat training associated with adverse physiological conditions.
2. Identify the ways in which eye tracking technology provide opportunities to enhance diagnostic debriefing.

[370] RESPONSES OF SALIVARY A-AMYLASE BEFORE AND AFTER THE HYPOXIA AWARENESS TRAINING

Ke-Ting Pan[1], Hung-Wei Huang[1], Wun-Wei Huang[2], Chao-Chien Cheng[2], Chung-Yu Lai[1]

[1]*National Defense Medical Center, Taipei City, Taiwan, Greater China;* [2]*Kaohsiung Armed Forces General Hospital Gangshan Branch, Kaohsiung City, Taiwan, Greater China*

(Original Research)

INTRODUCTION: Stress is an important factor that affects work performance. During the flight, hypoxia has been recognized as a stressor to impair human performance and endanger flight safety. Salivary α-amylase has been shown to have a positive relationship with blood norepinephrine, which would increase when facing stress. Therefore, the aim of the study was to understand the change of the

salivary α-amylase before and after the hypoxia awareness training. **METHODS:** This study was a cross-sectional study conducted in October 2022 at the Aviation Physiology Research Laboratory, Taiwan. Flight cadets from the Air Force Academy were recruited to participate in the study when they attended the hypoxia awareness training. Hypobaric chamber Contract 540 (Guardite Inc., Chicago, IL) was used to undertake the hypoxia awareness training. Before and after the training, we collected the saliva from cadets and determined the value of α-amylase with a salivary α-amylase monitor (Nipro CM-21, Japan). During the hypoxia awareness training, we also recorded the time of useful consciousness (TUC) at 25,000 feet. All data were managed and analyzed by the SPSS 24.0 software. **RESULTS:** There were 22 subjects (20 males and 2 females) with an age range from 22 to 24 years old. The mean of TUC was 3.6 ± 0.9 minutes at 25,000 feet. Results showed that the value of α-amylase significantly increased after the hypoxia awareness training (Before vs. after: 14.8±8.6 kIU/L vs. 21.2±14.6 kIU/L, p-value =0.036). However, the correlation between the value of α-amylase and TUC during the hypoxia awareness training was not established in this study. **DISCUSSION:** Our findings illustrated that hypoxia exposure could increase the value of α-amylase among the flight cadets. It also means that α-amylase could be a potential factor to understand the physiological responses induced by in-flight hypoxia. However, the relationship between the value of α-amylase and TUC was not determined due to the small sample size. In addition, residual confounding effects on the α-amylase such as demographic factors and lifestyle habits were not also eliminated from this study. Next work will continue to collect more data and information to clarify the change level of α-amylase by the TUC and altitude.

Learning Objectives

1. The audience will learn about the change of the salivary α-amylase before and after the hypoxia awareness training.
2. The participant will be able to understand the physiological responses induced by in-flight hypoxia.

Wednesday, 05/24/2023 ***4:00 PM***
Grand Ballroom A-B-C-D-E

[S-66]: PANEL: 13TH ANNUAL RAM BOWL

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Allen Parmet
Co-Chair: Rebecca Blue

PANEL OVERVIEW: *The 13th Annual RAM Bowl features participants from the Air Force, Navy, Army, Mayo Clinic, UTMB and international representatives competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field.*

[371] 13TH ANNUAL RAM BOWL

Allen Parmet[1], Rebecca Blue[2], Joanna Nelms[3], Rahul Suresh[4], Roy Allen Hoffman[5], Alex Garbino[6], Walter III Dalitsch[7], Mary Cimrmancic[8], Joseph McKeon[9]
[1]*University of Southern California, Kansas City, MO, United States;* [2]*UTMB, Galveston, TX, United States;* [3]*Texas Air National Guard, Austin, TX, United States;* [4]*NASA JSC, Galveston, TX, United States;* [5]*U.S. Navy, Falls Church, VA, United States;* [6]*GeoControl Systems-NASA JSC, Houston, TX, United States;* [7]*U.S. Navy, Xenia, OH, United States;* [8]*Marquette University, Milwaukee, WI, United States;* [9]*Humana Military, San Antonio, TX, United States*

(Education - Program/Process Review)

The 13th Annual RAM Bowl features participants from the Air Force, Navy, Army, Mayo Clinic, UTMB and international representatives competing for the Louis H. Bauer Trophy. Aerospace Medicine Residents are required to demonstrate multiple competencies to satisfy the requirements of ACGME and ABPM and serve as specialists in the field. Multiple tools are available for developing appropriate didactic knowledge in aerospace medicine, public health, epidemiology, biostatistics and health care management. Residents participate in a college bowl format that test aerospace medicine competencies including the flight environment (atmosphere, radiation, vibration, acceleration, and microgravity), clinical aerospace medicine, aircraft and space vehicle systems/operations, accident investigation, historical events, aerospace physiology, human factors, ergonomics, medical standards, Federal Aviation Administration regulations, passenger transport, restraint and escape, cockpit resource management and aeromedical transportation. Questions are divided into toss-up and bonus questions. Multiple rounds of competition will lead to the selection of an individual victor and awarding of the Louis H. Bauer Trophy to the top team, sponsored by the American Society of Aerospace Medicine Specialists.

Learning Objectives

1. Participants will understand the positive predictive value of commonly used screening tests in determining public health management decisions.
2. Participants will understand gas laws and how they affect physiology during flight.
3. Participants will understand regulatory requirements for certification of civil aviation pilots in the United States.

THURSDAY, MAY 25, 2023

Thursday, 05/25/2023 ***8:15 AM***
Grand Ballroom

57TH HARRY G. ARMSTRONG LECTURE

Student presentations from the 2023 Greater New Orleans Science and Engineering Fair

Thursday, 05/25/2023 ***10:00 AM***
Grand Ballroom A-B-C

[S-67]: PANEL: COMMERCIAL SPACEFLIGHT APPLICATIONS FOR SPACE MEDICINE: A MULTI-CARRIER AND MISSION AGNOSTIC STANDARDIZED APPROACH

Sponsored by the Aerospace Nursing and Allied Health Professionals Society

Chair: Emmanuel Urquieta
Co-Chair: Jimmy Wu

PANEL OVERVIEW: *This panel presents the results from three commercial spaceflight missions: Inspiration4, MS-20, and AX-1. The Translational Research Institute for Space Health (TRISH) has developed a commercial spaceflight research program and a standardized series of high-priority experiments to be collected across spaceflight carries regardless of mission duration or destination. The TRISH Essential Measures encompass sensorimotor and space motion sickness, cognitive performance, physiologic monitoring, biochemical and genetic testing, and spaceflight associated neuro-ocular syndrome (SANS) surveillance. In addition, environmental data and health records are also collected. All of these datasets are coded/de-identified and stored in a database and biobank with the goal of making them accessible to future investigators and spaceflight carriers. The panel will present results from n=9 commercial spaceflight participants across the three missions. Each presentation will highlight the value of the data from a research and clinical perspective with a focus on its use for personalized and predictive medicine. As large standardized and diverse datasets such as the one presented here are created, the opportunity to use the data to improve mission safety, selection criteria, mission experience, and personalized medicine approaches will become a possibility.*

[372] EXPAND DB: AN OPEN, STANDARDS-BASED DATA REPOSITORY FOR COMMERCIAL SPACEFLIGHT BIOMEDICAL RESEARCH DATA STORAGE, DISSEMINATION AND ANALYSIS

Sharib Khan, Chintan Patel
TrialX, New York, NY, United States

(Original Research)

INTRODUCTION: Recent spate of commercial space flights and orbital missions have created an exciting avenue to understand human health in space. Such missions are being undertaken by civilian astronauts who are also participating in biomedical research, thus providing an opportunity to collect unprecedented data on the impact of space on the average human body. The space health research conducted on the three such commercial missions since September 2021, involved capturing and storing multimodal data from a variety of data sources including hand-held ultrasounds, wearables, surveys, electronic health records, biosamples including genomics and environmental/telemetry data from the space capsule. Furthermore, the data collected from these missions is shared across researchers, missions and flight operators, going beyond the usual siloed study-by-study data models. Towards these goals, we have built the EXPAND DB (Database) with the Translational Research Institute for Space Health (TRISH) that has collected data from 9 civilian astronauts from three commercial missions. **METHODS:** The EXPAND DB has been architected using an Entity-Attribute-Values (EAV) data modeling approach to allow storage of diverse data types, for example, an Entity (Subject-345), Attribute (blood_glucose) has Value (105 mg/dL). The data repository has been designed to allow granular permission-based data access for all stakeholders using a secure token-based architecture. The repository also enables researchers to analyze the data through an analytics and visualization tool. **RESULTS:** The database currently houses 903,301 data points from 9 subjects across the three space missions: Inspiration 4 (688,537, 76.2%), MS-20 (143,824, 15.9%), Axiom-1 (70,940, 7.9%) and 3,159,155 data points from environmental telemetry. In terms of data types, the database is currently storing 446 neuro-cognitive and other surveys, 197 ultrasounds, 442,940 wearables data points and 4TB of genomic sequence data. The database has been accessed 135 times to store/retrieve data by 18 researchers or flight operators since September 2021. **DISCUSSION:** As more commercial missions conduct health research activities, the EXPAND DB can provide a foundational resource for the scientific community to store and collaborate on space health research. We are working further towards adding capabilities to add meta-data, data dictionaries and medical vocabulary based data tagging to facilitate standardization and data reuse.

Learning Objectives

1. The participant will be able to learn new results from high-priority space medicine research in commercial spaceflight participants.
2. The audience will learn about a new approach to collecting and using data from commercial spaceflight missions for space medicine applications.
3. The participant will be able to understand the new opportunities as well as the current limitations of implementing research in commercial spaceflight missions.

[373] THE MULTIMODAL EVALUATION OF SPACEFLIGHT HEALTH AND COMMERCIAL SPACEFLIGHT DATA REPOSITORY: LESSONS FROM MEDICAL RESEARCH IN COMMERCIAL SPACEFLIGHT

Eric Bershad[1], Mohammad Hirzallah[1], Jimmy Wu[3], Mathias Basner[4], Mark Shelhamer[5], Doug Ebert[6], Frederic Zenhausern[7], Jaime Mateus[8], Sharib Khan[9], Kathy Johnson-Throop[10], Emmanuel Urquieta Ordonez[11]
[1]*Baylor College of Medicine, Houston, TX, United States;* [3]*Translational Research Institute for Space Health, Houston, TX, United States;* [4]*University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, United States;* [5]*Johns Hopkins University School of Medicine, Baltimore, MD, United States;* [6]*KBR, Houston, TX, United States;* [7]*University of Arizona, Phoenix, AZ, United States;* [8]*SpaceX, Hawthorne, CA, United States;* [9]*TrialX, New York City, NY, United States;* [10]*Throop Data Consulting, LLC, Houston, TX, United States;* [11]*Translational Research Institute for Space Health, Houston, TX, United States*

(Original Research)

INTRODUCTION: As the commercial space exploration sector grows, future crews should have a battery of self-performed, multi-modal tests to monitor their health and performance in addition to a database to store valuable biomedical data and biospecimens. **METHODS:** We established the Multimodal Evaluation of Spaceflight Health (MESH) protocol to enable understanding some of major effects of short-duration spaceflight on humans on commericial spaceflight missions. The Commercial Spaceflight Data Repository (CADRE) aimed to incorporate results into a long-term biomedical data and biospecimen repository. We present our experience with integrating and managing the human research experiments performed on during commercial crew flight. Tissue samples are organized using Open Specimen, a system that allows for monitoring of the type of biosamples, quantities, and storage location and environmental parameters. Access to the CADRE data repository can be made by any researchers with an authorized research purpose and IRB approval. A data privacy release board consisting of physicians, scientists, and administrative personnel, will review data requests and help facilitate data release. **RESULTS:** MESH and CADRE have served the medical research and data and biospecimen storage needs of 3 space missions to date: Inspiration4, Space Adventures, and Axiom-1, with n=9 and n=5 subjects respectively. Data collected is diverse and includes cognition, sensorimotor, ultrasound, vision, biospecimens, and biometric data. **DISCUSSION:** Logistical challenges included: time limitations requiring expedited Institutional Review Board (IRB) review, multisite investigators, training without direct crew access, development of data storing and sharing agreements to permit cross-disciplinary analysis, and a mixture of academic and industry sites. During development of CADRE, challenges included: broad diversity of mission and test subject data types, plans for enrollment over multiple mission, standardization of data elements, and privacy challenges. Our efforts allowed us to complete our intended aims within a compressed timeline, including collection and storage of data into CADRE, which will allow future researchers to access these valuable data for the benefit of all humankind. This research is supported by the Translational Research Institute for Space Health (TRISH), funded under NASA Cooperative Agreement NNX16AO69A.

Learning Objectives

1. The audience will learn about the logistical challenges and solutions to developing the research infrastructure for commercial spaceflight missions.
2. The audience will learn about the development of the Commercial Astronaut Data Repository (CADRE), a unified platform to collect and preserve data and biospecimens from commercial spaceflight missions to enhance our understanding of the effects of spaceflight on human health and performance.

[374] COGNITIVE PERFORMANCE, SUBJECTIVE RESPONSES AND PHYSIOLOGIC CHANGES IN THE INSPIRATION 4 CREW

Mathias Basner[1], Adrian Ecker[1], Christopher Jones[1], Victoria Schneller[1], Marc Kaizi-Lutu[1], Sierra Park-Chavar[1], Yoni Gilad[1], Alexander Stahn[1], Anil Menon[2], Jaime Mateus[3]
[1]*University of Pennsylvania, Philadelphia, PA, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*SpaceX, Hawthorne, CA, United States*

(Original Research)

INTRODUCTION: SpaceX's first all-commercial crew flight, the 3-day Inspiration4 (I4) mission, launched a four-person crew on 9/15/2021 in the Dragon spacecraft from Kennedy Space Center. The primary objective of this project was to assess feasibility of collecting high-quality low-burden physiologic and behavioral data from commercial crews. **METHODS:** The crew filled out a brief alertness and mood survey prior to performing all 10 tests of NASA's Cognition test battery twice before, 2-3 times during and twice after the mission on an Apple iPad mini with the Joggle Research app. They wore an Apple watch series 6 for 2-3 days pre- and post-flight and continuously in-flight. **RESULTS:** Significant changes across mission phases were observed for crew heart rate (HR; $p<0.0001$) and heart rate variability (HRV; $p=0.0046$). Furthermore, the

crew exhibited substantially lower activity in-flight relative to pre-flight ($p<0.0001$), with reduced active energy expenditure ($p=0.0001$). Sound pressure levels were similar in-flight relative to pre-flight and remained below the occupational 8 h exposure limit of 80 dBA. In-flight, three of the four astronauts exhibited a significant and positive association between CO_2 levels and higher heart rate variability ($r=0.42$ to $r=0.63$). In general, crew cognitive performance was not affected in- relative to pre-flight. However, one astronaut exhibited a performance decrement early in-flight primarily due to decreased accuracy on the Psychomotor Vigilance Test, Line Orientation Test, and Matrix Reasoning Test. The crew reported a nightly sleep duration of 6.7 ± 0.7 h with relatively poor sleep quality in-flight, and a moderate level of stress that was lower in-flight relative to pre-flight, as well as a moderately high level of workload. **DISCUSSION:** Data acquisition rate was close to 100%. The observed in-flight physiologic changes were as expected and, except for one crewmember who struggled during first in-flight bout, cognitive test data were nominal across all mission phases. With few exceptions, the crew showed healthy survey responses across all mission phases. This demonstrates that commercial crews can collect valuable behavioral and physiologic data with relatively little crew burden. These data will help improve health and safety for future crews. **SUPPORT:** TRISH EXP0005 through NASA Cooperative Agreement NNX16AO69A, SpaceX

Learning Objectives

1. The audience will learn about how crew physiology measured with a smartwatch changes in a commercial crew on a 3-day flight.
2. The audience will learn about how crew cognition changes in a commercial crew on a 3-day flight.

[375] INITIAL ANALYSIS OF PRE- AND POST-FLIGHT REFRACTIVE ERROR CHANGES IN COMMERCIAL SPACEFLIGHT PARTICIPANTS

Shivang Dave[1], Carlos Hernández[2], Andrea Gil-Ruiz[2], Eric Bershad[3], Emmanuel Urquieta[3], Mohammad Hirzallah[3], Daryl Lim[1], Eduardo Lage[4]

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(Original Research)

INTRODUCTION: The effects of microgravity exposure, and its relation to spaceflight-associated neuro-ocular syndrome (SANS) [1][2], has previously been studied on cohorts of astronauts. Astronauts are selected via a rigorous standards that may be different from the variability present in non-astronauts [3]. Commercial spaceflights provide an opportunity to investigate SANS onset on non-astronaut participants during shorter spaceflights. This study examined the pre- and post-spaceflight refractive error changes on 5 subjects across 2 separate commercial launches (12 & 17 days long, respectively) with a handheld wavefront binocular autorefractor (QuickSee, PlenOptika), that provides objective measurements. **MATERIALS AND METHODS:** Five subjects (30-75 years old) participated in an IRB-approved clinical study part of the EXPAND program approved by Baylor College of Medicine. Measurements were taken three times per session across 2 sessions for both pre- and post-flight, ideally within 1 week of flight. Each session involved QuickSee measurements with and without a fogging lens (FL), to relax patient accommodation that could mask hyperopic patients [4]. Wavefront images were analyzed to provide spherical equivalent (M) autorefraction results of the right eye. Repeatability of the autorefraction results was assessed using the repeatability coefficient (RC). Four intrasession RCs were calculated comparing pre- and post-flight measurements with and without FLs, respectively, while the pre- and post-flight variation were plotted using the mean of the normalized measurements. **RESULTS:** We have not observed a significant variation in the refraction for either flight or patient between pre- and post-flight measurement sessions. The repeatability coefficient of the device pre-flight is 0.35 (Table 1). Figure 1 shows the variability of the pre- and post-flight refractive error, with (left) and without (right) FL normalized by the mean M of the four conditions. **DISCUSSION:** Although we did not observe hyperopic shift, further studies are needed to strengthen any potential conclusions due to the limitations of this initial study including the small number of research subjects, measurement timepoints not being within 24 hours of the flight which could alter refractive changes, and the variability of different launches, units, and flight surgeons. Future private spaceflights present an opportunity to expand this dataset to overall strengthen the conclusions.

Learning Objectives

1. The participant will be able to learn new results from high-priority space medicine research in commercial spaceflight participants.
2. The audience will learn about a new approach to collecting and using data from commercial spaceflight missions for space medicine applications.
3. The participant will be able to understand the new opportunities as well as the current limitations of implementing research in commercial spaceflight missions.

[376] OTOLITH AND POSTURE EVALUATION IN COMMERCIAL SPACEFLIGHTS

Mark Shelhamer[1], Serena Tang[2], Nabila Ali[1], Mallika Sarma[1], Michael Schubert[1], Anil Menon[3], Jaime Mateus[4], Jennifer Law[5], Emmanuel Urquieta[6]

[1]*Johns Hopkins University School of Medicine, Baltimore, MD, United States;* [2]*University of California Berkeley, Berkeley, CA, United States;* [3]*NASA, Houston, TX, United States;* [4]*SpaceX, Hawthorne, CA, United States;* [5]*UTMB, Galveston, TX, United States;* [6]*Translational Research Institute for Space Health, Houston, TX, United States*

(Original Research)

INTRODUCTION: Biomedical experiments have been performed on recent commercial orbital flights. One of these experiments is a sensorimotor study on otolith function and posture control, presented here. **METHODS:** This project has two parts. The first is an evaluation of otolith asymmetry, as manifest by vertical and torsional alignment of the eyes, assessed by a perceptual-nulling method. The second part is a posture evaluation: body sway during quiet standing with eyes closed, followed by sit-to-stand testing. This was carried out on the flights of Inspiration4 (I4), Soyuz MS-20, and Axiom-1 (Ax-1). **RESULTS:** In the I4 ocular-alignment study, we find a difference (retrospectively) between subjects who experienced space motion sickness (SMS) and those who did not. In vertical-alignment testing, when preflight and postflight testing both show consistent misalignment, but that alignment is different after flight than before flight, this is associated with SMS. We posit that this is because postflight testing reflects the inflight adaptive state (compensation for asymmetry in other than 1g), and that 0g compensation should in general be different from the 1g compensation. Postflight posture data during quiet standing were examined with Detrended Fluctuation Analysis (DFA). This examines fluctuations (variance) of body sway around a linear trend, at different time scales. Many biological processes follow a power law, where the magnitude of the fluctuations (F) is related to the duration of the time window (Δt) over which the fluctuations are measured: $F(\Delta t) \sim (\Delta t)^{\alpha}$. Those I4 subjects with SMS show deviation from power-law scaling. Processing of data from MS-20 and Ax-1 is ongoing. The dichotomy of the flights makes direct comparisons difficult. I4 spent 3d in orbit, while Ax-1 spent 17d, and the pre/post testing schedules were also different. SMS data are not yet available for all flights. From Ax-1, 2 subjects show deviation from power-law scaling in posture data. Unfortunately, these subjects do not exhibit the clear pattern in vertical alignment (VAN) that we believe from I4 to indicate SMS. This discrepancy may be because of the longer duration of Ax-1 or the difference in postflight schedules. **CONCLUSIONS:** I4 results hold promise for using ocular alignment to predict SMS susceptibility and alterations in postural control; we hope to verify these findings in the later flights.

Learning Objectives
1. Understand otolith asymmetry and its role in adaptation to spaceflight.
2. Understand the analysis of posture data through power-law scaling of body-sway magnitude.

[377] IMAGING EXPERIMENTS ON THE INSPIRATION4 MISSION: A GLIMPSE INTO THE FUTURE

Ashot Sargsyan[1], Douglas Ebert[1], Kadambari Suri[1], Jaime Mateus[2], Michael Loesche[2], Steven Uhl[1], Aaron Everson[1]
[1]*KBR, Houston, TX, United States;* [2]*SpaceX, Hawthorne, CA, United States*

(Original Research)

INTRODUCTION / BACKGROUND: We pursued ultrasound imaging-based human research objectives during the 3-day private orbital mission Inspiration4 aboard a Crew Dragon spacecraft (SpaceX, CA, USA). Imaging targets included urinary bladder, eyes, and internal jugular veins (IJV) with inspiratory resistance. We also examined data quality in autonomously performed procedures of different levels of complexity. **METHODS:** Four volunteer subjects consented to this IRB-approved investigation. Imaging data were collected preflight and on flight days 1, 2, and 3 with a Butterfly iQ+ ultrasound system (Butterfly Network, USA) interfaced with mobile computing platform. ResQGuard ITD 7.0 impedance threshold devices (Zoll, USA) provided inspiratory resistance. Procedural instruction materials were used for autonomous imaging procedures. Imaging data analyzed in Osirix MD DICOM viewer (Pixmeo, Switzerland). Due to the small number of subjects, statistical analysis options were limited; the team anticipates pooling of the data with future compatible datasets. Procedural compliance and data quality were evaluated in addition to physiological parameters. Data quality was scored on a scale from 0 to 3, with 2.0 or higher considered successful. **RESULTS:** Combined success score averages for bladder (least demanding), IJV, and eyes (most demanding) were 2.3, 2.4, and 0.76, respectively. The IJV data set was the most complete. Preflight, ITD reduced IJV cross-sectional area (CSA) from 0.71±0.26 to 0.45±0.34 cm^2 (36%). In-flight, ITD intervention reduced CSA from 0.73±0.17 to 0.52±0.31 cm^2 (29%). These and other trends represent preliminary results from the small sample size in early space flight. **DISCUSSION:** Autonomous performance of complex imaging procedures is feasible with adequate skill management tools. Bladder and IJV exams (low and moderate complexity) were highly successful. However, the most complex exam (eyes) resulted in success scores below the acceptability threshold. Reduction of IJV capacity upon ITD intervention was the most consistent observation in this small dataset. In conclusion, we report reassuring results of a new paradigm of autonomous imaging-based human research. We also report unique physiological data from early microgravity exposure, which may be pooled with compatible data sets for robust analysis and conclusions. This research is supported by the Translational Research Institute for Space Health (TRISH), NASA Cooperative Agreement NNX16AO69A.

Learning Objectives
1. The audience will be able to understand the feasibility, value, and limitations of imaging-based human research in highly constrained autonomous space missions.
2. The audience will learn about physiological effects of resistance breathing in microgravity.
3. The audience will learn about the significance and approaches to procedural compliance and data quality assessments in imaging-based research.

Thursday, 05/25/2023 ***10:00 AM***
Grand Ballroom D-E

[S-68]: SLIDES: TAKING SENSORIMOTOR STUDIES FOR A SPIN

Chair: Pierre Denise
Co-Chair: Jeffrey Hovis

[378] EVALUATION OF SPATIAL DISORIENTATION TRAINING: END USER SURVEYS FOR THE WILDCAT HELICOPTER SIMULATOR

Alaistair Bushby[1], Steven Gaydos[2]
[1]*RAF Centre of Aviation Medicine, Henlow, United Kingdom;* [2]*HQ Army Air Corps, Middle Wallop, United Kingdom*

(Original Research)

INTRODUCTION: Spatial disorientation (SD) remains a significant operator threat and safety issue among military rotary wing (RW) aircrews, particularly during times of high workload and deceptive visual cues. With endorsement from the tri-Service Consultant Advisors in Aviation Medicine, British RW Forces employ a layered training approach that includes simulator-based immersive scenarios. The training was developed by a multi-disciplinary team and embedded within advanced training packages that were not solely focused on SD. **METHODS:** Ten separate RW SD training scenarios were developed for the AW159 Wildcat helicopter simulator. A post-sortie survey instrument was distributed to assess 1) hazard awareness, 2) training effectiveness, 3) role and mission relevance, and 4) perceived ability to respond to future SD threat. Aircrew participation and responses were voluntary and anonymous. A corresponding assessment from the simulator instructor was used for independent determination if the crew became disoriented during the training. **RESULTS:** The six-month training cycle yielded 69 completed surveys with elevated seven-point Likert-scale assessments across all four categories (6.0 median scores, respectively). Results suggest favorable aircrew perceptions of training objective success with illustrative free-form feedback comments. Of all sorties flown, the majority of aircrew (68%) became disoriented at some point during the sortie. **DISCUSSION:** Results support a high level of operator satisfaction with training objectives within a RW simulator environment. SD simulator-based training can serve as an important component of a layered, multimodal approach. Advantages include a safe, interactive, environment for immersive crew training, ability to address root causes of provenance, and compatibility with role-specific mission sets.

Learning Objectives
1. Participants will broadly recognize most common causes of operator threat and flight safety risks associated with RW SD.
2. Participants will appreciate unique capabilities presented by SD training through immersive simulation.

[379] FIELD ASSESSMENT OF SENSORIMOTOR FUNCTION FOLLOWING LONG-DURATION SPACEFLIGHT

Scott Wood[1], Sarah Moudy[2], Timothy Macaulay[3], Michael Bishop[3], Gilles Clément[3]
[1]*NASA JSC, Houston, TX, United States;* [2]*Aegis Aerospace, Houston, TX, United States;* [3]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Field assessments of functional task performance following long duration spaceflight are critical to characterize the risk associated with sensorimotor adaptation. A portable test battery involving sit-to-stand, prone-to-stand, walk and turn with obstacle, and tandem walking has been implemented during pre- and postflight testing to provide Sensorimotor Standard Measures that could be implemented in remote test locations. **METHODS:** To date, 19 astronauts (12 males, 7 females) participated in this study before and after 6–8-month expeditions to the International Space Station (198 ± 70 days, mean ±std). Ethics approvals were obtained, and all subjects provided informed consent. Tests were conducted preflight, within a few hours after landing, and then 1 day and 6–11 days later. Time to stability was the outcome measure for both standing tasks, time to completion and turn rate for the walk and turn task, and percent complete steps for the tandem walking (eyes open and closed). Statistical analyses included mixed effects (multi-level) generalized linear models. **RESULTS:** Consistent with previous Field Tests, significant effects of spaceflight were observed during the initial testing including longer times to stabilize posture when standing, longer times to complete the short obstacle walk, and fewer correct steps during tandem

walking. The recovery timeline varied with task complexity, generally taking longer when either the basis of support was limited (e.g., tandem walk) and/or visual cues were deprived (eyes closed). **DISCUSSION:** These data suggest that additional sensorimotor-based countermeasures may be necessary to maintain functional performance during long-duration spaceflight. Maintaining core measures as new countermeasures are implemented during future missions will be instrumental in assessing their efficacy. This test battery will also serve as the basis for developing sensorimotor assessments during future space exploration.

Learning Objectives

1. Understand the purpose of obtaining a core set of field measures to characterize the risk of sensorimotor adaptation following spaceflight.
2. Understand the initial decrements observed during the early post-flight testing and the timeline of recovery.

[380] PILOT-VEHICLE CLOSED-LOOP COMPUTATIONAL MODELS

Tara Nibhanupudy[1], Moein Nazifi[1], Elena López-Contreras Gonzalez[1], Kassia Love[1], Megan Reissman[2], Timothy Reissman[2], Torin Clark[3], Yoon Chan Rah[1], Faisal Karmali[1]
[1]*Mass Eye and Ear, Boston, MA, United States;* [2]*University of Dayton, Dayton, OH, United States;* [3]*University of Colorado Boulder, Boulder, CO, United States*

(Original Research)

INTRODUCTION: Spatial disorientation is a leading cause of aviation fatalities. These incidents often arise from interactions between vehicle dynamics and neural processes underlying pilot behavior. Increasing our ability to predict/prevent incipient adverse events during human-aircraft interactions could substantially mitigate risk. To address this problem, we aimed to 1) develop a closed-loop cybernetic model including state-of-the-art spatial orientation and motor-control components, and 2) validate and refine the model using human experiments. **METHODS:** Closed-loop "comprehensive models" were developed for rotation control with and without changing orientation relative to gravity. These (Matlab/Simulink) incorporated validated spatial orientation, motor control , and vehicle models. Subjects (n=9) ages 21-38 sat in a motorized rotary chair (Neurokinetics) and used a joystick to control chair motion, with instructions to minimize chair velocity while experiencing a pseudo-random sum-of-sines "disturbance" (0.004-1.7 Hz). Model predictions included gain and phase values averaged across subjects as a function of disturbance frequency. Experimental data was used to enhance and tune the model. **RESULTS:** The closed-loop model predicted wide variations in task performance by frequency. In particular, the models predicted that human performance was mediocre for rotation control about an Earth-vertical axis in the dark (gravitational cues did not provide useful information about task performance). Human experimental data closely followed the frequency response predicted by the model. The most effective nullification was seen to occur in a small band of medium-range frequencies (0.01-0.1 Hz), due to combined dynamics of high-pass filter vestibular perception low-pass filter motor control. Innovations that improved model predictions were 1) addition of a decision-making element reflecting the corruption of sensory feedback by neural noise 2) tuning of parameters of pilot effort (Kp) and the central nervous system (CNS) delay. **CONCLUSIONS:** The model accurately predicts the human experimental frequency response. These novel models of human-vehicle systems increase understanding of the dynamic interaction between vehicle states and human sensorimotor systems. With this, performance decrements in vehicle control, e.g., during spatial disorientation or weightlessness, can be more accurately predicted/mitigated. Multi-axis rotational tasks remain to be characterized.

Learning Objectives

1. The audience will learn about how, within a human-vehicle system, the dynamics of spatial orientation, motor control, and the vehicle combine to contribute to active control of motion tasks.
2. The audience will gain an understanding of the applications of human-vehicle closed-loop models toward increasing safety of airplane and spacecraft operation.

[381] VESTIBULAR FUNCTION ASSESSMENT IN AIRCREW

Oded Ben-Ari
Israeli Air Force, Ramat Gan, Israel

(Original Research)

INTRODUCTION: Spatial Disorientation is a significant cause of fatal aviation accidents, hence the importance of an intact vestibular system. The Video Head Impulse Test (V-HIT) uses the Vestibulo-Ocular Reflex (VOR) to evaluate the function of the semi-circular canals. The V-HIT measures the Gain (the ratio of the eye velocity to the head velocity), which normally ranges from 0.8 to 1.2 in the general population. The objective of the current study was to define V-HIT Gain norms for healthy Israeli Air Force (IAF) aviators. **METHODS:** This was a retrospective study that included 174 V-HIT Gains of aviators (of them 165 healthy and 9 dizzy) that were examined in the IAF Aeromedical Center between March 2020 to March 2022. Only Gains of horizontal canals were included in the study. **RESULTS:** The mean age was 28.1 (range: 17-60). Gain values were 0.85-1.05 and 0.88-1.12 in the right and left ear, respectively. A significant negative correlation was found between Gain and age. A significant difference between the Gain of the healthy ear and that of the impaired ear was found in the dizzy group. **DISCUSSION:** Vestibular screening of aviators is important and feasible. The normal range of Gains for IAF aviators differs from that of the normal population. V-HIT Gains can be used to detect both impairment and aging of the vestibular system.

Learning Objectives

1. Considering implementation of a vestibular assessment as part of the yearly medical checkup.
2. Defining a of normal range for Gain values in aircrew.

[382] VIBROTACTILE FEEDBACK AS A COUNTERMEASURE FOR SPATIAL DISORIENTATION

Vivekanand Vimal, Alexander Panic, James Lackner, Paul DiZio
Brandeis University, Waltham, MA, United States

(Original Research)

INTRODUCTION: Spatial disorientation (SD) is a major contributor to fatal aircraft accidents. Vibrotactile feedback has been shown to be useful, however it is unknown whether it will be immediately beneficial or whether training will be needed to ensure pilots and astronauts can rely on vibrotactile feedback when disoriented. **METHODS:** Blindfolded participants (n=30) were secured into a Multi-Axis Rotation System device that was programmed to behave like an inverted pendulum and they used a joystick to stabilize around a balance point. In the horizontal roll plane, they did not tilt relative to the gravitational vertical and therefore did not have gravitational cues to determine their ongoing position. In our prior work, 90% of participants reported SD, and collectively, they showed minimal learning, poor performance and significant loss of control. Here, Group C (Control) balanced in the vertical roll plane on Day 1 where they could use gravitational cues and they subsequently balanced in the horizontal roll plane on Day 2. Group V did the same but had 4 vibrotactors on each arm that signified the extent and direction of tilt from the balance point on both days. Group VT had training on Day 1 using the vibrotactors to find and orient at non-zero balance points in the vertical roll plane. On Day 2 they used the vibrotactors in the horizontal roll plane. **RESULTS:** Group V performed significantly better than Group C on Day 2, but had minimal improvement across trials and still had elevated levels of losing control. 90% of Group V participants reported a conflict where their perceived orientation differed from what the vibrotactors were indicating. Group VT performed statistically better than Groups V and C, and they showed continued learning and improvements on Day 2. On the final 5 trials of Day 2 we deactivated the vibrotactors for both Group V and VT. While performance worsened it was not statistically worse than the Control group, suggesting that the vibrotactors did not create a negative dependence. **DISCUSSION:** Vibrotactile feedback is a valuable countermeasure to SD, however it may cause a conflict between perceived and cued orientation. Exposure to vibrotactors in ground-based conditions may not be enough to overcome the conflict that will arise in aerospace conditions. We show

that an effective training program has a component where participants need to rely on vibrotactile feedback to complete the task.

Learning Objectives

1. The audience will learn about how vibrotactile feedback may cause a conflict between perceived and cued sense of self orientation when spatially disoriented.
2. The audience will learn how the conflict caused by vibrotactile feedback during disorientation can be reduced by using a specialized training program.

[383] IDENTIFICATION OF INDIVIDUAL DIFFERENCES FOR INCORPORATION IN OPERATOR STATE MONITORING

Amanda Kelley, Aaron McAtee, Katie Feltman, Michelle Duffy
U.S. Army Aeromedical Research Lab, Fort Rucker, AL, United States

(Original Research)

INTRODUCTION: Ongoing work within the military continues to pursue the goal of operator state monitoring (OSM) through psychophysiological metrics. This approach would allow for a mostly non-invasive, objective assessment of the operator's cognitive state. While much of the work completed to-date has yielded promising results, a key obstacle remains: accounting for individual variability. This study used archived datasets from four studies of physiological measures and workload. **METHODS:** De-identified datasets from four studies completed at the U.S. Army Aeromedical Research Laboratory were included within this study. Study 1 consisted of discrete computerized cognitive tasks, whereas Study 2 and 3 were completed within the UH-60 simulator. Study 4 used an unmanned aerial system (UAS) simulator. Participants included rated aviators; and cognitive-normal Soldiers. Physiological measures included electrocardiogram (heart rate, heart rate variability [HRV]); respiration rate; electroencephalogram (frontal alpha, theta, beta); and electroocoulogram (blink rate, number of blinks, blink velocity). Individual differences included intelligence, sleepiness, anxiety, and depression symptoms. Workload was measured using the NASA task load index (NASA-TLX). **RESULTS:** Workload scores and effect sizes for the physiological measures were inconsistent across studies, discouraging aggregate analysis. Correlational analyses of individual studies did not yield consistent patterns across studies, with the exception of a moderate to strong positive relationship seen between depression and blink measures in Studies 1 and 4. Six machine learning algorithms were run predicting subjective workload and another six predicting workload conditions. Age and number of blinks were the most consistent predictors (age 4/6, number of blinks 5/6) of subjective workload whereas NASA-TLX scores and total frontal beta and alpha electroencephalogram activity consistently predicted workload condition (6/6 algorithms). **DISCUSSION:** The findings from this study support continued evaluation of physiological measures to predict workload levels with emphasis on electroocoulogram and electroencephalogram measures, but do not suggest a large influence of the individual factors explored, with the exception of age's influence on workload. Next steps include evaluating individual participant's data to quantify the variability of each physiological response under high and low workload manipulations.

Learning Objectives

1. Participants will learn about physiological measures and how they relate to cognitive workload and performance.
2. Participants will learn whether, and if so, to what extent, individual differences correlate with physiological measures under varied levels of workload.

Thursday, 05/25/2023 ***10:00 AM***
Grand Chenier

[S-69]: PANEL: AEROMEDICAL ETHICS PANEL

Sponsored by the American Society of Aerospace Medicine Specialists

Chair: Mark Mavity

PANEL OVERVIEW: *Aerospace medicine may present an array of potential ethical dilemmas to aviation medicine physicians and other aeromedical professionals that may arise out of conflicts between the interests, rights, and responsibilities of those within our profession, individual patients/aircrew, private employers, and governmental certifying agencies. Case studies will be presented for open audience discussion that address a variety of relevant ethical and/or legal value conflicts in the current practice of aerospace medicine.*

Learning Objectives

1. The audience will explore the process of ethical decision-making and it's impact upon the practice of aerospace medicine.
2. The audience will learn about the current foundational resources which form the framework of current medical ethical guidance, particularly the ASAMS Ethical Guidelines as they relate specifically to the practice of aerospace medicine.
3. The audience will be encouraged to provide thought and attention to the ethical issues impacting the practice of aerospace medicine.

[384] AEROMEDICAL ETHICS

Mark Mavity
The American Society of Aerospace Medicine Specialists, McLean, VA, United States

(See Overview)

Thursday, 05/25/2023 ***10:00 AM***
Napoleon Ballroom C1-C2

[S-70]: SLIDES: COLLISION STRESS AND VISION

Chair: Harriet Lester
Co-Chair: Kevin Gildea

[385] COMPARISON OF SCHEDULES, STRESS, SLEEP PROBLEMS, FATIGUE, MENTAL HEALTH AND WELL-BEING OF LOW COST AND NETWORK CARRIER PILOTS

Marion Venus
Venus Aviation Research, Training & Pilot Support, Universität Bern Institut für Psychologie, Zurich, Switzerland

(Original Research)

OBJECTIVE: This research investigates and compares working-conditions, duty rosters, stress, sleep problems, fatigue levels, mental health, and well-being of pilots working for network (NWCs), and low-cost carriers (LCCs). This study extends previous research by investigating working conditions, pilots' actual rosters, fatigue and mental health of two groups of pilots flying for LCC or NWC. **METHOD:** A comprehensive cross-sectional online survey was completed by N=338 pilots (185 NWC, 153 LCC pilots). All pilots reported their roster data of the last 2 months during peak flight season, psychosocial and work-related stress (e.g., high job insecurity, less total flight-experience, lower income, more time pressure, more early starts), sleep difficulties, levels of fatigue, well-being, symptoms of depression, anxiety, and common mental disorders (CMD). **RESULTS:** LCC pilots reported significantly more work-related stressors like lower income, younger age, less total flight experience, more demanding rosters (more sectors, more early starts, more duty and flight hours), significantly more sleep difficulties, and very high levels of fatigue. Moreover, LCC pilots' well-being was significantly more impaired: 24.2% of the LCC vs. 14.8% of NWC pilots reported positive depression screening results, and 7.1% of LCC and NWC pilots reported significant symptoms of anxiety. **CONCLUSIONS:** This study confirms that different airline business models and management strategies result in more stressful working conditions for LCC pilots, whose health is more impaired by high fatigue and mental health issues. Although LCC pilots did not report significantly higher duty and flight hours, the work-related stressors like more bogus self-employment, high job, and income insecurity, more time

pressure, were associated with even higher levels of fatigue, significantly more sleep problems, and more impaired mental health and well-being. In line with previous research, LCC pilots reported more safety issues and more fatigue-related incidents compared with NWC pilots.

Learning Objectives

1. The audience will learn about the differences in fatigue and mental health issues of pilots flying for network or low-cost carriers.
2. The audience will learn about general and pilot-specific stressors, and which stressors specifically apply to low-cost carrier pilots.

[386] PILOTS' STRESS, FATIGUE, DEPRESSION, ANXIETY, COMMON MENTAL DISORDERS AND WELLBEING - "SLIDING DOWN A DANGEROUS PATH"

Marion Venus

Venus Aviation Research, Training & Pilot Support, Universität Bern Institut für Psychologie, Zurich, Switzerland

(Education - Program/Process Review)

OBJECTIVE: This study investigated international pilots' rosters (duty, flight hours, early starts, night flights, standby days, ...), work-related and psychosocial stress, sleep difficulties, fatigue levels, wellbeing, symptoms of depression, anxiety, and common mental disorders (CMD), and how they are interrelated. **BACKGROUND:** Several scientific studies have confirmed that fatigue can pose a significant risk to flight safety. Other studies reported high accumulated fatigue, sleep problems, positive depression screening results for more pilots, compared with the general population - despite fatigue risk management, flight time limitations and sophisticated safety management systems. **METHOD:** A cross-sectional online survey was completed by 406 international pilots, who reported their duty rosters of the last two months. Pilots also self-assessed their stress-levels, sleep problems, fatigue, wellbeing, and mental health. **RESULTS:** Although pilots were on average rostered for only 60% of maximum legal duty and flight hours, three out of four pilots (76%) reported severe or high fatigue. Every fourth pilot reported considerable sleep difficulties (24%). 18.7% pilots reported positive depression screening results, 8.5% positive anxiety screenings, 7.2% reported significant symptoms of depression and anxiety. Highly significant to high correlations between stress, sleep problems, fatigue, symptoms of depression, anxiety, CMD and well-being were found. Pilots reported negative experiences with fatigue risk management and failures of safety management systems. **CONCLUSIONS:** Chronic stress appears to be linked to psychophysiological wear and tear, and was associated with higher levels of fatigue, more sleep disturbances and more impaired mental health. Future research should not only consider fatigue as an immediate threat to aviation safety, but also as a significant threat to pilots' safety-relevant fitness to fly.

Learning Objectives

1. Participants will learn, how widespread fatigue and sleep problems are among professional pilots.
2. Participants will learn, how many pilots may suffer from significant symptoms of depression and anxiety, and reasons why.
3. Participants will learn which cases of confidential reporting of flight safety issues led to repression, harassment, dismissal and eventually to court.

[387] MAKING SENSE OF SPECIAL SENSES: TWO FATAL ACCIDENTS, CATARACTS AND MACULAR DEGENERATION

Harriet Lester[1], Kevin Gildea[2], Benisse Lester[3]

[1]*FAA, Jamaica, NY, United States;* [2]*FAA, Oklahoma City, OK, United States;* [3]*Consultant, Washington, DC, United States*

(Education - Case Study)

INTRODUCTION: Two vision related fatal aircraft accidents are presented. The first involved symptomatic cataracts, with a failed landing at night in a Cessna 172K. The second involved under-reported macular degeneration, with a stall in a Cessna U206C. **BACKGROUND:** Vision is a critical and vulnerable special sense for the aviator. Cataracts and macular degeneration are common conditions that can compromise visual perception and contribute to aviation accidents, especially in the aging pilot. Visual challenges abound in aviation under the best of circumstances. The normal aviator perceives a three dimensional world with a two dimensional retina, scans to overcome the limitations of our visual field and photoreceptor array, and adapts to atmospheric changes that alter contrast, color perception, and acuity. The aviator with cataracts may experience symptoms related to the optical properties of light as both particle and wave, interacting with the changing chemical substance of an aging lens. Symptoms may range from early dysfunctional lens syndrome to decreased acuity, overt glare, halos, contrast loss, color distortion, and other phenomena. Symptomatic cataracts are treated with surgery. The aviator with macular degeneration may experience defects and distortions in the central visual field. Macular degeneration degrades the best seeing portion of the eye, diminishing acuity and color perception with dry and wet varieties. Anti-vegf intravitreal injections treat wet macular degeneration. **CASE PRESENTATION:** NTSB Report WPR14FA078 is the cataract case. 12/26/13, a Cessna 172K crashed into a tree in Fresno, California, on the third landing attempt, 1821 local, in the dark. The pilot was 72 years old, 1500 hours daytime, low night hours, with difficulty navigating from a familiar lit runway to the taxiway 3 weeks prior. He had a 4 year history of cataracts, 20/20 acuity, but complained of halos around stars. NTSB Report CHI08FA156 is the macular degeneration case. 6/8/08, a Cessna U206C impacted terrain after a stall at a charity fly-in in Freemont, Ohio, 1256 local. The pilot was 86 years old, 55,000 hours, with a 2 year history of macular degeneration which was not reported properly. The pilot had a car accident 10 days before the fatal crash. **DISCUSSION:** NTSB recommendations resulted in increased training about how cataracts can degrade night vision. The macular degeneration case resulted in termination of FAA AME designee privileges.

Learning Objectives

1. The participant will understand how cataracts can adversely affect vision in aviation.
2. The participant will understand how macular degeneration can adversely affect vision in aviation.

[388] A MIDAIR COLLISION, VISUAL FIELD DEFECTS, AND THE LIMITS OF THE HUMAN VISUAL SYSTEM

Kevin Gildea[1], Harriet Lester [2]

[1]*FAA, Oklahoma City, OK, United States;* [2]*FAA, Jamaica, NY, United States*

(Education - Case Study)

INTRODUCTION: This case report addresses a midair collision where one pilot had visual field defects resulting from severe glaucoma. **BACKGROUND:** Detecting other aircraft while in flight can be challenging without visual impairments. Minimal color and luminance contrast between an aircraft and the background can make detection difficult. Any anomalies, such as visual field defects, can make the detection task more difficult. Individuals with glaucomatous defects may also have compromised contrast sensitivity. **CASE PRESENTATION:** The pilot of a PA-12 flying under Part 91 struck the rear portion of a DHC-2 flying under Part 135 in Alaska on July 31, 2020 at 0827 local time (NTSB Report ANC20LA074). The PA-12 pilot had open-angle glaucoma in both eyes with visual field loss; the FAA denied medical certification June of 2012 and sustained the denial July 2012 upon request for reconsideration. The NTSB review of the pilot's personal medical records showed that there were visual field defects in both eyes from severe glaucoma with optic nerve damage. An NTSB cockpit visibility study indicated that the pilot of the PA-12 would have needed to look in the general direction of the sun to observe the DHC-2; the latter aircraft was 20 degrees below the sun. The PA-12 pilot would have had an unobstructed view of the DHC-2 for periods totaling 40 seconds or more prior to the collision. The pilot of the DHC-2 would have had an unobstructed view of the PA-12 for 53 seconds preceding the collision. In spite of the unobstructed views, both pilots failed to avoid the other aircraft. The PA-12 struck the fuselage of the DHC-2 near the tail. The resulting midair collision resulted in fatal injuries to the six people on the DHC-2 and sole occupant of the PA-12.

DISCUSSION: This case presents a fatal midair collision where glaucoma-induced visual field defects made a challenging visual detection task more difficult. The pilot with the visual defect was flying with a denied medical certificate under conditions of sun glare and struck the other aircraft. Although the pilots of both aircraft would have had periods of unobstructed visibility in the direction of the other aircraft, a collision was not avoided. Adherence to FAA vision requirements combined with vigilance and an effective visual scan in the air are necessary to reduce the probability of midair collisions. Additional mitigation recommended by the NTSB was the installation of ADS-B In and Out for Part 135 operators.

Learning Objectives

1. Aircrew, effective visual scanning, and the limits of visual perception.
2. The effects of visual field defects on the ability to detect aircraft in flight.
3. Visual field requirements for pilot aeromedical certification.

Thursday, 05/25/2023 ***10:00 AM***
Napoleon Ballroom D1-D2

[S-71]: PANEL: USAFA GRADUATE CONTRIBUTIONS TO AEROSPACE MEDICINE: LEADERS WHO INSPIRED CADETS IN "THE NEXT GENERATION"

Chair: Jennifer Giovannetti

PANEL OVERVIEW*: *BACKGROUND: *The U.S. Air Force Academy (USAFA) is the only service academy with a dedicated biology major feeding into a larger aerospace medical professional career field. Cadet biology majors researched USAFA graduate's careers and contributions to the aerospace medicine community specifically focused on how former USAFA graduates influenced the next generation of aerospace medical professionals.* ***OVERVIEW:*** *USAFA's biology department connected with cadets interested in aerospace medicine careers to find the "Next Generation of Aerospace Medicine." Cadets connected with several USAFA graduates, researched archives, and arranged interviews of those who contributed to the aerospace medicine community. They will share graduate's stories, contributions and how they inspired "The Next Generation." This was a great opportunity for cadets to break out of the day-to-day cycle and expand their horizons to potential career choices and real impact on the broader community. The cadets hope to share a unique presentation that shows how the next generation looks forward to scientific communication in this community.* ***DISCUSSION****: Standing on the shoulders of giants, cadets learn from these inspiring leaders in the aerospace community. From integration in the joint community on the ground, breaking barriers in the air to breaking records in space, the cadets connect with leaders from the past in order to become our aerospace medicine leaders of the future.*

[389] USAFA GRADUATE CONTRIBUTIONS TO AEROSPACE MEDICINE: LT GEN (RET) ROBB'S JOINT EFFORTS

Ayla McKean
U.S. Air Force Academy, Colorado Springs, CO, United States

(Education - Program/Process Review)

BACKGROUND: Lieutenant General (ret) Douglas Robb is a recognized contributor in the aerospace medical community and is an inspiration to the next generation of aerospace medicine specialists. After graduating from USAFA, class of 1979, he attended medical school at Chicago College of Osteopathic Medicine and later Harvard University for a Master's in Public Health. He served as an Air Force flight surgeon, Chief of Flight Medicine, Aerospace Medicine Squadron Commander, Chief Flight Surgeonon the Joint Staffand culminated his career as the Director of the Defense Health Agency. Influential flight surgeons and joint leaders such as Lt Gen Robbenable the next generation to work as a joint team for the future. **OVERVIEW:** The military is medically educated and prepared to keep pace with technological changes with the support of the aerospace medicine community. The military able to perform at the highest of standards with a physiological and psychologically ready joint force. **DISCUSSION**: Lt Gen Robb served as the command surgeon for U.S. Central Command and Air Mobility Command. During that time, he developed the Joint Trauma systems as the Joint Staff Surgeon. In addition, he responded as the Senior Medical Officer during the Khobar Towers terrorist attack. Lt Gen Robb's dedication to creating a medically adaptable and effective military in all branches is inspiring. With a broad view of how the military can improved through medical interventions and its medical systems inspires the younger generation to innovate in a way that will improve the military as a whole. For cadets at USAFA interested in pursuing aerospace medicine, he inspires the future of medicine from a broad point of view to improve the joint mission. After his efforts in the Joint sector, Lt Gen Robb became the first director of the newly developed Defense Health Agency. This integrated healthcare system across all services modernized medical care, allowing for effective patient care across all branches and better allow the services to focus on medical readiness. With the current national threats, it is more important than ever that our military is a medically ready force.

Learning Objectives

1. The audience will learn how Lt Gen Robb supported joint healthcare.
2. The audience will understand that Lt Gen Robbs education and military training prepared him to hold the high ranking jobs and positions that he had in his career.
3. The audience will understand Lt Gen Robbs impact on the future generation.

[390] ASMA PANEL ABSTRACT_USAFA GRADS_MAU_CADET KINKADE FINAL

Kimberly Kinkade
U.S. Air Force Academy, Colorado Springs, CO, United States

(Education - Program/Process Review)

BACKGROUND: The U.S. Air Force's newest 5th generation fighter aircraft, the F-35A, is one of the most advanced and capable fighter jets. Only 3.17% of all USAF fighter pilots were female in 2015. With these odds against her favor, Lt Col (ret) Christine "Grinder" Mau became the first female F-35A pilot on May 5, 2015. As a female pioneer in this airframe, she helped the aerospace medicine community understand the challenges to fit and equip this airframe. **OVERVIEW:** Growing up Southern California, Grinder continuously watched the Marine Corps station's aircraft. When her mother told her women could not do that "yet," it fueled her to work harder to become a fighter pilot. After she graduated USAFA in 1997, she excelled in pilot training and earned her place as an F-15E pilot. She was later a part of the 389th Expeditionary Fighter Squadron's first all-female combat sortie, providing air support to coalition and Afghan forces in Kunar Valley, Afghanistan. Competitive and thick skinned, she took Squadron Command at Seymour Johnson AFB, N.C. After 16 years and logging over 500 flight hours in the Strike Eagle, she become the 33rd Fighter Wing Operations Group Deputy Commander and the first female to fly an F-35A. Grinder flew F-35s for the rest of her career until retirement in 2017. **DISCUSSION:** Grinder's legacy opened the door for future female fighter pilots in 5th generation aircraft and initiated a diversity spike within the F-35 community. Grinder created the opportunity to study supersonic flight's physiological effects: how decompression sickness, reaction time, and motion sickness affect women specifically. Finally, by becoming the first female F-35A pilot, she proved that while gender should be considered by the aerospace miedical and aircrew flight equipment communities to improve their support of women fighter pilots, it does not indicate a pilot's flying abilities. Grinder states, "In order to get the best pilots, we need to recruit the best people. If we want to come up with the best solutions to problems and continue to be an innovative force, we need to have people who think differently and look at problems differently."

Learning Objectives
1. The audience will learn that Lt. Col. (ret) Mau helped the aerospace medicine community understand the challenges to fit and equip the F-35A airframe.
2. The audience will learn that Lt. Col. (ret) Mau created the opportunity to study supersonic flight's physiological effects: how decompression sickness, reaction time, and motion sickness affect women specifically.
3. The audience will learn how Lt. Col. (ret) Mau opened the door for future female fighter pilots.

[391] USAFA GRADUATE CONTRIBUTIONS TO AEROSPACE MEDICINE: DR. MARK MAVITY

Elizabeth Shearns
U.S. Air Force Academy, Colorado Springs, CO, United States

(Education - Program/Process Review)

BACKGROUND: Dr. Mark Mavity is a distinguished graduate of the United States Air Force Academy class of 1984 and received his Doctor of Medicine Degree in May 1988. He is board certified by the American Board of Preventative Medicine in the specialties of Aerospace Medicine and General Preventative Medicine and is a certified Physician Executive. He was a United States Air Force physician for 34 years and after retirement became the NASA Director of Health and Medical Systems. Additionally, he is a Chief Flight Surgeon with over 1400 flight hours in multiple aircraft. **OVERVIEW**: Of all Dr. Mavity's incredible achievements, his most notable work as the Command Surgeon for Air Forces Central Command from 2011-2013 and his work as a Special Assistant for the Invisible Wounds and Wounded Warrior Programs stands out as an inspiration the next generation of aerospace medicine specialists. As the Command Surgeon, he integrated multiple nations' health service support with a focus on sustaining the health of our forces, strengthening partner-nation military medicine capability, and shaping the stability of medical operations through these partners. His work in Invisible Wounds focused on removing barriers to care allow the care process to continue and create better environments for Airmen living with "invisible wounds." **DISCUSSION**: Dr. Mavity broadens our view of what such a long and hard-working career in medicine can be like in the Air Force. As he started from an intern to later a flight surgeon and command surgeon for these major regions, anyone would be captivated by the passion to continue medicine with programs like the Wounded Warrior Program and Invisible Wounds. Beyond working for ground level medicine, however, Dr. Mavity's work goes even further and allows the next generation to see where aerospace medicine can take them, from a flight surgeon to being the chief of aerospace medicine at different bases. The next generation is eager to follow his example with that same drive and investment towards new medical opportunities and advancements.

Learning Objectives
1. The audience will learn about Dr. Mavity's background in becoming a physician the United States Air Force as a physician.
2. The audience will learn about Dr. Mavity's contributions to medicine and aerospace medicine for the Air Force.
3. The audience will learn about how Dr. Mavity's contributions to aerospace medicine will inspire the next generation of physicians.

[392] USAFA GRADUATE CONTRIBUTIONS TO AEROSPACE MEDICINE: LT GEN (RET) HELMS; PIONEER. WARRIOR. LEADER. INNOVATOR.

Grace Newman
U.S. Air Force Academy, Colorado Springs, CO, United States

(Education - Program/Process Review)

BACKGROUND: Lieutenant General (ret) Helms commissioned from the U.S. Air Force Academy with an aeronautical engineering degree as one of the famous "80's ladies," the first graduating class to include females. She started her military career as an F-15 and F-16 flight test engineer then earned a Master's of Science in aeronautics and astronautics at Stanford University. She attended test pilot school then became a U.S. Air Force Exchange Officer Flight Test Engineer in Canada on the CF-18. Lt Gen Helms became an astronaut in July 1991, and was the first U.S. military woman in space and the first woman to serve on the International Space Station. During her time as an astronaut, she completed five space flights, served 211 total days in space, and performed a spacewalk of 8 hours and 56 minutes (a standing world record). Lt Gen Helms then returned to the Air Force and retired in 2014 as the commander for the Air Force Space Command and Joint Functional Component Command for Space. **OVERVIEW:** Lt Gen Helms stands out as an exemplary role model for all current aerospace medicine professionals and for the next generation. She is a fearless, servant leader and brilliant innovator, but also strives to show the younger generations that it does not take a superhuman to make history. As one of the first women to graduate from USAFA and one of a few women training for NASA in Russia, she displayed that competence and confidence can gain respect in difficult situations. Through her spacewalks and EVA training, she expanded our knowledge and tested the limits of the body. Her story and attitude can help others believe they, too, should be unafraid to attempt greatness. **DISCUSSION:** With her many "firsts", and as the world record holder of the longest spacewalk, General Helms is an inspiration to the next generation of women in STEM attempting to reach for the stars. Lt Gen Helms' story inspires by example, hopefully other graduates from USAFA and other woman in STEM, will pursue the field of aerospace medicine.

Learning Objectives
1. The audience will learn how Lt Gen Helms (ret.) contributed to aerospace medicine.
2. The audience will learn how Lt Gen Helms (ret.) contributed to the air and space forces.
3. The audience will learn how Lt Gen Helms (ret.) inspires women in STEM fields and the military.

Thursday, 05/25/2023 ***10:00 AM***
Napoleon C3

[S-72]: PANEL: EDUCATION IN SPACE MEDICINE

Chair: Dana Levin

PANEL OVERVIEW: *The past few years have seen a number of innovations in space medicine education. These innovations reflect a dramatic increase in interest in space medicine as well as the rapidly changing career environment of both government and commercial spaceflight around the world. This panel presents a sample of some of the most developed of these opportunities to highlight how the education space is preparing for the future. It is intended to help those interested in space medicine training learn about the new opportunities, understand the efforts to ensure quality and standards, and highlight the background and rising expertise of the trainees soon to enter the career space.*

[393] UTMB AEROSPACE MEDICINE RESIDENCY

Ronak Shah, Serena Aunon-Chancellor
UTMB, Galveston, TX, United States

(Education - Program/Process Review)

For nearly three decades, the Aerospace Medicine Division of the University of Texas Medical Branch has been training physicians to become experts in the field of Aerospace Medicine. The graduates of this Accreditation Council for Graduate Medical Education (ACGME) accredited program have provided support in all arenas of flight including the Federal Aviation Administration (FAA), National Aeronautics and Space Administration (NASA), Department of Defense (DoD) and more recently within the commercial space industry. From short duration to long duration flights, from domestic shuttle launches to international Soyuz launches, our alumni have been supporting the mission from operational, research, and managerial standpoints. The space industry is evolving and as such so has the strategic plan and vision of the Aerospace

Medicine Division of the University of Texas Medical Branch. By pulling on the expertise of its diverse leadership team and that of industry, the Aerospace Medicine Division aims to transform the content of its educational pathway. The result – Aerospace Medicine experts trained in a manner to help ensure the success of every human who endeavors to travel to the skies.

Learning Objectives

1. The participant will be able to describe the unique facets of the Aerospace Medicine Residency training at the University of Texas Medical Branch.
2. The participant will have a working knowledge of the curriculum of the Aerospace Medicine Residency training at the University of Texas Medical Branch.
3. The participant will understand the job opportunities available to graduates of the Aerospace Medicine Residency at the University of Texas Medical Branch.

[394] DEVELOPING ENGINEERING SKILLS FOR FUTURE HUMAN SPACEFLIGHT CLINICIANS

Benjamin Easter[1], Arian Anderson[1], Jay Lemery[1], Allison Anderson[2]

[1]*University of Colorado, Aurora, CO, United States;* [2]*University of Colorado, Boulder, CO, United States*

(Education - Program/Process Review)

BACKGROUND: NASA's Artemis Program plans to land the first woman and next man on the Moon by 2024. These missions are a prelude to a human mission to Mars, the most complex technological feat our species has ever contemplated. Such missions will involve challenges that push humans to the extremes of their physiology and psychology. Maintaining human health and performance under these circumstances will demand spacecraft engineering and design beyond any current precedent in human spaceflight. These challenges demand partnership between engineers, who are responsible for designing and building spacecraft and habitat medical systems, and clinicians, who will use the systems to provide care to the astronauts. Unfortunately, the integration of clinical and engineering expertise has, historically, been far from seamless. **OVERVIEW**: In response to this need, the University of Colorado created a first-of-its-kind interdisciplinary dual MD-MS degree program, in which students complete a 5-year program to obtain a medical degree and also a Masters of Science in Aerospace Engineering with a focus in bioastronautics. In addition to the traditional requirements of a medical degree, students complete an additional year focusing on aerospace engineering and bioastronautics, specifically studying space life sciences, spacecraft habitat design, systems engineering, life support systems, human operation of aerospace vehicles, extravehicular activity (EVA), and medicine in space and surface environments. In addition to this coursework, students have the opportunity to perform research via a thesis or develop hands-on engineering skills via a Graduate Project to design and build a mock-up of a human spacecraft. **DISCUSSION**: Traditionally, individuals working in aerospace human health and performance are formally trained in one of the encompassed disciplines (i.e., engineering or medicine) and then are introduced to the other through exposure on the job. The intent of this dual degree is to develop professionals with a unique perspective and greater capabilities to contribute to this rapidly advancing field. As clinicians with engineering expertise, they will be well positioned to lead future exploration missions and the expanding commercial spaceflight industry. This presentation will describe the background and goals of the dual degree program, the longitudinal curriculum, and plans for partnering with existing government, academic, and industry leaders.

Learning Objectives

1. The audience will describe the importance of both clinical and engineering expertise for success in human spaceflight.
2. The audience will describe an interdisciplinary curriculum for training physician-engineers.

[395] SPACE HEALTH FOR MEDICAL STUDENTS LAUNCHES IN MELBOURNE

Rowena Christiansen

University of Melbourne Medical School, Melbourne, Australia

(Education - Program/Process Review)

BACKGROUND: From 2022, the four-year University of Melbourne MD includes a linearly integrated 'Discovery Subject' stream alongside the core subjects and clinical school placements. "*Human Health in the Space Environment*" (12.5 points/100) was selected as one of seven initial flagship topics for MD1, and launched in March 2022 with 32 MD1 students (~10% of the cohort). As Topic Coordinator, the author curated the content and worked closely with learning designers to develop an engaging and interactive online learning experience using the 'flipped classroom' approach. The new course has been well-received by both students and faculty. **DESCRIPTION:** The course is presented as a seven-month mission, with a mission patch and ID badge. The 24-week curriculum is divided into systems-based blocks paralleling the MD1 core biomedical science subject: *Foundation, Cardiovascular, Respiratory, Gastrointestinal, Renal and Locomotor, Endocrine and Metabolism*, *Neuroscience*, and *Reproduction*. Students learn though exploring 'spacewalks' (EVAs), which draw on websites, videos, and publications from international space agencies and experts, and interactive tutorial activities. External engagement occurs through virtual 'Meet an Expert' sessions. The incorporated LEGO "*Build to Launch*" (Artemis I) program educates students about the teamwork and collaboration essential for successful space missions, and students experience a Challenger Center virtual mission. Translational space health is introduced through learning about spinoffs. The assessment tasks are designed to build the skills of the students in accessible public science communication, including group and individual presentations and videos, and a written article about space health. **DISCUSSION:** This innovative and unique new course provides an opportunity to introduce students to human physiology in extreme environments and aerospace medicine as a discipline. It also functions as a stepping-stone in training and building a future space-enabled workforce. It is hoped this initiative will lead to a four-year pathway in space health for MD students. An anonymous informal student survey (~50% response rate) indicated a core body of interest. Further subjects might include the challenges around clinical medicine and surgery in space, and translational space health. In MD4 Discovery, students will have the opportunity to undertake a major research project with potential for international collaboration and engagement.

Learning Objectives

1. Participants will learn about the role of 'Discovery Subjects' in the restructured University of Melbourne four-year MD program.
2. Participants will be introduced to the 'flipped classroom' approach to learning, and how it is integrated into the 'Canvas' Learning Management System platform for this new subject.
3. Participants will gain an awareness of how international aerospace medicine engagement is an essential part of learning about 'space health'.

[396] EDUCATIONAL NEEDS ASSESSMENT IN SPACE MEDICINE

Daniella Ortiz, Erik Antonsen, Amit Padaki, Mohammad Hirzallah, Dana Levin

Baylor College of Medicine, Houston, TX, United States

(Original Research)

INTRODUCTION: Space medicine is a rapidly evolving field that requires collaboration between many different disciplines. As the career adapts to fit the needs of new government and commercial programs it is critical that space medicine educators understand these needs to ensure their trainees are well prepared for the workforce. This study is a snap shot intended to highlight the current practice needs in space medicine and identify any gaps in present training. **METHODS:** A survey of current practice needs, utilization of past training, and training practitioners wish they had was distributed to healthcare providers currently working in support

of Space Medicine. Data from this survey was collected and analyzed. **RESULTS:** Key areas in current space medicine practice include; acute care, screening and prevention, engineering expertise, risk assessment, operational experience, administrative skills, clinical research, physiological research, psychological and performance research, human factors design, computational modelling, and epidemiological research. Not all areas of expertise are covered in current training programs. **DISCUSSION:** It is important for educators in space medicine to ensure that training requirements reflect the present and anticipated needs of the industry. The data from this study may be helpful in identifying the key skillsets asked of space medicine practitioners and guiding educational program design.

Learning Objectives

1. It is important to understand skillset needs in order to guide training.
2. Needs assessment surveys can help identify mismatches between skillsets and training.
3. What skillsets are important for healthcare providers in space medicine today and how does this compare to training curricula.

[397] DEVELOPMENT OF A GRADUATE MEDICAL EDUCATION PROGRAM FOR ACUTE CARE AND ENGINEERING IN SPACE MEDICINE

Dana Levin[1], Daniela Ortiz[1], N. Stuart Harris[2], Erik Antonsen[1]
[1]*Baylor College of Medicine, Houston, TX, United States;* [2]*Harvard MGH, Boston, MA, United States*

(Education - Program/Process Review)

BACKGROUND: The development of new government and commercial spaceflight programs has generated demand for space medicine practitioners with new skillsets. While preventive medicine is unquestionably a critical component of spaceflight safety, changes in the volume of flyers, their demographics, and the mission profiles have increased the need for practitioners skilled in acute care, disaster response, and engineering. Commercial entities have not found a sufficient supply of physicians with these skillsets and have begun training practitioners with internal programs to address this gap. It is important for the space medicine community to respond by developing standards and providing guidance to ensure trainees have comprehensive, sufficient, and high quality skills. **DESCRIPTION:** The Baylor College of Medicine – Harvard MGH Space Medicine Fellowship is one example of an interdisciplinary training program working to ensure these standards. This fellowship grew from discussions with industry and government partners to identify training needs. Following these discussions, a team of physicians with extensive clinical and operational experience in engineering, emergency medicine, aerospace medicine, wilderness medicine, hyperbaric medicine, education, and spaceflight operations was assembled. This team sought input from industry leaders, program directors and professional society leaders to develop a robust curriculum that meets industry needs and complements existing training pathways. Additional data to inform curriculum development was collected from a survey of current space medicine practitioners on required skillsets, past training, and desired knowledge. This presentation steps through the development process for this fellowship program to provide insight into the rationale for curriculum considerations and future directions. **DISCUSSION:** The degree of work required to develop new training programs to meet industry needs and academic standards is substantial. However, this effort is essential to ensure that providers are trained and held to sufficiently high standards to ensure astronaut safety. Baylor College of Medicine-Harvard MGH has taken on the work of developing these standards while working with other space medicine training programs and traditional preventive medicine programs.

Learning Objectives

1. The medical support needs of human spaceflight industry are changing rapidly and Industry would greatly benefit form the experience of Aerospace Medicine physicians.
2. Space medicine training programs must adapt their curricula to meet the new requirements of industry in order to ensure qualified candidates exist in in the workforce.

Thursday, 05/25/2023 ***10:00 AM***
Napoleon Ballroom A1-B3

[S-73]: PANEL: RESIDENT IN AEROSPACE MEDICINE (RAM) GRAND ROUNDS IV

Chair: Paul Newbold
Co-Chairs: Thomas Jarnot, Jonathan Elliot, David Miller

PANEL OVERVIEW: *Resident in Aerospace Medicine (RAM) Grand Rounds consists of 6 clinical case presentations. Each case is presented by current RAMs who will review the clinical case, diagnosis, treatment pathway and current policies from different agencies. The aviator's aeromedical disposition and waiver or special issuance outcome (if applicable) will be discussed. These unique case presentations describe clinical aviation medicine as well as policy updates for common medical and/or mental health conditions encountered in the practice of Aerospace Medicine.*

[398] CASE PRESENTATION: CHEST PAIN IN A PILOT

Catie Cole
Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: A 28-yr-old male developed typical chest pain and was diagnosed with myocardial infarction with non-obstructive coronary arteries (MINOCA) due to myocarditis. This presentation will discuss evaluation and diagnosis, as well as return to flight requirements for this case. **BACKGROUND:** While typical chest pain due to myocardial infarction is seen frequently in the emergency room, approximately 5-10% of these cases are unrelated to coronary artery disease. MINOCA is a diagnosis of myocardial infarction in which no substantial coronary artery stenosis is seen, defined as <50%. This disease can have a variety of different causes, with myocarditis found as an etiology via cardiac MRI (CMR) in approximately 30% of cases. Myocarditis can be caused by different sources of inflammation, with the most common being viruses such as Parvovirus B19, HHV 6, and Coxsackie virus. **CASE PRESENTATION:** A 28-yr-old male naval aviator presented to the ER with typical chest pain and was found to have ST elevations as well as positive troponins. On cardiac catheterization, however, no coronary artery disease was found. The patient had never experienced prior chest pain or shortness of breath, was not taking any medications or supplements, and was in excellent physical health with a high intensity exercise regimen. The patient was diagnosed with MINOCA and had a thorough laboratory, imaging and functional evaluation with full recovery. He was thought to have developed MINOCA due to myocarditis from an HHV 6 infection based on laboratory evaluation. He was cleared by multiple cardiology specialists after 6 months of rehab, monitoring, and workup and was granted a waiver to return to flight. **DISCUSSION:** This case highlights the importance of a thorough medical evaluation in patients with unusual findings. In addition, thorough evaluation of the literature, discussion with subject matter experts, and weighing the pros and cons of a flight waiver is critical in making an appropriate decision for return to flight. This decision making process allows for safe flight in the high reliability organization that is the US Navy.

Learning Objectives

1. Learn about MINOCA and workup of this condition through a case presentation format.
2. Learn about myocarditis and its association with specific viral infections.
3. Understand the aeromedical implications of myocardial infarction and myocarditis.

[399] INTRAOCULAR LENS REPLACEMENT IN A HIGH-PERFORMANCE FIGHTER PILOT: A CASE STUDY

Micah Rejcek, Clifford Nolt
U.S. Air Force, Wright-Patterson AFB, OH, United States

(Education - Case Study)

INTRODUCTION: This case report describes a fighter pilot who was diagnosed with cataracts and required intraocular lens replacement. This resulted in the first case of multifocal intraocular lens waiver approval in a U.S. Air Force fighter pilot. **BACKGROUND:** Cataracts are an opacity of the lens of an eye that cause blurred or distorted vision and glare problems and can progress to blindness. They frequently occur with advancing age, but contributing factors include poor nutrition, metabolic insults, exposure to sunlight and other radiation, trauma, and certain medications such as corticosteroids. In many patients, a myopic shift occurs due to an increase in refractive power of the lens and gradual progression to cataracts as opacities develop. The concern for aviation is worsening night vision, glare, and distance vision degradation with progression of disease. **CASE PRESENTATION**: A 41-yr-old male fighter pilot experienced subjective and objective worsening vision, and during his annual flight physical, he was referred to Optometry for evaluation. An initial diagnosis of cataracts was made at that time, and referral to Ophthalmology ensued. Recommendation of intraocular lens replacement was obtained by primary and secondary opinions. In separate surgeries 3 weeks apart, the aviator received multifocal lens implantation (Johnson and Johnson Model ZXR00). After subsequent recovery, and with recommendation by Ophthalmology, a waiver to return to flight status was pursued. No known associated factors for glaucoma were identified in this aviator. **DISCUSSION:** This case highlights a common age-related concern in our aviator community and recognition that frequently changing prescriptions with loss of distance vision can be a harbinger to cataract progression. Cataract lens replacement with mono-focal lenses has been approved since 1979, but multifocal lenses have not been approved until this case. Newer lens options offer many advantages, but historically did so at the expense of degraded contrast sensitivity, postoperative glare and halos at night, and loss of best corrected visual acuity. This case demonstrates excellent recovery, and the aviator's current state of ocular health demonstrates low risk of acute degradation; therefore, aeromedical waiver was recommended with an annual comprehensive eye exam.

Learning Objectives

1. Understand the natural progression and aviation risk factors of cataracts.
2. Understand early signs and symptoms of cataracts and safety concerns related to the flying community.

[400] INNER EAR BAROTRAUMA AND IMPLICATIONS ON AEROMEDICAL CLINICAL PRACTICE: A CASE REPORT

Karl Kuersteiner, Angel Perez
Naval Aerospace Medical Institute, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a Naval Aircrewman (Search and Rescue Swimmer Applicant) who presented to his flight surgeon after experiencing inner ear barotrauma during introductory mask clearing exercises at shallow depth, with clear clinical implications for practitioners in the primary care and aeromedical environment. **BACKGROUND:** Patients engaged in occupational or recreational activities which involve excursions through the barometric pressure continuum have various degrees of experience in mitigating pressure-related hazards. Following operational or training incidents, such patients may commonly seek care from clinicians who have received specialized training pertaining to their expected community exposures. Therefore, in many clinical settings the flight surgeon may be the primary contact with the healthcare delivery system who is best equipped for commencing appropriate and expeditious evaluation and treatment. **CASE PRESENTATION:** We are presenting the case of a 24-year-old Naval Aircrewman (Search and Rescue Swimmer Applicant) approximately seven days after experiencing sudden onset of hearing loss, vertigo, and nausea in the setting of repeated unsuccessful attempts to aggressively clear his dive mask at shallow underwater depth during his initial training evolutions. During the aircrewman's initial clinical evaluation, unilateral tympanic membrane erythema was noted and the member was referred to the Emergency Room where systemic steroids were commenced and a community Otorhinolaryngology (ENT) consultation was requested. After a week, the patient presented to ENT clinic. Formal audiometric testing was performed which was consistent with inner ear barotrauma, and follow-on management will be discussed. **DISCUSSION:** This case serves to highlight important and severe otologic manifestations of dysbarism. Optimal clinical actions include commencement of systemic corticosteroids for sudden hearing loss and early ENT referral for completion of audiometric testing and therapeutic steps to maximize the patient's chances of functional recovery.

Learning Objectives

1. The audience will review the pathophysiology and clinical presentation of inner ear barotrauma.
2. The audience will appreciate the role of correct and timely evaluation and management to minimize the patient's risk of adverse sequelae from inner ear barotrauma.
3. Attendees will consider how to complete the must-do emergency action items in the attendee's unique practice environment.

[401] SUPERIOR OBLIQUE MYOKYMIA IN A FAST-JET PILOT: A CASE STUDY

William Smith[1], Steven Nordeen[1], Joe Zhang[2]
[1]*U.S. Air Force, Wright-Patterson AFB, OH, United States;* [2]*U.S. Air Force, Langley AFB, VA, United States*

(Education - Case Study)

INTRODUCTION: This case describes a military aviator who experienced spontaneous eye twitching due to superior oblique myokymia (SOM). **BACKGROUND**: SOM is a rare eye condition typically affecting young, healthy adults and more often the right eye. Presenting symptoms include diplopia and oscillopsia (rotating images), making SOM aeromedically significant. Triggers include stress, fatigue, caffeine use, and heat. No definitive treatment has been identified, although some topical medications and microvascular decompression of the trochlear nerve have been used successfully. This case is believed to be the first described in an aviator. **CASE PRESENTATION**: This fast-jet aviator presented in his 30s with years of intermittent right eye twitching. He described a fluttering, upward twitch lasting seconds to minutes and not involving the eyelid or left eye. Symptoms worsened with stress and improved with blinking or changing ocular focus. He sought medical care due to an increased frequency of twitching and inability to self-resolve his symptoms. While he adapted to flying with the condition, he did admit to occasional diplopia looking downward and oscillopsia. He denied pain, headache, blurry vision, or other neurologic symptoms. Ocular history included bilateral photorefractive keratectomy, left eye laser retinopexy for a retinal hole without high-risk features, and prophylactic laser treatment of bilateral lattice degeneration. Neurologic and ophthalmologic workups were normal including electroencephalogram, slit lamp exam, and brain and orbital magnetic resonance imaging. After neuro-ophthalmologic evaluation, he was diagnosed with SOM and started a trial of timolol maleate 0.5% eye drops twice daily. The medication was discontinued after 3 mo without return of symptoms. The aviator reported being symptom free and was granted a waiver for single seat operations. **DISCUSSION**: SOM is a rare, but aeromedically significant disorder requiring careful consideration of the symptoms, treatment, and potential for incapacitation when making an aeromedical disposition. Although SOM is not specifically addressed in the military or civilian waiver guides, symptoms are disqualifying; therefore, return to flight decisions should be made only after careful evaluation of the precipitating factors and success of any treatments. In this case, the waiver authority considered the aviator's stability and demonstrated ability to accommodate in making the decision.

Learning Objectives

1. Ensure aerospace medicine clinicians consider superior oblique myokymia and other eye muscle disorders in their differential diagnosis when evaluating aviators with complaints of eye twitching.

2. Review the common considerations for superior oblique myokymia as it pertains to the aeromedical environment.

[402] BACKPAIN IN A DIFFERENT LIGHT: A RARE CAUSE OF ACUTE KIDNEY INJURY

Kristina O'Connor
U.S. Navy, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes a 36-year-old Marine helicopter pilot who presented to the aviation clinic with back pain and was subsequently diagnosed with acute kidney injury. **BACKGROUND:** Acute kidney injury is a relevant concern for young military members. Acute kidney injury can present in a variety of ways and has a broad differential. Appropriate work up, diagnostic clarity, and expeditious management of these cases can improve patient outcomes as well as improve overall safety in the aviation environment. Hypothyroidism is not on the common differential for causes of kidney injury but should be considered. **CASE PRESENTATION:** The subject pilot in this case is a 36-year male Marine, experienced helicopter pilot who presented to the aviation clinic with improving back pain and fatigue. Patient noted, "I felt similar to this when I was diagnosed with pancreatitis a few years back". He had completed a combat fitness test four days prior but did not note any muscle soreness. Patient's presentation and exam were unremarkable. Basic metabolic panel was ordered and revealed stage 3 acute kidney injury. The pilot was admitted to the hospital. The underlying cause of the patient's kidney injury was found to be hypothyroidism. Patient was immediately started on Synthroid and as his TSH normalized as his kidney injury resolved. The final diagnosis of hypothyroid induced acute kidney injury presented both aeromedical and military implications. A waiver for hypothyroidism was approved once all requirements were met. **DISCUSSION:** This case will discuss the broad differential of acute kidney injury as well as the inciting factor in this case and the aeromedical concerns. This presentation is intended for Aerospace Medicine Residents and Flight Surgeons.

Learning Objectives

1. The audience will learn about acute kidney injury through a review of physiology and the broad differential, including rare causes.
2. The participants will be familiar with the aeromedical concerns of acute kidney injury and hypothyroidism, and the waiver requirements for each.

[403] ASYMPTOMATIC ADULT DIAPHRAGMATIC HERNIA INCIDENTALLY FOUND DURING INITIAL FLYING PHYSICAL: A CASE STUDY

Isaac Yourison, Phillip Strawbridge
Residency in Aerospace Medicine, Dayton, OH, United States

(Education - Case Study)

INTRODUCTION: This case details a patient presenting for an initial flight physical to qualify as a remotely piloted aircraft (RPA) pilot who was incidentally found to have an asymptomatic anterior diaphragmatic hernia. **BACKGROUND:** Diaphragmatic hernias constitute a rare condition usually identified perinatally. However, a small number can either be unrecognized or do not fully manifest until adulthood. While not always causing an immediate concern for the patient, they could strangulate abdominal contents, leading to a surgical emergency. The timing of that pathology is unpredictable and, if uncorrected, poses a risk for sudden incapacitation incompatible with the risks of flying duties. **CASE PRESENTATION:** The applicant RPA pilot recently had COVID-19 and, incidental to that workup, underwent a chest X-ray that exhibited a thoracic mass later characterized on computed tomography to be a left-sided anterior diaphragmatic hernia. The patient had been previously unaware of this diagnosis, was experiencing no symptoms, and noted no functional limitations. The applicant was then referred to Cardiothoracic Surgery and underwent laparotomy and thoracostomy repair. His immediate recovery was complicated by a left-sided pneumothorax, acute kidney injury, and small bowel obstruction, all of which resolved upon hospital discharge without long-term sequalae. On follow-up, he was noted on computed tomography to have a small, fat-containing remnant hernia, remained asymptomatic, and had resumed his previous exercise activities absent any problems. He was therefore granted a 2-yr waiver for RPA pilot duties with scheduled follow-up to include physical exam, interim history, and spirometry. **DISCUSSION:** This case discusses anterior diaphragmatic hernia in adults, which is a rare condition often unrecognized by both the aviator and the flight surgeon. Symptoms are usually mild and non-specific, so they are often overlooked and only identified on incidental radiologic findings. Anterior diaphragmatic hernia can be managed with surgical correction from a variety of approaches. Given the rarity of this condition, there is a paucity of long-term follow-up data, and it is completely absent from the aeromedical literature. Most follow-up studies of diaphragmatic hernia are focused on congenital cases that are far more severe and have multi-organ involvement; therefore, they are of limited applicability in this case.

Learning Objectives

1. Describe the epidemiology and pathophysiology regarding non-traumatic/iatrogenic adult diaphragmatic hernias.
2. Describe management and aeromedical disposition of an aviator with an incidental diaphragmatic hernia.

Thursday, 05/25/2023 ***10:00 AM***
Nottoway & Oak Alley

[S-74]: POSTERS: CLINICAL MEDICINE & SAFETY POSTERS

[106] CERVICAL EXERCISE REGIMEN FOR PREVENTION AND MITIGATION OF ACUTE AND CHRONIC NECK PAIN IN HIGH-PERFORMANCE AIRCREW

Ryan Keller, Reece Rosenthal, Nicole Butler, Sawan Dalal, Jeffrey Jones
Baylor College of Medicine, Houston, TX, United States

(Original Research)

INTRODUCTION: Neck pain among aviators is a top 10 aeromedical concern for the United States Navy. High-performance jet aircraft (HPJA) and rotary-wing aircraft (RWA) aviators often experience acute and chronic neck pain as a result of heavy g-loading, abrupt head maneuvering, heavy and sophisticated helmet-mounted systems, and frequent flight hours. These demands impose high risk of cervical spine injury, leading to reduced range of motion (ROM), pain, loss of flight years, and possible disability. We hypothesize that by strengthening and stretching weak and fatigued neck musculature, aviators will adapt to the flight environment so that the long-term risk of neck pain may be decreased. **METHODS:** Aviators and civilians engaged in a 6-week program of five exercises (two sets/day, 10-15 reps, five days/week) using progressive band-loading principles on a head-mounted device. ROM and muscular endurance were measured at weeks 0, 3, and 6. Pain magnitude and frequency were self-reported weekly. Data were analyzed using non-parametric testing. Participants consented and enrolled either through a Naval Air Warfare Center Aircraft Division approved IRB or a Veterans Affairs approved IRB. **RESULTS:** Data was collected and analyzed (n=29). There was a significant ($p<0.001$) increase across all ROM and muscular endurance measures. In self-reported outcomes, improvements were noted in flexibility, strength, and stiffness, faster recovery time after flying, and decreased magnitude and frequency of pain. Usage of over-the-counter pain medication decreased. **DISCUSSION:** This collaboration between the DoD and academia demonstrated that consistent, specific cervical exercises with a

portable, head-mounted resistance band device can significantly improve cervical ROM and muscular endurance, with subjective improvement of neck pain, flexibility, strength, and stiffness. This may reduce long-term prevalence of cervical pain in aviators, lead to increased mission success, and decrease medical disqualifications. Strengths of the study are multi-aircraft involvement, epidemiologic data, and study of aviators and non-aviators. Limitations are small study size and limited female subjects. We recommend collaboration in developing an inter-service recommendation of cervical exercises for aviators.

Learning Objectives

1. Assess effects of a progressive head-mounted resistance band exercise regimen on cervical range of motion and muscular endurance
2. Summarize how a progressive head-mounted resistance band exercise regimen leads to subjective improvements in neck flexibility, strength, stiffness, and pain

[404] CONSIDERATIONS FOR USE OF COMMERCIAL WEARABLE PHYSIOLOGICAL MONITORING DEVICES IN AVIATION ENVIRONMENT

Veronika Puisa, Peter Hodkinson
King's College London, London, United Kingdom

(Education - Program/Process Review)

BACKGROUND: Fast jet pilots are subjected to stressors such as hypoxia, altitude exposure, acceleration, fatigue, physical and thermal strain. These stressors elicit physiological response as the body of a pilot adapts to unfamiliar environments. Physiological Episodes (PEs) occur when aircrew are physically impaired, experiencing decreased performance due to a variety of factors. Unexplained PEs occur when no identifying cause for such event is found. PEs have been identified as a cause for mishaps and mission or training failure on multiple high-performance fast jet aircraft. Lack of physiological monitoring and cockpit habitability are cited as shortfalls in addressing PEs. **OVERVIEW:** With the development of the latest generation of fast jet aircraft, the performance envelope of the aircraft surpasses the limits of human tolerance. Several militaries are registering PEs where the pilot is physically impaired and unable to perform their flying duties fully due to a variety of non-specific symptoms, including light-headedness, headache or confusion. In some cases, aircraft or pilot examinations do not reveal a particular cause for PEs which remain unexplained and suspected to be multifactorial. Inflight physiological monitoring could bridge this knowledge gap by directly tracking pilot responses to flight stressors and determining possible causes for PEs. Main challenges are large sensor systems interfering with flight duties, historical reliance on self-detection and reporting of symptoms, as well as lack of comprehensive inflight physiological data analysis. A way to address this issue could be by using wearable monitoring technology developed by the rapidly expanding fitness industry. Commercially available devices that utilise small and inexpensive sensors can provide data about the objective state of the human piloting the aircraft and supply data on actual physiological needs in certain environments. **DISCUSSION:** Commercially available wearable technology has a potential use in aeromedical research to help explore the nature of PEs and shed light on previously unexplored physiological states and adaptations, however it requires validation in aviation-relevant analogue environments. This can be followed by developing a dataset of parameter changes corresponding to a range of physiological states which can be further used in data analysis and implementation of AI solutions.

Learning Objectives

1. The audience will learn about a knowledge gap of what happens to human body in environments that are difficult to study using historically available sensors.
2. The participants will be invited to consider potential uses of commercial wearable technology in aeromedical research, particularly opportunities to gain data from previously inaccessible environments, such as inflight fast jet pilot monitoring.

[405] THE EFFECTS OF SHORT-TERM FASTING ON COGNITIVE FUNCTION IN AIRCREW

Mary Nimmer
Naval Medical Research Unit-Dayton, Dayton, OH, United States

(Education - Program/Process Review)

BACKGROUND: The U.S. Navy Flight Surgeon's Manual emphasizes proper pre-flight nutrition for aviators.[1] In Naval aviation, human error accounts for more than 80% of mishaps.[2] The Naval Safety Center cites aeromedical factors, including diet and hypoglycemia, as contributing to physiological events,[3] and aircrew have reported hunger and symptoms of low blood sugar prior to mishaps, such as runway overshoots and altitude deviations.[4] Reports are supported by research showing low blood sugar, including levels not severe enough to be clinical hypoglycemia, may affect cognitive performance,[5,6] and pilots may not recognize impairment until adverse effects have developed.[7] CNAF M-3710.7 offers the following guideline: "Failure to eat within 12 hours preceding end of flight may impair performance and ability to adequately control aircraft."[8] This presentation will evaluate research on short-term fasting and cognition to provide evidence for a more specific meal timing guideline. **OVERVIEW:** Fasting affects blood sugar, which may impact brain function, causing changes in cognitive performance, such as concentration, memory, and executive function. A literature review on fasting as it relates to cognitive demands of aircrew was conducted including the following keywords: *blood glucose, fasting, hypoglycemia, executive function, cognition, aviation*. Keywords were combined with "and" (i.e., "fasting and cognition"). Studies with healthy adult participants or those that artificially controlled blood glucose were included. Studies on long-term fasting, religious fasting, and standalone neuroimaging data were excluded. There is a lack of research relating fasting to aviator performance. Research in each domain—physiological and cognitive effects of fasting and cognitive demands of flight—will be presented. **DISCUSSION:** Short-term fasting may have negative impacts on cognition, posing hazards to pilot safety. While studies evaluating the relationship between fasting and cognitive ability have variable methodologies and mixed results, a pattern has emerged suggesting a relationship between fasting and decrements in cognitive ability.[9] Until research is available to better define how fasting impacts aviator ability, proper nutrition around cognitively demanding tasks such as flight is never detrimental.[9,10] A more precise nutrition recommendation for pilots may help optimize performance. This work is of interest to those who provide nutrition guidance to aviators.

Learning Objectives

1. The audience will learn about how the physiological and cognitive effects of fasting or meal skipping may impact aviator safety and performance.
2. The audience will learn about the current nutrition timing guideline for naval aviators and understand the evidence for a more specific recommendation.

[406] ALTITUDE DECOMPRESSION SICKNESS IN A MILITARY AIRCREW MEMBER DURING HYPOXIA TRAINING: A CASE REPORT

Tyler Koss
Naval Residency in Aerospace Medicine, Pensacola, FL, United States

(Education - Case Study)

INTRODUCTION: This case report describes the treatment of a military aircrew member who experienced altitude decompression sickness during a hypoxic training evolution in a military hypobaric chamber. **BACKGROUND:** Military service members regularly practice in austere environments that expose their bodies to extremes. One of the extremes experienced is hypobaric environments with flight. Knowledge of how to treat altitude decompression sickness is important for both special operators who regularly dive and for members of the aviation community. Altitude decompression sickness may range from lethal to

debilitating with potentially service limiting conditions if not appropriately treated. Timely recognition and initiation of treatment are important for all healthcare providers to understand. **CASE PRESENTATION:** This patient was a 24-year-old Active Duty male aircrew who was conducting altitude training in the hypobaric chamber to recognize symptoms of hypoxia. During the training, the service member reported experiencing acute left shoulder pain during the rapid alternation of altitudes up to 25,000 feet. He did not report the symptoms until a few hours later. His flight surgeon then directed him to the base's Emergency Department. He underwent medical evaluation and treatment. Pain was rated a 7 upon arrival and decreased to a 5 after receiving ground-level 100% oxygen via non-rebreather mask at 15L. His Flight Surgeon referred him for hyperbaric oxygen therapy (HBOT). Prior to HBOT, pain was a 4. Following a Navy Treatment table 6, he reported complete resolution of symptoms. **DISCUSSION:** This case highlights one of the most common symptoms experienced with altitude decompression sickness, joint pain, and the coordinated approach to treating servicemembers experiencing the condition. Understanding options for medical therapy is important to the aerospace medicine specialist to ensure timely intervention. Navy HBOT treatment tables are readily available but should be implemented only by those with appropriate medical competency given the medical risk versus benefit and logistical implications. From a non-operational medicine aspect, this treatment knowledge is important since recreational diving is a common hobby among servicemembers increasing the likelihood of physicians encountering this condition among their personnel.

Learning Objectives

1. Understand the most common clinical presentation of altitude decompression sickness.
2. Understand the treatment protocol for altitude decompression sickness and the need to identify the nearest treating chamber.

[407] INFLUENCE OF JOB ASSIGNMENT ON MELANOMA INCIDENCE IN COMMERCIAL AIRCREW: A META-ANALYSIS.

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(Original Research)

INTRODUCTION: Commercial cabin and cockpit aircrews are at increased cutaneous melanoma (MEL) risk versus teh general popualtion. Occupational and social factors have been invoked to explain this. However, the two groups work in on-board environments with different types/levels of potential exposures. Meta-analysis was conducted to address the hypothesis that differences exist in aircrew MEL risk based on location of in-aircraft job assignment, reflecting differential etiologic occupational exposures. **METHODS:** Medline was searched with the keywords "Cancer," "Aviation," and "Melanoma." Included studies: (1) primarily focused on cutaneous MEL; (2) were in commercial aircrew; (3) measured risk vs a general population; (4) measured risk by Standardized Incidence Ratio (SIR) with 95% confidence intervals (CI); (5) defined the gender distribution; and (7) defined cabin vs cockpit job assignment. Summary SIRs and CIs were calculated using maximum-likelihood, random effects meta-analysis. Values obtained were compared to one another using a z-test, with $p<0.05$ pre-specified for null hypothesis rejection. **RESULTS:** 6 primary studies were identified in the initial search. These were screened for other pertinent references. The secondary search yielded an additional 9 primary studies. For cabin crew, 10 study groups from 6 studies were included. 411,561 person-years of follow-up among 28,093 subjects (86% female) were included (SIR 2.18, 95% CI 1.83-2.60). For cockpit crew, data from 9 studies representing 830,670 person-years of follow-up among 45,986 subjects (1% female) were included (SIR 2.44, 95% CI 1.94-3.08). *z*-test for the difference indicated that the two SIR values were not statistically different ($z=0.77$, $p=0.441$). **DISCUSSION:** Though cockpit crew demonstrate an increased SIR vs cabin crew, this is not statistically significant. The difference may be explained by the far higher proportion of males among cockpit crew. These results suggest that job assignment to different locations within commercial aircraft does not influence MEL risk. Other factors, such as cosmic radiation, non-aircraft occupational exposures and avocational exposures, should be the targets of further assessment.

Learning Objectives

1. Appreciate the increased risk of melanoma among commercial flight crew, versus the general population.
2. Understand that a meta-analysis of existing data did not demonstrate an association between in-aircraft job assignment (cabin versus cockpit) and melanoma risk.
3. Be aware of alternative hypotheses for elevated melanoma risk in aircrew, including cosmic ray exposure, other occupational exposures, and avocational exposures.

[408] DUPILUMAB IN ASTHMATIC AND ALLERGIC AVIATORS: A CASE-SERIES

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(Original Research)

INTRODUCTION: Allergic or type 2 inflammatory diseases (T2I), such as asthma, chronic rhinosinusitis with nasal polyps (CRS) and eczema, affect ~10% of U.S. adults, including trained U.S. aviators and potential aviator recruits. These diseases are potentially impairing for aviators in flight, especially high-performance aviators (HPA) in single-seat jet aircraft exposed to dry air and high-G maneuvers without pilot backup should an incapacitating medical event occur. A novel FDA-approved therapy that blocks T2I, dupilumab, significantly improves these diseases, though it has not been aeromedically-approved for routine use by the USAF. We present a case-series of 4 aviators, 3 HPA and 1 rotary wing, with severe atopy, including CRS, asthma, and eczema indicating a need for dupilumab. 3 aviators agreed to treatment, 1 declined. We compare disease states between these aviators and review aeromedical implications. If dupilumab is proven to be effective and tolerated by USAF aviators, it could improve flight performance, deployability and retention of USAF aviators thereby maximizing mission effectiveness while reducing USAF medical and training costs, currently ~$5-10 million per HPA vs. $400,000 for 10 years of treatment with dupilumab. **RESULTS:** Two of three treated aviators and 1 control aviator were evaluated for follow-up since starting dupilumab. Significant subjective and objective improvements in atopy occurred in treated vs untreated aviators, including resolution of chronic anosmia within days of starting treatment, a 400cc increase in FEV1, and complete resolution of eczema vs worsening of CRS in control. Treated pilots flew over 100 hours without issue or side effects. **DISCUSSION:** Early results suggest dupilumab can improve atopy without flight impairment or significant side effects, mirroring FDA data, thereby reducing the need for sinus surgery under general anesthesia. If replicated, these data may suggest that dupliumab should be aeromedically-approved for USAF aviators without waiver. Also, many aviators with CRS and/or eczema also have asthma, suggesting a need for screening spirometry in aviators with CRS or eczema. **DISCLAIMER:** The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the Department of Defense or of the United States Air Force.

Learning Objectives

1. Attendees will learn the aeromedical and deployability concerns related to asthma, CRS, eczema, and dupilumab.
2. Attendees will learn to utilize the Aeromedical Consultation Service Medical Risk Assessment and Airworthiness Matrix (AMRAAM) for risk assessment pre and post-dupilumab treatment.

[409] ASSOCIATION BETWEEN GZ EXPOSURE AND DEGENERATIVE CERVICAL SPINE CHANGES AMONG FIGHTER PILOTS

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(Original Research)

INTRODUCTION: Fighter pilots' neck pain is usually associated with the degeneration of the cervical spine. However, the evidence of the effect of Gz exposure on cervical degeneration is conflicting. The aim of the study was to explore the association between cumulative G exposure and degenerative cervical spine changes among Finnish Air Force (FINAF) fighter pilots in a 5-year follow-up. **METHODS:** Cumulative +Gz exposure levels were measured using the fatigue Index (FI) of the aircraft. The degenerative changes of cervical spine (from C2 to T1) were assessed by magnetic resonance imaging (MRI). The study population consisted of 56 volunteered FINAF fighter pilots. The MRI examinations were collected at the baseline and after 5 years of follow-up. The intervertebral disc (IVD) degeneration sum score (Pfirmmann class 1-2=0p, 3=1p, 4=2p, 5=3p) was used to assess IVD degeneration. IVD herniations, kyphosis, scoliosis, spinal canal stenosis, Schmorl's nodes and Modic changes were also evaluated. **RESULTS:** The mean FI was 1.98 (±0.47) after follow-up. IVD degeneration sum score median was 1.5 (IQR 1-3) at baseline and 3 (IQR 2-5) at follow-up. There was no association between IVD degeneration progression and FI (0.11, p 0.42). The prevalence for herniations was 0.23 (±0.50) at baseline and 0.45 (±0.60) at follow-up. There was a negative correlation (-0.39, $p < 0.01$) between IVD herniation incidence and FI. The prevalence for kyphosis was 0.30 (±0.46) at baseline and 0.21 (±0.41) at follow-up. There was a positive correlation (0.36, < 0.01) between incidence of kyphosis and FI. **DISCUSSION:** IVD degeneration progressed significantly among study group with no correlation to individual FI scores. IVD herniations seemed to increase in numbers during follow-up however, the correlation with FI was negative. This could be caused by avoidance behavior in pilots with IVD herniations. The conflicting findings of the present study highlight the need of longer follow-ups and further research to reveal the possible association between the Gz exposure and degenerative cervical spine changes.

Learning Objectives

1. The audience will learn about the cervical spine degenerative changes among young men in 5-year follow-up.
2. The audience will learn about the relationship between G exposure and cervical spine degenerative changes.
3. The novel method of FI (measuring cumulative G exposure) will be presented to the audience.

[410] SUPERIOR SEMICIRCULAR CANAL DEHISCENCE IN A US MARINE CORPS F35B LIGHTNING PILOT: A CASE REPORT

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(Education - Case Study)

INTRODUCTION: This case report describes a U.S. Marine Corps F35B Lighting Pilot that was diagnosed with Superior Semicircular Canal Dehiscence. **BACKGROUND:** Superior Semicircular Canal Dehiscence (SSCD) is a rare condition caused by defects in the temporal bone that expose the superior semicircular canal to the brain cavity. Symptomatic patients experience pressure or sound-induced vertigo, conductive hearing loss and pulsatile tinnitus. To confirm the diagnosis, a patient must have clinical symptoms consistent with the disorder, documented hearing loss and a high-resolution CT scan showing SSCD. The treatment for some symptomatic patients is surgery to re-surface the bony covering of the canal. **CASE PRESENTATION:** The case patient was a 33yo M F35B pilot that presented with tinnitus, vertigo, and hearing loss that started while jogging. The vertigo resolved a few minutes after stopping the run and all symptoms resolved within 24 hours. A thorough physical exam was performed without significant findings. Additionally, an audiogram and an MRI of the brain were ordered and the patient was referred to otolaryngology. Five weeks later, the workup including MRI, audiogram and ENT consults were without abnormal findings. The patient was asymptomatic for five weeks and was returned to flight status. The pilot flew three flights in the F35B and on the third flight the patient experienced vertigo during a G warm up maneuver. The pilot was able to abort the flight and safely land. After return to medical, a high-resolution CT scan of the head was performed which showed a left superior semicircular canal dehiscence. The patient was successfully treated with surgery and eventually returned to service group 3 flight status. **DISCUSSION:** Inner ear pathology and its resultant incapacitation during flight operations is a serious concern. The symptoms of vertigo, sudden hearing loss, and tinnitus caused by SSCD are not compatible with flight. Superior Semicircular Canal Dehiscence is unique in that, with successful surgical intervention, patients may potentially return to flying duties.

Learning Objectives

1. Know the diagnostic criteria for Superior Semicircular Canal Dehiscence.
2. Know the best treatment option for a symptomatic patient wanting treatment.
3. Understand the aeromedical safety concerns associated with Superior Semicircular Canal Dehiscence.

[411] PREVALENCE TO OVERWEIGHT AND OBESITY AMONG GERMAN MILITARY PILOTS

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(Original Research)

INTRODUCTION: Overweight and obesity are associated with risk factors for several health constrains like cardiovascular disease and type 2 diabetes. Particularly in case of pilots, a poor physical condition can lead to withdrawal of the flight permit. Cardiovascular conditions are the most frequent cause for grounding pilots. This study investigates the prevalence to overweight and obesity among all active German military pilots. **METHODS:** The medical records of all German military pilots and candidates (n = 2123; 1.5% female; median age 35.9 years) who had medical examinations between 11.01.2017 and 10.30.2020 were consulted as part of this study. A retrospective view of the data followed; data were acquired usually in a three-year cycle during the mandatory periodical medical examination. Height and weight data were used to determine Body-Mass-Index (BMI). The prevalence determined by this method was compared with the prevalence of the general population. **RESULTS:** It was found that military pilots, like the general population, tend to overweight and obesity with age. It is particularly remarkable that the proportion of overweight military pilots in the youngest age cohort (18 – 29 years) is higher than in the general population. Subsequently, older military pilots have lower BMI than the general population. In addition, it has been noticed that the group of jet pilots has the lowest prevalence of overweight and obesity in comparison to fixed-wing and helicopter pilots. **DISCUSSION:** It is assumed that the obligation to have a higher physical fitness and to do sports on duty is a reason for a lower prevalence to overweight and obesity. Furthermore, German military pilots are provided with rations based on the recommendations of the German Nutrition Society (DGE). The above-average prevalence in the youngest cohort is explained by the lack of time for physical activity during pilot training and university study.

Learning Objectives

1. The participant will learn that German military pilots compared with the general population have a similar tendency to overweight, but less tendency to obesity.
2. The participant will learn that the prevalence of overweight and obesity in this special occupational group increases with age.

[412] WHAT'S UP WITH THAT TOE? A CASE REPORT

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(Education - Case Study)

INTRODUCTION: This case report describes a case of subungual exostosis originally diagnosed as a pyogenic granuloma in a young healthy female who had been having worsening foot pain and symptoms for over five months. **BACKGROUND**: Subungual exostosis is a rare cause

of toe pain and deformation. It's frequently misdiagnosed with the average time to definitive treatment being six months or longer. Depending on the severity of symptoms there are multiple potential duty limitations including the inability to fly as operating rudders could trigger intense pain. **CASE PRESENTATION:** This is the case of an 18-year-old who had a lesion on her right distal great toe underlying the nail which had been present and slowly enlarging over the last year. She had been having pain for the previous five months and had a tennis shoe chi meaning she was allowed to wear shoes instead of boots as her boots worsened her pain. The patient's initial diagnosis was a pyogenic granuloma, and she was referred to dermatology. A radiograph of the nail lesion demonstrated subungual exostosis and the patient underwent surgical excision performed by podiatry 2 weeks later. She had a full recovery and returned to duty 6 weeks postoperatively without restrictions. **DISCUSSION:** This case highlights subungual exostosis, a rare disease common in younger individuals with an average age of onset of 25. It can cause significant pain and disfiguration of the affected digit. It's frequently misdiagnosed causing prolonged symptoms. Radiographs of the affected digit are usually diagnostic for ruling in or out disease and surgical excision is curative with a very low recurrence rate. Knowledge of this rare but sometimes debilitating disease is important for prompt diagnosis and treatment to reduce unnecessarily extended grounding periods in aviators.

Learning Objectives

1. Recognition of subungual exostosis which is a rare but painful cause of toe pain.
2. Understanding treatment and expected recovery of subungual exostosis to decrease potential grounding time.

[413] THE INFLUENCE OF AIRCRAFT NOISE ON THE HEARING CAPACITY OF PILOTS DURING THEIR CAREER

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(Original Research)

INTRODUCTION: Modern military aircrafts are powerful and efficient yet generate high noise levels. Despite state-of-the-art aero engines and noise protection measures, sound pressure levels of over 91 dB (A) are still reachable in the cockpit, which could injure the hearing ability. This would evoke a reduced communication efficiency, a higher stress level, fatigue and especially a temporary and permanently hearing loss. To prevent this wearing a hearing protection, for example an otoplastic, during the flight duty, is necessary. The aim of the study was to analyze the audiograms of fixed wing aircraft, helicopter, and jet pilots to detect possible damage of the hearing capacity caused by noises during the flight duty. **METHODS:** The medical archive of the German Air Force Centre of Aerospace Medicine was accessed for data collection. To focus on all active pilots only subjects who had a periodic medical examination between Nov. 1, 2017, and Oct. 30, 2020, were regarded based in this analysis. Age, gender, particular aircraft type and the first and the last examination of hearing ability for each pilot during the career from 125 Hz up to 10,000 Hz were collected. For anonymous descriptive statistical analysis 1,748 subjects remained. In a comparison with DIN EN ISO 7029:2017-06, it was examined whether the pilots suffered hearing loss deviating from the age-differentiated norm hearing capacity. **RESULTS:** The results of the study showed the greatest decrease in hearing capacity among jet pilots, followed by helicopter pilots, and the least decrease among fixed wing aircraft pilots. However, despite the high intensity of noise exposure for the aircraft pilots, there was no clinical hearing loss in comparison to the norm hearing capacity in all age groups. In addition to these results the hearing ability during the flight career showed no clinical reduction overall. **CONCLUSIONS:** In summary, it can be stated that the high noise levels of the different aircraft types used by the German Armed Forces did not pose any danger to the hearing ability of the examined subject collective while using the provided hearing protection.

Learning Objectives

1. The audience will learn that in modern military aircraft there is still a very high level of noise exposure.
2. The audience will learn that with the hearing protection provided, the flight duty in modern military aircraft presents no danger to the pilots' hearing.

[414] AN OCCUPATIONAL LENS: INTEGRATING MULTI-THERAPEUTIC STRATEGIES TO OPTIMIZE PILOT PERFORMANCE AND WELL-BEING

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(Education - Program/Process Review)

BACKGROUND: There is limited awareness and understanding of the relationship between musculoskeletal workload, psychosocial workload, and flight performance among civilian and military pilots. Challenges of fatigue, sleep impairment, work related stress, and pain pose a threat on aviation safety and pilot quality of life. The future of aviation is contingent on the development of preventative countermeasures that exude evidence-based practice. An informal survey will be presented, using an occupational lens, to explore professional pilots' experience with risks in musculoskeletal functioning, mental health, and pilot well-being. **OVERVIEW:** Pre-habilitation programs are being implemented to improve chronic musculoskeletal symptomatology among military aircrew of various flight environments. However, there are limited therapeutic approaches in place that are capable of considering both the physical factors and the psych-social factors affecting flight performance. Both civilian and military multidisciplinary teams can utilize skilled therapy practitioners to conduct performance-based assessments, provide individualized therapeutic interventions, and optimize aviator performance. The evidence-based therapeutic interventions that will be discussed at greater length are within the scope of pre-habilitation services, airframe ergonomics, and health promotion programs. **DISCUSSION:** Training and operational flight performance is governed by complex interactions among the pilot, environment, and flight task. An overview of this project's proposed therapeutic interventions include:

- Identifying manual therapy techniques and modalities applicable to targeted population
- Providing injury prevention care to at-risk aviators *(ergonomic assessment/postural training; stretching/exercises; etc.)*
- Educating aviators on health management strategies *(pain management; work-life balance; sleep impairment; healthy aging; energy conservation strategies, etc.)*

Through education and training, therapeutic practice can be integrated into multidisciplinary teams to optimize human performance and pilot well-being among civilian and military aviation.

Learning Objectives

1. The audience will learn about therapeutic approaches capable of considering physical, psychosocial, and environmental factors among aviators.
2. The audience will learn about task analysis and performance-based therapeutic assessments to evaluate pilot well-being and risks for disability.
3. The audience will be able to understand the opportunities and obstacles associated with integrating skilled therapeutic practice in aerospace multidisciplinary teams.

[415] FIREFIGHTER SELF-CONTAINED BREATHING APPARATUS COMPARISON: ATMOSPHERIC VS MANUFACTURED COMPRESSED AIR USE DURING EXERTIONAL TRAINING

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(Education - Tutorial/Review)

INTRODUCTION: During the last few years some fire departments, spacecraft recovery & rescue teams, and other mission critical support personnel in both private & government sectors have switched from using traditional atmospheric compressed air (TACA, 20ppm H_2O) to manufactured air (MA, 2ppm H_2O) in their SCBAs (self-contained breathing apparatuses). MA is now utilized for job-related tasks, fitness testing, survival systems, and rescue operations. Understanding the full benefits and limitations to this recent technological shift is vital. **TOPIC:** Some firefighters have anecdotally reported post-exertional reactive airway symptoms while using MA during intense physical training which had not occurred previously with TACA. One potential mechanism is the tenfold decrease in MA moisture content exacerbated by increased exertional intensity. This study aims to evaluate the potential for lower moisture content to incite reactive airway symptoms & negatively impact human performance. Current literature shows that breathing cold & very dry traditional SCBA air during strenuous training negatively affects peak physical performance. Additionally, respirating through SCBA devices increases mechanical pulmonary system strain due to an increased work of breathing. These effects amplify with increased exertional intensity. However, no known studies exist addressing differences in utilizing MA over TACA. We intend to further elucidate any differences between TACA and MA use and provide additional insight on the necessity to solely respirate through an SCBA during rigorous training exercises where extended use may be detrimental to performance. **APPLICATION:** As advances in manufactured air provide convenient options for producing high-quality SCBA & life support system air, additional military, private aerospace, and local municipalities may begin to implement these technological advances in addition to the spacecraft recovery & rescue teams, fire departments, and other aerospace personnel currently using MA. Randomized controlled trials are needed to assess the full effects of utilizing MA versus TACA in mission-critical SCBA systems. If a significant effect from low moisture manufactured air is found, this may illustrate the need for a post-regulator humidification device. Additionally, these trials should evaluate the necessity for personnel to exclusively respirate through SCBAs during extremely strenuous training exercises and potential overtraining prevention.

Learning Objectives

1. Recognize differences between compressed air and atmospheric air regarding moisture content and the effect on respiratory physiology (TACA ≈20ppm, MA= 2ppm, and atmospheric air ≈20,000ppm). Inspiring cool extremely dry SCBA air can have negative performance impacts and lead to potential reactive airway symptoms during job-related tasks.
2. Gain understanding of the increased work of breathing mechanics while using SCBA systems to respirate during training or job-related duties. As a confined, user-actuated system activated by negative inspiratory pressures, SCBAs act as an extra-pulmonary obstructive device, exacerbated by increased demand for oxygen and rapid, deep inhalations in strenuous activity.
3. Acknowledge the limits of human ability when designing and executing training protocol given the intensity of the exercise, the constraints of the survival support system involved, and prepare for additional consequences of increased stressors in situations where reductions in training or job-related demands cannot be reduced.

[416] OPERATIONAL NECK PAIN QUESTIONNAIRE

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(Original Research)

INTRODUCTION: Military pilot neck pain is a common occurrence. To develop useful musculoskeletal models of neck pain development, one must know the operationally relevant, specific pain location(s), severity, character, and exacerbating or relieving conditions. **METHODS:** An anonymous, web-based questionnaire was developed, vetted, approved, and disseminated to military pilots. Pilots were asked to indicate pain contributing flight tasks, equipment, and maneuvers; the neck and upper back dull-aching and stinging-burning pain and 5-level severity at 14 locations; pain onset time, duration and relief; and three axis neck mobility. A weighted response numerical index was developed with an expert panel to classify severity. **RESULTS:** Fighter, helicopter and other fixed wing pilots submitted 110 responses. Bilateral moderate muscle pain (Level 3 of 5) in the 10 posterior muscle areas was most common (32%). Pilots (43%) reported neurogenic pain with a prevalent response of 17% moderate pain along the 10 posterior muscle areas. Pilots reported multiple muscle (72%) and nerve (36%) pain origin sites. Flexor muscles were indicated less than 5% for both pain types. Typically neck pain started within 30 minutes of flight (72% were already in pain), pain duration was less than 7 days, and pain relief was given by rest with OTC medications or by a chiropractor or physical therapist. For neck motion, 4% of pilots had complete, 33% very limited, 27% slight, and 36% had no restriction. For pain contribution, the helmet was the most indicated equipment followed by the night vision goggles then vest; maneuvers with head turning, high acceleration, and in combination predominated; and piloting and night vision goggle flight tasks predominated. The index scores were computed and divided into 5 severity ranges based on responses. The response scores showed a bimodal distribution with peaks at 53(mild) and 112 (moderate). **DISCUSSION:** This new tool/metric approach addresses significant flight-specific pain and differentiates between musculogenic and neurogenic pain by discrete location and severity which addresses the important questions of pain pattern, structural involvement and functional decrement beyond pain absence or presence. The index has potential medical use in tracking pain progression and treatment progress.

Learning Objectives

1. This index demonstrates the multifocal nature of operational pilot neck pain and that means in the medical community to assist in pain relief.
2. This index can provide a means for the pilot and physician to track pain treatment efficacy and progression.

[417] CONTINUING DEVELOPMENTS IN 5G TELEMEDICINE, TELEMENTORING, AND MEDICAL TRAINING FOR THE REMOTE WARRIOR

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(Education - Program/Process Review)

BACKGROUND: 5G is a vital strategic technology that the DoD must master to also touch every operational mission of military medicine. Since June 2020, the Office of the Undersecretary of Defense (Research & Engineering) has established Joint Base San Antonio (JBSA) as a testing site to leverage 5G augmented and virtual reality (AR)/(VR) support for Military Health System (MHS) telemetoring and medical training. The Defense Health Agency understands that utilizing AR/VR is a means for enhancing in-garrison readiness and improving global medical training. Progress with 5G core development has shaped several JBSA Objective activities/scenarios to provide realistic experiments with commercially available solutions that when 5G-enabled will take advantage of augmented network characteristics to measurably improve healthcare to save lives. **OVERVIEW:** Phased experimental processes with civilian partners and MHS Virtual Medical (Operational) Centers help shape key component issues/concerns brought up by the JBSA Medical Steering Committee regarding remote warrior care. The Medical Training Prototype addresses frequent battlefield injury/illness scenario recognition, treatment, and tracking with scalable student performance measures. End-user participant access/availability increases while maximizing limited training resources for efficient and effective readiness training.

Telementoring applies AR combined with 3-D real-time interactive digital content overlaying physical space, physiological data sensor reports, high-definition video, digital imaging, and accessible electronic health records to provide remote medical healthcare providers with enhanced clinical situational awareness to supplement on-site care delivery. The likely decreased response time to diagnosis/treat enabled by this technology will measurably reduce casualty morbidity/mortality. **DISCUSSION:** Mission demands, tech applications, or remote care under 5G enhancements create different challenges than those under 4G concepts. JBSA's utmost outcomes are to leverage 5G applications/equipment that will require seamless transition into appropriate DoD medical support missions to cover all global domains. Network solutions must ensure record data security and improve efficiency to allow effective training, proficiency, or competency for military medics. This presentation provides further awareness for the phases of current JBSA experiments in 5G Telementoring and Medical Training for the remote warrior.

Learning Objectives

1. Participants will be able Identify and describe gaps to link medical support initiatives and strategies involved utilizing 5G technology in learning and training performance to enhance the support of remote military medical personnel.
2. Participants will be able to provide and share initiatives and strategies with JBSA consultants involved in learning and improving training performance tools/applications, which will enhance operational care activities of the military medic.
3. The audience will understand the need to maintain an awareness of 5G capabilities projects; focus on risk reduction or mitigation for record/imaging access; and formulate a continuing gameplan to enhance medical support capabilities while working within resource-limited environments.

[418] INHIBITION OF MITOCHONDRIAL SUPEROXIDE OR NITRIC OXIDE DELAYS SEIZURES IN RATS EXPOSED TO HYPERBARIC OXYGEN: THE GOOD NEWS/BAD NEWS

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WITHDRAWN

[419] HUMAN FACTORS CLASSIFICATION USAGE AND RECOMMENDATION INCLUSION IN USAF MISHAPS

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(Original Research)

INTRODUCTION: The United Stated Air Force (USAF) aims to enhance the safety of aviation through mishap analysis and recommendations. The USAF uses the Department of Defense Human Factors Analysis and Classification System (DoD HFACS) as a tool to provide a framework for identifying and capturing the human factors involved. Anecdotal evidence suggested that HFACS usage and inclusions of recommendations decreased as severity of mishap decreased. This study was undertaken to explore HFACS coding trends and relationship with recommenations. **METHODS:** Used five years of aviation mishap reports (Class A – D, N=7376) to conduct frequency analysis of HFACS usage and recommendations for all aviation mishaps. Compared numbers of HFACS codes included per mishap by class and reports that did not include recommendations by class. Analyzed reports that included at least one human factor but did not include recommendations for trends. **RESULTS:** As mishap class severity decreased (from A to D), the percentage of reports without recommendations increased (from 7.4% to 93.2%). For class C and D mishaps, reports that coded Act and Precondition level human factors were more likely to omit recommendations compared to reports that coded Supervision and Organization level human factors. **DISCUSSION:** Differences between investigative team composition may be impacting HFACS usage. Class A and B mishaps typically have larger investigative teams that frequently include human factors subject matter experts compared to class C and D mishaps. Advertising the availability for human factors consultation may improve the robustness of HFACS classification in class C and D mishap reports. 81.6% of Class C and 93.2% of Class D mishap investigations did not include recommendations. Class C and D investigations that identified at least one human factor in the Act or Precondition bins are more likely to omit recommendations compared to investigations that identified at least one Supervision or Organizational human factor. This suggests it may be inherently more difficult to draft recommendations for human factors pertaining to the person level (e.g., decision making error, performance error, state of mind, mental awareness, physical problem) or environmental factors (e.g., physical, technological). This may indicate an ongoing prevalence of the "old view" of human error. Overall, more research is needed to determine the range of reasons investigators chose not to include recommendations.

Learning Objectives

1. The participant will be able to understand the trends identified in HFACS usage in recent safety investigative reports.
2. The participant will understand the relationship between HFACS codes and inclusion/omission of recommendations in recent safety investigation reports.

[420] THE ROLE OF DAY- AND NIGHTTIME CONDITIONS IN LASER ILLUMINATION OF AIRCRAFT: RESULTS OF A RISK FACTOR ANALYSIS FOR THE LOS ANGELES AREA 2010-2019

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(Original Research)

BACKGROUND: Despite reduced numbers of flights due to the COVID19 pandemia, laser attacks on aircraft continue to increase. By the year 2021, the FAA recorded the highest event rate ever documented for the US, with the city of Los Angeles representing one of the hotspots of occurrences. In this study, we investigated the endemic event rates in this area according to day- and nighttime including twilight conditions. **METHODS**: Laser events from 2010 to 2019 were extracted from the public database as provided by the FAA and retrospectively (re)transformed into local time data. Historical data were set into relation to sunrise, sunset and moonlight conditions, including subdividing in astronomically precise twilight phases and statistical adjustment for local daylight saving times. Since all events were recorded in the hours/minutes format, the overall precision of calculation per astrophysical event was about 1 min. Astronomical terms and conditions were defined as given by the United States Naval Observatory (USNO). **RESULTS**: A total of 1407 laser events was identified for the Los Angeles airport area. Of these, 636 events (45,2%) were allocated to night, 235 (16.7%) to twilight, and 537 (38.1%) to daylight conditions. Substratification of twilight incidences showed that most laser events occurred at astronomical twilight (6,6%), while nautical and civil twilight lasers were less frequent (6.3% and 3.8%). Taken together, laser activities were significantly higher during sunset than at sunrise. Moonlight had no significant effect on event rates. **DISCUSSION**: Our results unmask a considerable rate of laser strikes under daylight conditions which has not been observed in previous reports. The most convincing explanation of this observation is the increased visibility of stronger laser devices including blue, white, and multicolor types of lasers that enable tracking of aircraft even under normal light conditions.

CONCLUSIONS: Although low-light conditions including the transition phases between day and night are still the preferred times for outdoor use of laser pointers, daytime illumination of aircraft appears to increase. Given the much higher air traffic at daytime, this may indicate the need of public health intervention even in areas where the sun keeps shining most of the day.

Learning Objectives

1. The audients will learn about the flight safety hazards of aircraft illumination by laserpointers.
2. Participants will learn about the environmental light conditions that are preferred by perpretrators for illumination of aircraft.

[421] SAFE TO FLY? A DOUBLE-BLIND PLACEBO-CONTROLLED CROSSOVER STUDY ON MODAFINIL AS A MODEL TO EXAMINE INSIGHT IN FATIGUE SELF-AWARENESS.

Martine Van Puyvelde, Jeroen Van Cutsem, Xavier Neyt, Nathalie Pattyn
Royal Military Academy, Brussels, Belgium

(Original Research)

INTRODUCTION: Pilot fatigue still accounts for 15-20% of fatal flight accidents and its impact is often under-detected by the affected subject. A well-known medical countermeasure is "modafinil", meant to use for maintenance or recovery of wakefulness, alertness, and cognitive performance when sleep deprived. However, intake may be non-effective when self-awareness about fatigue is not optimal. Moreover, it is not yet clear whether modafinil-intake has an impact on this awareness itself. **METHOD**: We conducted 1/an in-depth systematic review of the use of modafinil in sleep deprived and non-sleep deprived subjects (i.e., as a cognitive enhancer or smart drug) and 2/a double-blind placebo-controlled crossover study (2 x 200 mg Modafinil for test period 1 and placebo for period 2; $n = 11$ healthy pilot students) to examine the awareness of fatigue and sleepiness in terms of safe-to-fly estimation and pre/post-test confidence ratings during one night sleep deprivation in a modafinil and placebo condition. Subjective measures were compared with objective psychomotor vigilance (PVT). **RESULTS:** Two-factor repeated measures ANOVAs showed a significant higher vigilance after modafinil-intake compared to placebo during circadian nadir time-points (i.e., 02AM, 04AM, 06AM) ($p = .016$); although in both conditions, vigilance loss was present. After modafinil, confidence significantly increased pre-testing ($p = .013$) immediately after modafinil intake and during nadir hours (whereas there was a decrease in performance). Both after placebo and modafinil, despite performance decreases during nadir-hours, participants indicated that they were safe to fly in 77% (after placebo) and 93% (after modafinil) of nadir time-points. **DISCUSSION:** Modafinil has a beneficial effect on PVT-performances during nadir hours when sleep deprived. However, over-confidence and self-awareness concerning safe-to-fly conditions need to be thoroughly examined and self-awareness training should be implemented in future Fatigue Risk Management Systems. The fact that self-awareness is easily affected may lead to an over-use of modafinil to "be on the safe side". The systematic review, indeed, documented abuse of modafinil as a(n) (ineffective) smart drug in non-military populations; hence, a caveat for military populations. Moreover, the use of modafinil should be individually tailored in function of military profiles, performance level and task characteristics.

Learning Objectives

1. The audience will learn about pilot fatigue self-awareness, the impact of modafinil on it and the importance to implement fatigue self-awareness in future Fatigue Risk Management Systems.
2. The audience will learn about the effect of modafinil when used as a countermeasure against fatigue and sleepiness when sleep deprived versus as a cognitive enhancer without being sleep deprived.

Thursday, 05/25/2023 ***1:30 PM***
Grand Ballroom A-B-C

[S-75]: SLIDES: NASCENT SPACE MEDICINE CHALLENGES

Chair: Jeff Myers
Co-Chair: Adam Lam

[422] CARDIOVASCULAR PRESSURE RESPONSES TO MICROGRAVITY: A REVIEW

Riley Ferguson[1], George Pantalos[2]
[1]*University of Cincinnati College of Medicine, Cincinnati, OH, United States;*
[2]*University of Louisville, Louisville, KY, United States*

(Education - Program/Process Review)

BACKGROUND: It is widely accepted that central venous pressure (CVP) decreases with acute and chronic microgravity exposure. However, the mechanisms regulating this shift remain debated. Specifically, reduced load not only on the thoracic tissues, but throughout the endovascular system allowing for increased tissue expansion has been implicated. However, the role of an orthostatic "set point" adaptation as the body is exposed to long-duration spaceflight remains unclear. Here, we chronicle the most significant past experiments and publications contributing to our current understanding of cardiovascular adaptations in space. Our goal is to illuminate the current gaps in our understanding of this physiologic relationship to provide guidance for future research endeavors. **OVERVIEW:** The initial query using PubMed MEsH terms "Central Venous Pressure" and "Microgravity," "Spaceflight," and "Weightlessness" returned 131 results. 13 results were excluded as they were not available in English. 67 of these articles had their full manuscript accessible and a further 12 were excluded as they used only animal models, head-down tilt table studies, were experimenting with a specific countermeasure, or were determined to be beyond the scope of this review. True weightlessness simulations were preferred for their similarity to the long-term space environment. A remaining 55 total articles were fully accessible, ranged in date from 1969 to 2022, and were included in the review. **DISCUSSION:** As the number of humans traveling to space increases, in addition to the increased range and duration of exploration-class missions, so too does our need for effective countermeasures for space-associated pathologies, including the development of procedural and surgical interventions. In order to create procedural or surgical capability, better understanding of CVP in microgravity is required for the correct management of circulating fluid volume. In addition, once astronauts return to partial or full gravity environments, elucidation of the CVP and arterial pressure regulation mechanism will aid in combating debilitating orthostatic hypotension upon landing. These hemodynamic responses reveal fundamental physiologic relationships which are ultimately applicable across military, civilian, and commercial space medicine.

Learning Objectives

1. Review of theories of cardiovascular responses in acute and chronic microgravity.
2. Discuss potential countermeasures for 'set point' adaptations causing orthostatic hypotension.

[423] PREPARATION FOR A SUBORBITAL, HUMAN-TENDED EVALUATION OF MEDICAL TECHNOLOGY

George Pantalos, Sienna Shacklette, Brooke Barrow, Dalton Aubrey, Kessalyn Kelly, Erica Sutton, Michael Ray, Thomas Roussel
University of Louisville, Louisville, KY, United States

(Original Research)

INTRODUCTION: 2021 ushered in the era of passengers on commercial suborbital spacecraft. In anticipation of suborbital flights with researchers interacting with experiments during the 3-minute period of

μ-g, we have conducted ground and parabolic flight-based evaluations of investigator performance and safety. **METHODS:** A surgical system for reduced gravity was evaluated where the researcher performed several surgical tasks in a scripted sequence. Bleeding wound models inside a glovebox enabled interactive experiments during suborbital flight, where the investigator accessed the experiment through one of three pairs of sleeved arm access ports, mimicking flight in either Virgin Galactic's SpaceShipTwo or in Blue Origin's New Shepard. It was assumed the researcher will work alone during suborbital flight, attempting up to 25 surgical tasks. Other project team members observed and provided sequence prompts, minimizing their involvement in the parabolic flight procedures. A second set of evaluations took place in high-fidelity mock-ups of the suborbital spacecraft cabins with the glovebox mounted inside. Researcher movement was considered by an astronaut trainer and a human factors/safety engineer for how and when to leave their seat, position themselves by the glovebox, protocol task performance, glovebox preparation for re-entry, and return to seat. Evaluations considered room for and ease of movement to and from the glovebox, time available for productive work in microgravity, and potential for improvement of the research environment. Attention was given to the physical hazards present, ergonomic efficacy, environmental compatibility, mental stressors, and communications. **RESULTS**: Parabolic flights were conducted in May 2021 and in May 2022, and four surgeons performed scripted tasks for 15 parabolas in both spacecraft configurations. Typically, 15 surgical tasks were successfully completed. Ease of task performance varied with the location of surgical system components inside the glovebox. Suborbital spacecraft in-cabin evaluation emphasized safe movement and investigator restraint was well as efficient choreography of task flow and pre-flight rehearsal to maximize productivity. **DISCUSSION**: With careful planning and prior experience working in reduced gravity, a researcher will be able to successfully and safely accomplish many sequential and intricate research tasks in the extended microgravity of suborbital space flight. [NASA T0287-P, 80NSSC21K0359]

Learning Objectives

1. The audience will learn about the current opportunities to conduct human-tended suborbital flight research activities.
2. The audience will learn about the challenges and strategies for the researcher to safely and effectively conduct involved, interactive research experiments during suborbital flight.
3. The audience will learn about preparations for a human-tended suborbital flight by conducting simulation procedures during the reduced gravity of parabolic flight and inside the cabin of suborbital spacecraft.

[424] STANDARDIZATION OF THE COMMERCIAL ASTRONAUT

Mark Bourne, Susanna Gebhardt, Riley Ferguson
University of Cincinnati College of Medicine, Cincinnati, OH, United States

(Education - Program/Process Review)

BACKGROUND: With the advent of commercial spaceflight, more civilian astronauts, or spaceflight participants (SFP), are being launched into lower earth orbit and beyond. As commercial spaceflight becomes increasingly accessible to civilian participants, the question of formal safety regulation is paramount. The success of any future medical standards or screening guidelines hinges on the availability of evidence-based methods for evaluating physiological and psychological fitness of potential SFPs. This literature review explores the commonalities and differences between all currently published medical standards and screenings for SPFs, and the viability for their adaptation into a standardized, industry-wide guideline for the commercial spaceflight industry. **OVERVIEW:** We initially searched ResearchGate with query terms "(commercial AND spaceflight) AND (medical OR screening OR standards) AND (civilian OR participant OR passenger)" yielding 24 publications matching search criteria, of which 18 were deemed relevant and included for revision. An additional 6 publications were found as relevant citations. There are published medical standards and screenings for SFPs in use by the U.S. National Aeronautics and Space Administration (NASA) and the International Space Station (ISS), as well as guidelines and screening tools compiled by the U.S. Department of Transportation (USDoT) and Federal Aviation Administration (FAA), Aerospace Medical Association (AsMA), Center of Excellence for Commercial Space Transportation (COECST), University of Texas Medical Branch (UTMB), International Academy of Astronautics (IAA), and International Association for the Advancement of Space Safety (IAASS), among others. All frameworks are concerned with minimizing the risk of adverse events during spaceflight by prevention, but differ in their approach to medical screenings in a variety of measures. **DISCUSSION:** There is no set standard with regard to medical screening for SFPs across the commercial spaceflight industry, though many frameworks have been proposed, and some evaluated experimentally. Establishing consistent guidelines for pre-flight medical requirements across government and commercial spaceflight is ultimately in the best interest of passenger safety and reduces liability. Through this review, we suggest an actionable framework for the creation of a uniform SPF medical evaluation in all spaceflight endeavors.

Learning Objectives

1. Explore the benefit of a standard medical screening for potential commercial space flight participants to minimize risk of adverse events.
2. Discuss compilation of currently proposed guidelines addressing medical screening standards for commercial space flight participants.

[425] LONG DURATION MEDICAL SYSTEM FOUNDATION FOR LUNAR ORBITAL AND LUNAR SURFACE EXPLORATION MISSIONS

Jay Lemery[1], Ben Easter[1], Kris Lehnhardt[1], Sarah Arai[2], Christopher Laing[3], Mike Krihak[5], John Odina[6], Kerry McGuire[6]
[1]*NASA Exploration Medical Capabilities, Houston, TX, United States;* [2]*Leidos, Houston, TX, United States;* [3]*Analytical Mechanical Associates, Hampton, VA, United States;* [5]*KBR, Houston, TX, United States;* [6]*NASA, Houston, TX, United States*

(Education - Program/Process Review)

BACKGROUND: For long-duration lunar orbital and lunar surface (LDLOS) exploration missions, the NASA Human Research Program (HRP) Exploration Medical Capability (ExMC) Element has developed a medical system foundation through which clinical considerations may be represented via a systems engineering-based model. **OVERVIEW**: Components of the Long Duration Medical System Foundation model include a concept of operations (ConOps), functional decomposition, medical conditions to be addressed, clinical capabilities and resources, technical requirements, and traces of requirements to NASA standards documents and parent-level (Program- and Vehicle habitat system-level) requirements. The Foundation model offers the means to present information in a readily accessible format that is understandable across all clinical, engineering, scientific, and managerial disciplines. Collectively, these components constitute a foundation that serves future programs with similar long duration mission profiles as a starting point for medical system design. **DISCUSSION:** The Foundation was developed by a multidisciplinary team of systems engineers, scientists, and clinicians across NASA. The process started with ConOps development, subsequently decomposed into the functionalities needed to diagnose, treat, and prevent medical conditions. The clinical team identified medical conditions most likely needed to be diagnosed and treated during a long-duration lunar exploration mission. Through these approaches, requirements were codified for the LDLOS medical system. These requirements were then traced to NASA standards, medical conditions, medical capabilities, and medical resources, facilitating stakeholders' use of the Foundation model to analyze traces and to identify medical system interfaces with other vehicle systems or subsystems. In addition, the Foundation may be used as a basis for performing risk trades on medical system mass and volume allocation. This discussion will focus on the processes through which the LDLOS Medical System Foundation was developed, how the Foundation

builds a bridge between the medical and engineering domains, and how these processes may be applied more broadly to a crew health and performance system and other system domains.

Learning Objectives

1. Understand the rationale and strategy for establishing foundation models for future missions.
2. Understand how foundation models trace NASA standards to establish model requirements.
3. Understand how foundation models may build a bridge between the medical and engineering domains, and how these processes may be applied more broadly to a crew health and performance system and other system domains.

[426] DESIGN FOR TRUST AND TRUSTWORTHINESS OF FUTURE SPACE MEDICAL SYSTEMS IN HUMAN-AGENT TEAMING: A TRANSDISCIPLINARY APPROACH

Anna Berenika Wojdecka[1-2], Don Platt[2], Rhonda Lyons[3], Ondrej Doule[2], Aldo Fabregas[2], Tibor Balint[1], K. Jeffrey Myers[4]
[1]*Royal College of Art, Pasadena, CA, United States;* [2]*Florida Institute of Technology, Melbourne, FL, United States;* [3]*NYRAD, Inc., Melbourne, FL, United States;* [4]*University of Florida, Gainesville, FL, United States*

(Original Research)

INTRODUCTION: Exploration-class missions and future commercial space stations will require increased medical autonomy from earth-based support. Integrating emerging technologies, including machine agents and robotics, can open new pathways to crew self-reliance in medical decision-making, just-in-time training, and treatment delivery by enabling the shift towards astronauts working together with smart agents as Cyber-Physical-Human (CPH) teams. The design of new CPH-teams-oriented system architecture will require involving a wide range of stakeholder perspectives in a transdisciplinary approach. Incorporating human-centered design considerations alongside the optimization of occupied mass, volume, and reliability will play a crucial role in designing-in trust within the agent-crew interactions and facilitating a synergistic human-agent collaboration, maximizing safety and minimizing mission risks. **METHODS:** Within a human-centered design approach, we conducted expert interviews, design workshops and reviewed the state of the art. Twenty-five Subject Matter Experts (SMEs) participated in two rounds of qualitative interviews, focusing on identifying challenges and opportunities related to astronaut medical systems and defining trust components within agent-crew interactions. The SMEs represented diverse backgrounds and expertise: Space Medicine (Flight Surgeons, Exploration and Emergency Medicine), Astronauts and Training (public and private sector), Space Systems and Engineering, Architecture and Human Factors, Computing and Human-Computer Interaction. **RESULTS:** Thematic analysis of the interviews highlighted key themes around trust, challenges of medical interfaces, and performance gaps, which we present in the context of three dimensions of trust: human>agent, agent>human, and agent>database. A preliminary high-level model of future space system architecture has been developed, which illustrates data flow within the proposed Exploration Medical Ecosystem Infrastructure (ExMEDI), including the identified key data input sources. **DISCUSSION:** The results stress the importance of the interaction design in building trust relationships. Our next steps involve an iterative design of the agent-team interface of the ExMEDI clinical decision support to facilitate autonomy. Key opportunity areas of focus include the dynamic context-aware interfaces, design for medical privacy, shared decision-making, and explainability of the interface through visualizing risks.

Learning Objectives

1. The audience will learn about the identified key themes around trust, challenges of medical interfaces, and performance gaps, which we present in the context of three dimensions of trust.
2. The audience will learn about the developed preliminary high-level model of future CPH-teams-oriented space system architecture.

[427] INVESTIGATING THE POTENTIAL FOR PARASTRONAUTS: SUPPORT FOR THE ESA PARASTRONAUT PROJECT

Irene Di Giulio[1], Ryan Anderton[2], Stephen Harridge[1], Peter Hodkinson[1], Marco Narici[3], Ross Pollock[1], Jörn Rittweger[4], Thomas Smith[1], Mike Miller-Smith[5]
[1]*King's College London, London, United Kingdom;* [2]*UK Civil Aviation Authority, Crawley, United Kingdom;* [3]*University of Padova, Padova, Italy;* [4]*German Aerospace Center (DLR), Cologne, Germany;* [5]*Aerobility, Camberley, United Kingdom*

(Education - Program/Process Review)

BACKGROUND: The degree of disability that a person experiences depends on the condition or limitation and the environment. The environment changes dramatically in space. Our work supports the ESA parastronaut project to investigate the physiological feasibility of space missions being undertaken by people with a physical disability. The aim is to investigate the physiological challenges, risks and benefits associated with parastronauts' participation in space missions. **OVERVIEW**: We have established a multidisciplinary team to review the literature and investigate existing practices relating to people with physical disability and the aerospace environment. We investigate the feasibility of a parastronaut's space mission considering requirements and processes occurring before, during and after a mission. We ask three questions: What are the physiological limitations and considerations for safety? What are the environmental and technological adaptations needed? Is the space environment better suited for individuals with specific disabilities? As this field is unexplored, the lessons from para-athletes' training and recovery, and adaptations for pilots with disabilities are used as a foundation to define the problem, and to suggest relevant technological solutions and adjustments to existing processes. Given the diversity of disabilities, a personalised-medicine approach is followed. In the preliminary stage of the project, two additional tools are used, surveys and focus groups, where people with disabilities, charities, aerospace and medical experts share their insights on current practices and unmet needs. **DISCUSSION:** This work is in line with the ESA parastronaut feasibility project, which has global relevance. Our ambition is to show that space can be for everyone and every body. Space exploration has driven innovation in a variety of fields, and this project will show new solutions to make space exploration more accessible, supporting the development of tools that can lower the level of disability experienced in aviation and on Earth. This work is increasingly relevant for the civilian field, with the advent of commercial space flight and space tourism, where more heterogeneous groups of individuals may seek access to aerospace related opportunities. The work of our team will be fundamental in advancing our understanding of the human body adaptability to changes in environment and to make space travel more inclusive.

Learning Objectives

1. To discuss the differences in level of physical disability experienced on Earth and during a space mission.
2. To identify the risks and benefits of parastronaut missions, with a focus on adjustments before, during and after a mission.

Thursday, 05/25/2023 ***1:30 PM***
Grand Ballroom D-E

[S-76]: SLIDES: BODY OF KNOWLEDGE: PHYSIOLOGY UPDATES

Chair: Amanda Lippert
Co-Chair: Katie Samoil

[428] ASSESSMENT OF CARDIAC OUTPUT DURING PHYSICAL EXERCISE USING NONINVASIVE TECHNIQUE

Munna Khan, Kashif Sherwani
Jamia Millia Islamia, New Delhi, India

(Original Research)

INTRODUCTION: Cardiac output (CO) measurement has become increasingly important during physical exercise and critical care. The CO increases because of large increase in the heart rate and a small increase in stroke volume. A non-invasive method would be preferred over an invasive approach that may no longer be acceptable due to considerable morbidity linked to balloon tipped flow directed pulmonary artery catheters. An attempt has been made to monitor the CO using noninvasive technique before and after exercise. **METHODS:** The hemodynamic parameters such as CO, heart rate (HR), and stroke volume (SV) were measured using tetra polar electrodes configuration. One pair of electrodes placed at the level of the sternal-xiphoid junction and other pair placed at the base of the neck. The thoracic length (L) is determined by measuring the distance between inner electrodes. The transmitting thoracic electrodes introduced alternating current with high frequency of 50 kilohertz (KHz) and low amplitude of 1.5 milli ampere rms (mA). The 24 subjects (20 males and 4 females) were participated in the study. Bioelectrical impedance (BI) of thorax was recorded using LCR meter. The SV determined by measuring weight in kilogram (WiK) and approximating WiK into milli litres (mL). The HR was recorded using standard automatic blood pressure instrument. The CO as a product of SV and HR monitored during rest, before and after exercise. Further, the graph was plotted between CO and oxygen consumption (O_2). **RESULTS:** The BI values of thorax were found in the range from 70 Ω to 75 Ω at rest state. The BI value decreased upto 52 Ω during exercise. The average value of the CO was found as 6.2 L/min at rest and 13.5 L/min after exercise. The plotted graph between CO and Oxygen (O_2) consumption yielded the mean slope of 7.1, which found in the range from 5.4 to 7.8 as per standard. **DISCUSSION:** The BI values decreased during exercise because of systole by increased in blood volume, increased blood flow, and aligned red blood cells. The CO values changed linearly with O_2 consumption and may be used to predict the O_2 consumption for additional subjects.

Learning Objectives

1. Assessment of Cardiac Output (CO) using Bioelectrical Impedance Analysis (BIA).
2. Prediction of O2 consumption at rest, before and after exercise.

[429] ASSESSMENT OF WET BULB GLOBE TEMPERATURE (WBGT) HEAT STRESS LIMITS FOR APPLICATION IN THE AIR DOMAIN

Andrew S. Weller, Jonathan W. R. Boyd
QinetiQ, Farnborough, United Kingdom

(Original Research)

INTRODUCTION: Heat stress can degrade the performance and well-being of aircrew (heat strain). WBGT is an empirical heat stress index which takes account of the sources of heat stress (thermal environment, clothing and physical activity) with limits intended to prevent heat strain. The UK military has recently updated its heat illness prevention guidance, which include WBGT limits that are relevant to all service domains, including air. The aim of this study was to assess selected limits through laboratory simulations incorporating representative aircrew equipment assemblies (AEAs) and physical workloads, and to use mathematical modelling to extend the scope of the findings. **METHODS**: Ten men completed two 160-minute tests simulating rotary-wing (RW) 'Pilot' and 'Rear crew' sorties, each at two WBGTs (26 and 20°C). Aircrew workloads were generated through leg-press and treadmill exercise, and a Summer RW AEA was worn. Physiological (including gastro-intestinal (GI) temperature and metabolic rate), subjective (including thermal comfort) and cognitive performance measures were obtained. Modelling allowed WBGT limits to be generated as a function of flight time, crew role and AEA (Summer and Winter Sea). **RESULTS**: The time-weighted metabolic rate was higher in the Rear crew (258 Watts (W)) vs. Pilot (184 W) tests, but both were categorized as 'Easy' (< 250 W). Physiological and subjective measures indicated modest physiological strain in all tests with the highest GI temperature recorded in the RW Rear crew simulation at the higher WBGT (37.7 ± 0.2°C). Cognitive performance measures were similar for all tests. From modelling, WBGT limits of 31 and 27°C were predicted for Pilot and Rear crew roles respectively, with Summer AEA and a 2 hr flight duration. This reduced by 1°C with flight duration of 4 hrs, and by 5°C with Winter-Sea AEA. **DISCUSSION**: Two role-specific WBGT limits are not practicable, therefore, the lower WBGT limit should be used. Given the unknown impact on heat strain risk associated with other factors not accounted for in the trial (e.g. female aircrew, solar load, different rear crew physical tasks), the results support a WBGT limit of 26°C for RW aircrew wearing Summer AEA undertaking 2 hr flights. This is broadly consistent with current UK military guidance. Empirical evidence is advised to investigate whether this limit is valid for longer flights up to 4 hours and that a 5°C reduction will confer protection with Winter-Sea AEA.

Learning Objectives

1. The audience will learn about the use of the heat stress index WBGT to inform the risk assessment for helicopter aircrew undertaking hot-weather operations.
2. The audience will learn about the use of physiological trial data and mathematical predictions to inform the heat stress risk assessment.

[430] FLIGHT RELATED NECK PAIN CAN EFFECT PERCEIVED IN-FLIGHT TASK PERFORMANCE IN UK MILITARY HELICOPTER AIRCREW

Richard Vail[1], Stephen D. R. Harridge[2], Nicholas D. C. Green[3], Marousa Pavlou[2], Peter D. Hodkinson[2]
[1]*RAF, Elgin, United Kingdom;* [2]*King's College London, London, United Kingdom;* [3]*RAF, Henlow, United Kingdom*

(Original Research)

INTRODUCTION: Flight-related neck pain (FRNP) has been reported as an occupational concern amongst military rotary-wing (RW) aircrew. This study aimed to establish the 12-month prevalence of flight-related neck pain (FRNP) amongst UK military helicopter aircrew and its impact on perceived flight task performance. **METHODS:** A cross-sectional survey of UK military RW aircrew was conducted via an anonymous electronic questionnaire. 312 responses were received (pilots 60.9% (n=190); rear crew 20.2% (n=63); Observers 17.9% (n=56); Other 1% (n=3); 96.8% (n=302) male, 3.2% (n=10) female or not disclosed. The questionnaire used core questions defined by the NATO Task Group HFM-252 report and included the recommended definition of significant FRNP. Descriptive statistics and stepwise logistical regression were used for data analysis. The study protocol was approved by the UK MOD (Royal Air Force) ethics review process. **RESULTS:** The prevalence of significant FRNP was 39%. Rear crew reported the greatest proportion of significant FRNP (54%, n=34, 95% CI [41.8, 65.7), followed by observer 42.9% (n=24, 95% CI [42.3, 55.9]) and pilots 34% (n=65, 95% CI [27.8,41.2]). Amongst aircrew who reported significant FRNP (n=123), 46% (N=57) of aircrew indicated that significant FRNP affected task performance that began to impact flight safety (31.5%, n=39) or meant they were unable to complete the task (14.5%, n=18). Aircrew who reported significant FRNP flew a greater amount of flight hours (164hrs compared to 138hrs) (t=2.674 df 310, p=0.008) and hours with Night Vision Goggles (NVG) (24hrs vs 13hrs) (t-2.879, df 185.2, p=0.004). **DISCUSSION:** Prevalence of significant FRNP in UK rotary wing aircrew was lower than in previous studies but greater than neck pain in non-aircrew populations. This study is a shift in emphasis through the use of newly recommended criteria defining significant FRNP in military aircrew, linking the presence of FRNP to its effect on task performance. While FRNP is considered to have a multi-factorial etiology, our data suggest the overall exposures to increased head-mounted loads, especially for RW rear crews, and options to reduce these loads remain an important area of operational doctrine to consider. **LEARNING OBJECTIVES:** The prevalence of significant FRNP amongst UK military RW aircrew is higher than the general population; it can impair aircrew's ability to complete their in-flight tasks and is associated with both flying hours and NVG use.

Learning Objectives
1. The prevalence of significant FRNP amongst UK military RW aircrew is higher than non-aircrew military populations and the working-age general population.
2. Aircrew reporting FRNP is associated with greater levels of flying hours and NVG use.

[431] WATERPROOF OCULOMETRIC ASSESSMENT TOOL TO MONITOR AND ASSESS ILLNESS AND INJURY RELATED TO OPERATION IN HYPERBARIC AND HYPOBARIC ENVIRONMENTS

Connor Tate, Savannah Richardson, Jeffrey Philips, Timothy Hutcheson, Landon Casey
Florida Institute for Human and Machine Cognition, Pensacola, FL, United States

(Education - Tutorial/Review)

INTRODUCTION: Human operations in hypobaric and hyperbaric environments present several health risks including neurological syndromes such as: neurologic decompression sickness, hypoxia, hypercarbia, and CNS O2 toxicity. These syndromes manifest as cognitive decline, fatigue, vertigo, visual impairment, or hearing loss; increasing danger to the operator and their team. To provide early detection and monitoring of these syndromes, a mask fitted, waterproof video-oculographic (VOG) device was developed for in situ monitoring of operator cognitive function and physiological status. **TOPIC:** The developed tool integrates addressable LEDs and the Pupil Labs camera and software into the US Navy Divator MKII full face mask for waterproof operation at pressures of 73 psi up to 4 hours. The system provides unobtrusive monitoring of physiological status and cognitive function by measuring blink rate, fixation, gaze and pupillometry. To measure eye movement an IR camera has been enclosed in a small format custom pressure housing and mounted in the mask to optimize positioning and data capture. Embedded with the eye-camera is a LED which allows for programmable control of frequency, intensity, and wavelength; allowing for elicitation of pupil dilation and latency through via controlled pulses of 500 nm light. The eye-camera and embedded LED link to a rail mounted external housing where a world-view camera and sensor integration are housed. The world-view camera provides a mapping of the operators gaze angle to the world. **APPLICATION:** This system delivers a waterproof, pressure resistant VOG system as a research tool to detect early signs of neurological syndromes associated with extreme environments. Insight into operator oxygenation status, neurological dysfunction, intracranial pressure, decompression sickness and fatigue can be gained through the measurement of gaze, fixation, blink rate and pupil latency. The compatible Pupil Labs software offers a mobile, open-source, natural gaze-based system ensuring automatic slippage compensation making it possible to run eye-tracking studies in dynamic environments. The open-source software allows for extension of VOG based measures for scaling detection variables based on application. **RESOURCES:** Stepanek, Jan, et al. "Acute hypoxic hypoxia and isocapnic hypoxia effects on oculometric features." *Aviation, space, and environmental medicine* 85.7 (2014): 700-707.

Learning Objectives
1. The audience will learn about a new tool for the measurement and detection of hypobaric and hyperbaric related neurological syndromes.
2. The audience will learn about minimum detection parameters and sensor requirements for the capture of physiologically and neurologically significant eye-tracking.
3. The audience will learn about the process, difficulties and methods of developing a new detection tool for use in extreme environments.

[432] EFFECT OF LOWER BODY NEGATIVE PRESSURE ON OCULAR PERFUSION PRESSURE

Eric Hall, Richard Whittle, Ana Diaz-Artiles
Texas A&M University, College Station, TX, United States

(Original Research)

INTRODUCTION: Lower body negative pressure (LBNP) has been proposed as a method to mitigate the cephalad fluid shifts during spaceflight associated with the development of Space Flight Associated Neuro-ocular Syndrome (SANS). This study aims to quantify the effect of LBNP on intraocular pressure (IOP), mean arterial pressure at eye level (MAP_{eye}), and ocular perfusion pressure (OPP). **METHODS:** Twenty-four subjects (12M/12F) were subjected to graded LBNP in 0° supine and 15° head down tilt (HDT) postures from 0 mmHg to –50 mmHg, in 10 mmHg increments. IOP and MAP_{eye} were measured at each condition and OPP calculated as MAP_{eye} – IOP. Dose-response models quantifying the effects of pressure, sex, and posture were constructed over the range of LBNP using linear mixed models. **RESULTS:** Between 0 and –50 mmHg of LBNP, OPP significantly increased in 15° HDT from 90.5 ± 3.1 mmHg to 95.5 ± 3.1 mmHg ($p = 0.009$) but showed no significant change in 0° supine ($p = 0.539$). MAP_{eye} significantly decreased from 89.1 ± 2.6 mmHg to 84.2 ± 2.7 mmHg in 0° supine ($p = 0.018$) but remained constant in 15° HDT. IOP decreased significantly from 22.8 ± 0.9 mmHg to 17.5 ± 0.9 mmHg (1.0 ± 0.095 mmHg per 10 mmHg LBNP) in 15° HDT ($p < 0.001$). IOP also decreased from 19.1 ± 0.75 mmHg to 15.4 ± 0.76 mmHg (0.7 ± 0.09 mmHg per 10 mmHg LBNP) in 0° supine ($p < 0.001$). Sex did not have a significant effect on OPP or IOP. Sex differences were only found to be significant in MAP_{eye} in 15° HDT where MAP_{eye} in females was, on average, 11 ± 4.8 mmHg lower than in males ($p = 0.023$) Tilt angle was found to have a significant impact on OPP ($p < 0.001$), MAP_{eye} ($p < 0.001$), and IOP ($p < 0.001$). **DISCUSSION:** The reduction in IOP during increasing LBNP led to the increase in OPP in 15° HDT. Observed sex differences in MAP_{eye} can possibly be explained by the stature (i.e., females had, on average, a shorter hydrostatic column between heart and eye) and MAP differences between male and female subjects. Six of the twelve females did not complete the protocol in either 0° supine or 15° HDT conditions past the –30 to –40 mmHg pressure level. Only one male subject was unable to complete the full protocol (at 0° supine). The etiology behind this sex disparity should be well understood prior to long duration space missions. Future work should also seek to understand the relationship between OPP and SANS, and the impact of LBNP on these ocular responses as part of countermeasure development.

Learning Objectives
1. The audience will learn about the effect of lower body negative pressure on ocular perfusion pressure, mean arterial pressure at eye level, and intraocular pressure.
2. The audience will learn about sex differences observed in ocular perfusion pressure, mean arterial pressure at eye level, and intraocular pressure during lower body negative pressure

[433] PHYSIOLOGICAL MEASUREMENT METHODS TO AID AIR TRAFFIC CONTROLLERS PRE-TRAINING SELECTON SYSTEM

Botond Szűcs, Krisztina Szabó
PharmaFlight, Debrecen, Hungary

(Original Research)

INTRODUCTION: The 2-year training period for air traffic controllers puts heavy financial burden on the training organization, and means a continuous high workload to the ATCO-trainees. The high percentage of drop-outs during the training makes the procedure very expensive. To select the best candidates – thus reducing the number of drop-outs - we have been involved in the multistage selection process of the Hungarian ANSP, HungaroControl. **METHODS:** Monitoring and evaluating certain physiological parameters can contribute to a better assessment of an individual. The candidates, after FEAST-2 test were involved in a standard aeromedical examination and anthropometry, 6-min physiological evaluation, dry electrode EEG, sleep assessment and cognitive function test. We used heart rate variability (HRV), which gives information of the autonomic nervous system, the electric and the mechanical state of the heart, and the possible inflammations. Arteriography demonstrates the characteristics of large arteries and the endothelial function, cardiovascular risk factors. It reveals several parameters: augmentation index (AIX, optimal range < -30%) traces the degree of pulse

wave reflection, state of peripheral circulation, and is related with cardiovascular mortality. Pulse wave velocity (PWV, optimal range < 7 m/s) represents the speed of the pressure wave on the aorta generated by the heart's contraction, which is crucially affected by the elasticity of the aorta. PWVao is a solid, independent, proven risk factor of cardiovascular mortality. Diastolic area index (DAI, 50-60% among healthy individuals) represents the diastolic proportion of the cardiac cycle, gives information on pressure properties of the left coronary artery. With dry electrode EEG we also monitored the well-known brain wave range combinations. During the sleeping assessment by using a special device we got valuable information about the examinees sleeping habits, heart rate, breath frequency, deep sleep time, apnea time, sleep efficiency. **RESULTS:** We evaluated the findings of the 85 candidates and wrote a detailed report of all the candidates for HungaroControl. Based on our report a "ranking" could be given, and it was used as an important data for HungaroControl in the recruitment decision. **DISCUSSION:** The rate of the drop-outs from the 2-year training could be reduced by admitting the most competent applicants, based on our ranking. On average, the drop-out rate was decreased by a considerable 24%.

Learning Objectives

1. The audience will learn about air traffic controllers' selections system, possible helps in the selection protocol.
2. The participant will be able to understand some resting physiological measurement methods, optimal ranges of markers, deviations from optimal ranges. The possible good practices to help a participant to maintain high level of loadability and performance.

Thursday, 05/25/2023 ***1:30 PM***
Grand Chenier

[S-77]: PANEL: ABPM ASAMS BOARD REVIEW PREPARATION

Sponsored by ASAMS

Chair: Jeffrey Jones
Co-Chairs: Dwight Holland, James Elliot, Thomas Jarnot

PANEL OVERVIEW: INTRODUCTION: *To assist American Society of Aeromedical Specialists members prepare for periodic written examinations for those educated on the topics defined by the American College of Preventive Medicine GME requirements and wishing to become certified or re-certified under the American Board of Preventive Medicine, and to provide education on relevant topics to anyone interested in Aerospace and Preventive Medicine; the ASAMS education committee assembles topics for review by knowledgeable invited experts in the field.* ***TOPICs and Speakers:*** *Introduction to the Aerospace Medicine Board Exam- Jeff Jones Epidemiology- James Elliot Human Factors: Human-machine interface and Human performance- Dwight Holland Visual Illusions and Spatial Disorientation- Thomas Jarnot Physical Effects of Flight on Air and Space Operations- Jeff Jones.* ***APPLICATION:*** *The knowledge gained in this panel can be applied by the attendee to preparation for the knowledge examination in both the preventive medicine core and the aerospace medicine specialty examination. Others considering their possible involvement in clinical Aerospace Medicine or AM applied research may find the review topics interesting and educational. Preventive Medicine Core Content Outline: 25% - I. Clinical Preventive Medicine 25% - II. Public Health/Population Health Medicine Knowledge 20% - III. Epidemiology, Biostatistics, and Informatics Knowledge 15% - IV. Environmental Medicine 15% - V. Strategic Healthcare Leadership Knowledge Aerospace Medicine Content Outline: Outline: 40% - The Flight Environment 30% - Clinical Aerospace Medicine 20% - Operational Aerospace Medicine 10% - Management and Administration.* ***RESOURCES:*** *American Board of Preventive Medicine – American Board of Preventive Medicine – The American Board of Preventive Medicine was established to promote the health and safety of the American people through our high standards in the certification and maintenance of certification in the profession of preventive health. (theabpm.org) American College of Preventive Medicine- American College of Preventive Medicine | ACPM.*

[434] ABPM ASAMS BOARD REVIEW COURSE

Jeffrey Jones[1], Thomas Jarnot[2], James Eilliot[3], Dwight Holland[4]
[1]*Baylor College of Medicine, Center for Space Medicine, Houston, TX, United States;* [2]*U.S. Air Force, Dayton, OH, United States;* [3]*FAA, Fort Worth, TX, United States;* [4]*InnovaSpace, Roanoke, VA, United States*

(Education - Tutorial/Review)

INTRODUCTION: To assist American Society of Aeromedical Specialists members prepare for periodic written examinations for those educated on the topics defined by the American College of Preventive Medicine GME requirements and wishing to become certified or re-certified under the American Board of Preventive Medicine, and to provide education on relevant topics to anyone interested in Aerospace and Preventive Medicine, the ASAMS education committee assembles topics for review by knowledgeable invited experts in the field: Introduction to the Aerospace Medicine Board Exam- Jeff Jones. **APPLICATION:** The knowledge gained in this panel can be applied by the attendee to preparation for the knowledge examination in both the preventive medicine core and the aerospace medicine specialty examination. Others considering their possible involvement in clinical Aerospace Medicine or AM applied research may find the review topics interesting and educational: 25% - I. Clinical Preventive Medicine; 25% - II. Public Health/Population Health Medicine Knowledge; 20% - III. Epidemiology, Biostatistics, and Informatics Knowledge; 15% - IV. Environmental Medicine; 15% - V. Strategic Healthcare Leadership Knowledge. Aerospace Medicine Content Outline: 40% - The Flight Environment; 30% - Clinical Aerospace Medicine; 20% - Operational Aerospace Medicine; 10% - Management and Administration. **RESOURCES:** American Board of Preventive Medicine – American Board of Preventive Medicine – The American Board of Preventive Medicine was established to promote the health and safety of the American people through our high standards in the certification and maintenance of certification in the profession of preventive health. (theabpm.org) American College of Preventive Medicine- American College of Preventive Medicine | ACPM.

Learning Objectives

1. To familiarize the audience with an understanding of key principles of epidemiology needed for practitioners of preventive medicine, e.g. to explain the difference between sensitivity, specificity, and positive and negative predictive value.
2. To enhance the understanding of human factors involved in the operation of aircraft and space vehicles, and the key elements of the human-machine interface.
3. To outline the important visual illusions in the cockpit that can produce spatial disorientation and possible aircraft mishaps.

Thursday, 05/25/2023 ***1:30 PM***
Napoleon Ballroom C1-C2

[S-78]: PANEL: UPDATES ON HEALTH PROMOTION IN AEROMEDICAL REGULATION

Sponsored by the Air Transport Medicine Committee

Chair: Ben Johnston
Co-Chair: Ian Hosegood

PANEL OVERVIEW: *In 2018 ICAO amended their SARPS to include a requirement for Civil Aviation Regulators to apply SMS principles to Aeromedical Regulation, and to include health promotion activities in the aviation medical process. Due to the COVID pandemic there has been very little discussion of progress in this area since 2019. Regulators, Airlines, Aviation Medical Practices and Health Promotion Programme providers will be invited*

to present their contributions to developing knowledge and practice in this area of Air Transport Medicine.

[435] ICAO OVERVIEW OF PROGRESS WITH HEALTH PROMOTION IN AEROMEDICAL REGULATION

Ansa Jordaan
ICAO, Montreal, PQ, Canada

(Education - Program/Process Review)

BACKGROUND: In 2016, the International Civil Aviation Organization (ICAO) amended the medical Standards and Recommended Practices (SARPs) to include a "Health Promotion Standard". This amendment formed part of moving away from strict, prescriptive medical protocols to more flexible evidence-informed protocols, based on medical findings during aviation medical examinations, reasons for loss of licence, and causes of medical incapacity. Since then, both aviation operations and the science of medicine have developed at a fast pace. In addition, the COVID-19 pandemic had a significant effect on the health of aviation personnel. The implementation of health promotion is essential in current and future aviation activities. **OVERVIEW:** This presentation describes the evolution of the health promotion standard from 2016 to date, and the progress in its application in the medical certification process. The presentation includes lessons learned from COVID-19, and the need for closer connection with other existing aviation SARPs and guidance material, such as human performance, flight operations and safety management systems, to ensure a holistic health promotion approach to maintaining fitness to fly and flight safety. **DISCUSSION:** Implementing health promotion activities necessitates multi-disciplinary collaboration at several levels, involving all relevant stakeholders. Successful implementation of health promotion activities not only supports the wellbeing and career longevity of aviation personnel, but also aviation safety. ICAO will discuss its approach to consultation and publication of health promotion material, including best practices, updating the health promotion guidelines in the ICAO Manual of Civil Aviation Medicine, and aligning these guidelines with ICAO's Flight Operations, Human Performance, and Safety Management manuals and best practices.

Learning Objectives

1. The audience will learn about ICAO's perspective and approach to integrate health promotion in aviation to support the wellbeing and career longevity of aviation personnel, as well as aviation safety.
2. The participant will be able to understand ICAO's progress in the application of health promotion in the aviation medical process, since the implementation of the SARP.

[436] INTEGRATING HEALTH PROMOTION INTO AVIATION LICENCE-HOLDERS' MEDICAL ASSESSMENTS: A REGULATOR'S PERSPECTIVE AND EXPERIENCE

Chun Hon Chong, Benjamin Tan
Civil Aviation Authority Singapore, Singapore

(Education - Program/Process Review)

Routine medical assessments for pilots and controllers have traditionally been viewed as means to identify and mitigate medical conditions of flight safety significance. Based on the recommendation of the Medical Provisions Study Group, ICAO adopted Amendment 173 to Annex 1, which included the implementation of "aviation-related health promotion for license holders to reduce future medical risks to flight safety". This new paradigm recognized the role of regulators in health promotion. Since January 2017, the Civil Aviation Authority of Singapore (CAAS) instituted structured health screening within its licensing medical examination protocols and provided personal health appraisal (PHA) reports to pilots and controllers along with their medical assessments. The aim was to integrate early identification and preventive health advice to minimize future medical-related risks. On the first year of implementation, 4.65% (95/2042) were found to have abnormal fasting blood glucose, of which 2.35% (47/2042) were newly diagnosed cases of Impaired Glucose Tolerance or Diabetes Mellitus. More than 10% of the screening population had hypercholesterolemia. All affected pilots and controllers had commenced on lifestyle modification and/or medication. The PHAs were generated from a bespoke electronic medical platform developed by CAAS, designed to engender greater ownership of health outcomes. Information provided included individualized cardiac event risk (calculated using the Framingham Risk Score), risks of development of hypertension and Diabetes Mellitus, assessments of sleep adequacy, as well as trending of other key health parameters (eg. BMI). Future studies will be conducted to assess the impact on health outcomes from these health promotion efforts and interventions.

Learning Objectives

1. Participants would learn a regulator's approach and experience in integrating structured health screening processes within a licensing medical examination protocol, with the aim of minimizing future medical-related risks. They will be able to have access into the findings and evaluation of health data captured through this new initiative.
2. Participants would be able to observe and learn how to generate and automate customized personal health appraisal reports using health data captured in a regulator's electronic medical records.
3. Participants will understand the approach from a regulator's perspective on health promotion for Aviation certificate holders.

[437] A STITCH IN TIME - INCORPORATION OF PRIMARY CARE PREVENTIVE ACTIVITIES INTO THE AVIATION MEDICAL EXAMINATION IN AUSTRALIA

Kate Manderson
CASA Australia, Canberra, Australia

(Education - Program/Process Review)

BACKGROUND: Medical certification focuses mostly on the risk management of diseases once they have developed, while most health gains in modern medicine are made in the field of preventive activities. It is appropriate therefore that a safer approach to aviation medical certification is not to wait for a system failure, but to incorporate status checks and planned maintenance. This may prevent medical failures from ever happening, or reduce the impact and management needed when an issue is found. **OVERVIEW:** This presentation discusses the effectiveness of incorporating evidence-based primary care preventive activities into the aviation medical examination process, supporting early identification and management of medical conditions that may lead to an unsafe situation, loss of medical certification or even death. **DISCUSSION:** The Royal Australian College of General Practitioners publishes guidelines for preventive activities in general practice – "The Red Book". These guidelines have been optimised for the Australian health context based on epidemiology of preventable diseases. The Red Book recommendations are based on age, gender, ethnicity and risk profile for each patient. The treating GP then implements a patient-centred plan for screening or for surveillance of existing diseases to prevent deterioration. The Australian approach to building prevention into the aviation medical examination will start with a simple yes/no question on our electronic medical questionnaire for medical examiners: "Is this applicant up to date with the recommended RACGP Red Book preventive activities for their population?". A hyperlink will be provided to access The Red Book directly from the examiner's desktop for reference, and a prompt will also pop up when ANY response is recorded: "Preventive activities can help your aviation medical certificate-holder stay healthy and stay in the air safely." The response will not impact their medical certification, but will provide an opportunity for the discussion to be raised by the medical examiner, and a referral to the treating GP for an appropriate discussion. Following implementation, data can be analysed to look for any change in early disease detection, and in uptake of prevention/surveillance activities compared with the non-aviation population. In the very long term, we may be able to demonstrate a health benefit to the aviation community of having this relatively small interaction regularly with their AME.

Learning Objectives
1. The audience will learn about the schedule of preventive activities in Australian General Practice, and how these can be used to improve aircrew health and flying safety.
2. The audience will learn about the role of motivational interviewing as a tool for improving aircrew uptake of preventive health activities.

[438] HEALTH PROMOTION IN AEROMEDICAL REGULATION: AIRLINES' PERSPECTIVE

Ben Johnston[1], Ian Hosegood[2]
[1]*Air New Zealand, Auckland, New Zealand;* [2]*Qantas, Sydney, Australia*

(Education - Program/Process Review)

In 2016 ICAO updated their SARPs to include a recommendation that Civil Aviation Regulators include appropriate health promotion activities in the aeromedical regulatory process. As the employers of aviation certificate holders airlines have a role to play in the delivery of effective health promotion programs. There is potential for effective health promotion programs to deliver mutual benefit for aviation safety, the individual certificate holder, and also for the employer. This presentation will discuss the perspective of two airlines on existing health promotion initiatives and also opportunities and priorities for future development, in collaboration with regulators and experts in behavioral change. The presentation will also discuss how the Health Promotion concept fits within an integrated airline SMS, with reference to gaining senior leadership buy-in and commitment.

Learning Objectives
1. The audience will learn about current airline operator approaches being applied to health promotion for Aviation Medical Certificate holders.
2. The audience will learn about airline operator perspectives on key opportunities and priorities for future development of health promotion programs for Aviation Medical Certificate holders.
3. The audience will learn about how health promotion programs for Aviation Medical Certificate holders support other organizational interests.

[439] MULTI-COMPONENT HEALTH BEHAVIOR PREVENTIVE MEDICINE INTERVENTIONS TO IMPROVE CARDIOMETABOLIC HEALTH OF AIRLINE PILOTS

Daniel Wilson[1], Matt Driller[2], Ben Johnston[3], Nicholas Gill[4]
[1]*University of Waikato, Tauranga, New Zealand;* [2]*La Trobe University, Melbourne, Australia;* [3]*Air New Zealand, Auckland, New Zealand;* [4]*New Zealand Rugby and University of Waikato, Wellington, New Zealand*

(Original Research)

INTRODUCTION: The occupational demands of professional airline pilots such as shift work, sleep disruption, fatigue, physical inactivity, and psychological stress may promote adverse outcomes to cardiometabolic health. Indeed, recent studies indicate similar notable prevalence of physiological, behavioral and psychological cardiometabolic health risk factors to general population estimates globally. Obtaining adequate sleep, consuming healthy nutrition, and engaging in sufficient physical activity are three lifestyle behaviors that significantly reduce all-cause mortality and have a positive effect on short and long-term cardiometabolic health. In a series of controlled clinical trials utilizing face-to-face and digital modes of delivery, the effectiveness of a 16-week personalized healthy eating, sleep hygiene, and physical activity program was evaluated for enhancing cardiometabolic health parameters among airline pilots. **METHODS:** Parallel-group (intervention and control) studies were conducted among airline pilots in New Zealand. The intervention group received a personalized nutrition, sleep and physical activity program over a 16-week period. The control group received no intervention. Outcome measures of objective health (body mass index, blood pressure, resting heart rate, body composition, cardiorespiratory fitness, push-ups, plank hold) and self-reported health (weekly physical activity, sleep quality and duration, fruit and vegetable intake, self-rated physical and mental health, fatigue severity scale, and perceived stress scale) were collected at baseline and post-intervention. The control group completed the same assessments. **RESULTS:** Significant time x group interactions were observed for all outcome measures at post intervention ($p<0.001$). All outcome measures significantly improved in the intervention group when compared to the control group ($p<0.001$). Face-to-face consultations were associated with larger effect size improvements than the digital mode of delivery. **DISCUSSION:** Our findings demonstrate that a personalized 16-week healthy eating, physical activity, and sleep intervention can elicit and sustain long-term improvements in cardiometabolic health parameters in pilots and may support quality of life during an unprecedented global pandemic. These findings are of interest to professionals who may be in a position to apply preventive medicine research findings to occupational settings.

Learning Objectives
1. The audience will gain insight into evidence-based strategies utilized to deliver health behavior interventions.
2. The audience will understand the efficacy of health behavior interventions delivered to airline pilots.

Thursday, 05/25/2023 ***1:30 PM***
Napoleon Ballroom D1-D2

[S-79]: PANEL: THE SELF-REPORTED IMPACTS OF THE COVID-19 PANDEMIC ON PSYCHOLOGICAL HEALTH OF U.S. AIR FORCE PERSONNEL

Chair: Kristin Galloway

PANEL OVERVIEW: *Adjusting to COVID-19-related requirements likely increased the stress of already stressful jobs for military members and their families, which could have resounding impacts on emotional, social, and physical well-being. Therefore, it is important to evaluate the psychological health outcomes reported by military personnel and the self-perceived impacts of the changes presented by the COVID-19 pandemic to these personnel. This panel presents the results from three occupational health assessments given to U.S. Air Force personnel (cyber, Air Force Special Operations Command remotely piloted aircraft (RPA), National Air and Space Intelligence Center) and interviews conducted with RPA personnel and their embedded providers during the COVID-19 pandemic. The assessments and interviews were administered by Air Force Research Laboratory (AFRL) aeromedical operational clinical psychology researchers in late 2020 to 2021. The occupational health assessment study protocols were reviewed and approved by the AFRL Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol numbers FWR-2011-0068-E and F-WR-2009-0063-E. The embedded care interviews protocol was reviewed by the AFRL Institutional Review Board and designated as a programmatic evaluation (protocol number F-WR-2020-0117-N), exempting it from further oversight (AFRL Common Rule 32 CFR 219). The first presentation includes an overview of results from the three occupational health assessments and a comparison of psychological distress and self-reported stressors to previous studies. The second presentation provides feedback received from interviews with RPA airmen and their embedded providers during the COVID-19 pandemic. The third presentation discusses self-reported COVID-19 stressors and their association with work role strain within the RPA community. The fourth presentation is a qualitative review of the open-response self-reported negative and positive impacts (work, relationship, personal, and pandemic-specific) of the COVID-19 pandemic on cyber personnel. The fifth presentation is a review of the various aspects of concern during the COVID-19 pandemic and their relation to feelings of loneliness and psychological distress within the National Air and Space Intelligence Center community.*

[440] IMPACTS OF THE COVID-19 PANDEMIC ON INTELLIGENCE PERSONNEL AND THE ASSOCIATION WITH LONELINESS AND PSYCHOLOGICAL DISTRESS

Tyler Mulhearn[1], Tanya Goodman[1], Neal Scheuneman[1], Nicole Devlin-Giarrusso[1], Rachael Martinez[2], Kristin Galloway[2]
[1]*Neurostat Analytical Solutions, LLC, Great Falls, VA, United States;* [2]*USAFSAM, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: The nature of work and operational stressors among Air Force National Air and Space Intelligence Center (NASIC) personnel raise potential risk for loneliness. The physical distancing restrictions and changes to a remote workplace during the COVID-19 pandemic raise the risk for loneliness. Previous literature has shown links to loneliness and negative psychological health outcomes. **METHODS:** A total of 1128 NASIC operators completed an anonymous, web-based occupational health assessment from June-July 2021. The assessment included questions on demographics, sources of stress, health and occupational factors, and stress outcomes. The 3-item UCLA Loneliness Scale was used to measure loneliness, the 45-item Outcome Questionnaire was used to assess psychological distress, and the 16-item Maslach Burnout Inventory was used to measure burnout. The study protocol was reviewed and approved by the Air Force Research Laboratory Institutional Review Board and assigned protocol number F-WR-2011-0068-E. **RESULTS:** Loneliness was moderately correlated with exhaustion ($r = 0.418$), cynicism ($r = 0.399$), and psychological distress ($r = 0.682$). Both risk factors and protective factors for NASIC operators with high levels of loneliness were identified based on burnout, psychological distress, COVID-related impacts, and demographic variables. Individuals at higher risk of loneliness include unmarried individuals (relative risk (RR) = 2.262, 95% confidence interval (CI) = 1.835-2.793), individuals younger than 26 yr of age (RR = 1.419, 95% CI = 1.110-1.814), as well as individuals with higher rates of exhaustion (RR = 2.59, 95% CI = 2.124-3.158) and cynicism (RR = 2.50, 95% CI = 2.051-3.050). A worsening relationship with one's significant other (RR = 2.42, 95% CI = 1.886-3.117) and worsening mental health (RR = 2.716, 95% CI = 2.175-3.392) also increased risk of loneliness. **DISCUSSION:** Mental health support can be tailored to individuals based on the risk and protective factors found at the different levels of risk for loneliness.

Learning Objectives

1. The audience will learn about the prevalence of loneliness among intelligence personnel.
2. The audience will learn about risk factors for loneliness among intelligence personnel.

[441] SELF-REPORTED COVID-19 STRESSORS AMONG REMOTELY PILOTED AIRCRAFT AIRCREW

Neal Scheuneman[1], Tyler Mulhearn[1], Kristin Galloway[2], Tanya Goodman[1], Nicole Devlin[1], Rachael Martinez[2]
[1]*NeuroStat Analytical Solutions, Great Falls, VA, United States;* [2]*USAFSAM, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: U.S. Air Force remote warfare operations require the continuous coordinated efforts of remotely piloted aircraft (RPA) aircrew. In addition to the considerable demands placed on RPA aircrew during missions, these individuals encounter unique stressors such as long work hours and shift work that may exacerbate psychological health issues. The changes that the COVID-19 pandemic brought to the workplace as well as changes to their personal lives may have increased personal stress. **METHODS:** The present study included 207 Air Force Special Operations Command (AFSOC) and 516 Air Combat Command (ACC) RPA aircrew who responded to a comprehensive occupational health assessment (AFSOC: from November 2021-January 2022; ACC: from January 2022-July 2022). The assessment included questions on demographics, sources of stress, health and occupational factors, and stress outcomes. The study was reviewed and approved by the Air Force Research Laboratory Institutional Review Board at Wright-Patterson Air Force Base and assigned protocol number F-WR-2009-0063-E. **RESULTS:** COVID-19-related policies were rated as highly stressful (6+ on a 1-7 scale) by 14% of ACC and 20% of AFSOC RPA. The most commonly reported concerns among ACC and AFSOC RPA aircrew, respectively, included changing rules, regulations, and guidance (31%; 30%), social activities (25%; 25%), changes to work schedule (22%; 17%), concern for time spent with friends and family (22%; 29%), childcare or school status (closures) (17%; 18%), changes in work tasks (19%; 15%), and someone close to you getting COVID (19%; 14%). Personal mental health and physical health were reported as worsening for 56% and 64% of ACC, respectively, and 50% and 56% of AFSOC, respectively. Low social support among unit members was more commonly reported than in a similar study conducted in 2018, with 22% of ACC and 26% of AFSOC reporting low member social support compared to 19% and 18% from 2018, respectively. The rates of low leader social support decreased from the previous study, with 17% from ACC and 16% from AFSOC reporting low leader social support compared to 21% and 23% from 2018, respectively. **DISCUSSION:** Action-oriented recommendations related to the most commonly reported stressors will be discussed.

Learning Objectives

1. The audience will learn about COVID-19 specific stressors reported by Remotely Piloted Aircraft Aircrew.
2. The audience will learn about the COVID-19 impacts on physical and mental health among Remotely Piloted Aircraft Aircrew.

[442] A QUALITATIVE REVIEW OF SELF-REPORTED COVID-19 IMPACTS ON CYBER PERSONNEL

Tanya Goodman[1], Rachael Martinez[2]
[1]*Neurostat Analytical Solutions, LLC, Great Falls, VA, United States;* [2]*USAFSAM, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: While there is extensive evidence demonstrating the negative psychosocial impact of COVID-19 on the general population, very few studies have examined the impact of the pandemic in unique employment contexts such as U.S. Air Force personnel. These personnel faced changes in their workplace, fitness routines, and personal lives during the COVID-19 pandemic. It is important to evaluate the perceived impacts of the changes presented to these personnel because of the pandemic. **METHODS:** An online occupational health assessment was administered to 1488 cyber personnel from November 2020 to February 2021. The assessment included demographics, standardized measures of burnout, psychological distress, work role strain, health behaviors, and perceived impacts of the COVID-19 pandemic. Qualitative analyses of impact themes and analyses of variance for types of impact on psychological health outcomes were conducted. The study protocol was reviewed and approved by the Air Force Research Laboratory Institutional Review Board and assigned protocol number F-WR-2011-0068-E. **RESULTS:** From qualitative coding for responses to the open-ended question "How has the COVID-19 pandemic impacted you as an individual?" 32 negative themes and 13 positive themes were created within 4 impact categories—work, relationship, personal, and pandemic-specific (e.g., COVID-19 fatigue, illness, and precautions). Of the themes created, 966 (68%) reported at least one negative impact, 440 (31%) reported at least one positive impact, and 195 (14%) reported at least one positive and at least one negative impact. Top-reported negative impacts were limited face-to-face interactions (12%), loss of personal activities (10%), separation from family and friends (7%), COVID-19 fatigue (7%), and physical and fitness limitations (5%). Negative impacts were associated with negative psychological health outcomes (e.g., psychological distress, exhaustion, cynicism) and work role strain. Top-reported positive impacts were improved relationships (9%), teleworking preference (8%), self-care (4%), and work-life balance (4%). **DISCUSSION:** The findings from the current study provide evidence that COVID-19, specifically, heightened work stress, physical fitness stress, and relationship/personal stress for many, which was linked to

higher levels of negative psychological health outcomes. Action-oriented recommendations are given in the event of another pandemic.

Learning Objectives

1. The audience will learn about the associations found between COVID-19 pandemic related stressors and negative psychological health outcomes.
2. The audience will be provided with action-oriented ways to mitigate the top reported stressors in the event of another pandemic.

[443] PROVIDER AND AIRMEN PERSPECTIVES ON EMBEDDED MENTAL HEALTHCARE SERVICES DURING THE COVID-19 PANDEMIC

Rachael Martinez, Kristin Galloway
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: The COVID-19 pandemic posed changes to the workplace and personal lives of workers worldwide. While a large portion of the workplace transitioned to remote work, mission-essential workers remained in the workplace. Current available literature on mission essential workers is limited to frontline workers, such as healthcare personnel (nurses, doctors), and teachers and does not account for other career fields that were required to remain in their current roles in the changing COVID-19 pandemic environment. During the pandemic, embedded mental healthcare providers played a critical role in supporting the psychological health and operational success of airmen tasked with defending our nation. Providers and airmen spoke to the COVID-19-related challenges/strategies associated with delivering and accessing embedded mental healthcare services during the pandemic. **METHODS:** We conducted semi-structured interviews with 26 embedded mental healthcare providers and 15 airmen. Interviews were audio-recorded and transcribed verbatim for qualitative analysis, involving thematic content analysis to identify and tabulate key themes emergent from the data. The embedded care interviews protocol was reviewed by the Air Force Research Laboratory Institutional Review Board and designated as a programmatic evaluation (protocol number F-WR-2020-0117-N), exempting it from further oversight (Air Force Research Laboratory Common Rule 32 CFR 219). **RESULTS:** The most commonly reported themes were staying engaged with the team when not face-to-face, safety, higher incidence rates of mental healthcare, delayed initiatives, unavailability of resources, shifting responsibilities, and technology as a substitute for face-to-face communication. Providers and airmen also agreed that the top strategy for delivering/accessing care during COVID-19 was using technology (e.g., telehealth) to interact with each other and other unit members. **DISCUSSION:** This is the first systematic qualitative exploration of provider and airmen perspectives on embedded mental healthcare services, including COVID-19 considerations. Action-oriented recommendations related to the most commonly reported themes will be discussed.

Learning Objectives

1. Describe the perspectives of embedded mental health providers on the barriers and strategies to delivering mental health services during the COVID-19 pandemic.
2. Describe the perspectives of U.S. Air Force airmen on the barriers and strategies to accessing mental health services during the COVID-19 pandemic.

[444] OCCUPATIONAL HEALTH ASSESSMENTS DURING THE COVID-19 PANDEMIC: A REVIEW OF SOURCES OF STRESS AND RATES OF PSYCHOLOGICAL DISTRESS

Kristin Galloway
USAFSAM, Wright-Patterson AFB, OH, United States

(Original Research)

INTRODUCTION: U.S. Air Force researchers conducted occupational health assessments on cyber, intelligence analysis, and remotely piloted aircraft (RPA) personnel during the COVID-19 pandemic to provide a deeper understanding of self-perceived impacts of the pandemic on these samples. **METHODS:** In all, 1128 intelligence analysis, 2010 cyber, and 723 RPA participants responded to a comprehensive occupational health assessment covering demographics, sources of stress, health/occupational factors, and stress outcomes. The Outcome Questionnaire assesses difficulties in interpersonal relationships, social roles, and overall quality of life and was used to rate psychological distress. The Maslach Burnout Inventory was used to measure exhaustion, cynicism, and professional efficacy, the three burnout facets. The study protocols were reviewed and approved by the Air Force Research Laboratory Institutional Review Board and assigned protocol numbers FWR-2011-0068-E, FWR-2011-0070-E, and F-WR-2009-0063-E. Rates of burnout and psychological distress were examined, most commonly reported stressors were compiled, and comparisons among the studies and to findings from previous assessments were conducted. **RESULTS:** Organizational issues were rated as one of the top two sources of high stress (6+ on a scale of 1-7) for intelligence analysis and cyber (20-25%). Unit manning concerns (20%), training issues (15%), being in a one-deep position (10-14%), and long work hours (11%) were also rated as a source of high stress for cyber. The most commonly reported source of high stress in intelligence analysis was mission-related equipment and technology (28%); other sources included environmental issues (17%), being in a one-deep position (15%), physical support facilities (14%), and unit manning concerns (14%). Commonly reported sources of high stress for RPA were COVID-related policies (14-20%), schedule changes (14-16%), administrative duties (14-19%), lack of professional opportunities (14-15%), and unit manning concerns (14%). High exhaustion was endorsed by 30-31% of RPA and 24-26% of intelligence analysis and cyber participants. High overall psychological distress was reported by 15-20% of RPA, 14-18% of cyber, and 14% of intelligence analysis participants. **DISCUSSION:** Action-oriented operational recommendations are discussed in relation to the sources of stress and psychological health concerns among cyber, intelligence analysis, and RPA personnel during the COVID-19 pandemic.

Learning Objectives

1. Members will understand the similarities and differences between the Psychological Distress and Burnout reported by several high demand career fields in the USAF.
2. Members will be able to clarify the most commonly reported and impactful sources of stress among different high demand USAF career fields.

Thursday, 05/25/2023 ***1:30 PM***
Napoleon C3

[S-80]: SLIDES: SPACEFLIGHT IS RISKY BUSINESS

Chair: Yael Barr
Co-Chair: Erik Antonsen

[445] ACUTE INHALATIONAL EXPOSURE TO HYDRAZINES: SPACEFLIGHT RECOVERY CONSIDERATIONS

Brian Hanshaw[1], Valerie Ryder[2], Benjamin Johansen[2], James Pattarini[2], HoanVu Nguyen[3], Craig Nowadly[4], Rebecca Blue[1]
[1]*UTMB, Galveston, TX, United States;* [2]*NASA JSC, Houston, TX, United States;* [3]*U.S. Air Force, Travis AFB, CA, United States;* [4]*U.S. Air Force, San Antonio, TX, United States*

(Original Research)

INTRODUCTION: Inhalation of hydrazine or hydrazine-derivative vapors during spaceflight operations remains a risk to crew and ground support personnel. Exposure can cause adverse health effects ranging from distracting mucosal irritation to life-threatening respiratory, hematologic, and central nervous system (CNS) dysfunction. However,

with a limited number of human exposure cases, much of the evidence driving the regulatory and medical treatment standards is anecdotal or extrapolated from animal studies or non-inhalational human case reports. An evidence-based approach to inform acute clinical treatment guidelines for inhalational exposures during a non-catastrophic contingency spaceflight recovery scenario is necessary. **METHODS:** A review of published literature was conducted concerning hydrazine/hydrazine-derivative exposure and clinical sequelae. Priority was given to studies that described inhalation through studies of alternative routes of exposure were additionally reviewed. Where possible, human clinical presentations were prioritized over animal studies. **RESULTS:** Rare human case reports and multiple animal studies of exposures to hydrazine and derivatives provide evidence of varied clinical sequelae, including mucosal irritation, respiratory concerns, neurotoxicity, hepatotoxicity, hemotoxicity (including Heinz body development and methemoglobinemia), and longitudinal risks. In an acute timeframe (minutes to hours) of inhalational-only exposures, clinical sequelae are likely to be limited to mucosal and respiratory risk; neurological, hepatotoxic, and hemotoxic sequelae are unlikely without recurrent, longitudinal, or non-inhalational exposure. **DISCUSSION:** This presentation will highlight the acute clinical management concerns as supported by existing data. We will detail the evidence that should drive recovery medical posture for management of potential exposures. Acute rescue posture should focus on the management of mucosal irritation and respiratory concerns, including the potential need for advanced airway management. There is little evidence supporting the need for acute interventions for neurotoxicity, and there is no evidence driving a need for on-scene management of acute hemotoxic sequelae. Overemphasis on neurotoxic or hemotoxic treatments may increase the risk for inappropriate treatment or operational fixation.

Learning Objectives

1. The audience will learn about the evidence base regarding physiological sequelae of acute hydrazine exposure.
2. The audience will understand the risk stratification and time frame of likely or anticipated sequelae following acute hydrazine exposure.

[446] DYNAMIC CARBOXYHEMOGLOBIN MODEL FOR CARBON MONOXIDE EXPOSURE

Esther Putman, Diana Dayal, Jaime Mateus
Space Exploration Technologies, Hawthorne, CA, United States

(Education - Program/Process Review)

BACKGROUND: A major medical risk associated with a spacecraft cabin fire is the production of toxic combustion products. Carbon monoxide (CO) is one such product, and can be produced in large quantities even from small fires. As a competitive inhibitor of oxygen, CO binds with hemoglobin to form carboxyhemoglobin (COHb), reducing the body's capacity to carry oxygen to vital organs. In the era of commercial human spaceflight in new vehicles with unique environmental control and life-support subsystems (ECLSS), it is critical to develop dynamic models to define and address short-duration toxic exposure for diverse crew member populations, particularly for contingencies such as emergency deorbit planning in the setting of limited consumables. **DESCRIPTION**: The Coburn-Forster-Kane (CFK) equation is a well-validated method of predicting CO uptake in the blood. It captures changes in COHb, a clinically relevant indicator of carbon monoxide poisoning, as a function of CO exposure. A Python model of the CFK equation was created to model changes in COHb concentrations as a function of parts per million CO exposure and time. This dynamic model allows for user input of any cabin pressure and oxygen concentration, allowing for estimation of COHb in scenarios beyond nominal atmosphere. The model can be further customized to crew-specific physiological parameters, such as average blood volume and ventilation rate. **DISCUSSION**: Previous uses of the CFK model rely on assumptions that are often invalidated in spaceflight scenarios, such as the effect of increasing carboxyhemoglobin on oxyhemoglobin concentration which is likely invalid at higher concentrations of carbon monoxide exposure. Through a comprehensive literature review, our model sought to address assumptions that are invalidated in off-nominal atmospheres, such as mean pulmonary capillary O2 pressure. This model enables the creation of a concept of operations for fire scenarios, and can be used in real-time alongside data from CO cabin sensors to evaluate physiological risks to crew. The operational value of a robust carboxyhemoglobin model is significant, particularly for post-fire procedures and emergency deorbit timeline planning. This tool is useful for determining maximum allowable exposures for environments that are being considered for future exploration missions, such as NASA's exploration atmosphere.

Learning Objectives

1. The audience will understand how to model carboxyhemoglobin following acute carbon monoxide exposure over time.
2. The audience will understand how to customize the model to unique environmental conditions, such as NASA's exploration atmosphere.

[447] MAPPING MITIGATION RISK CONSEQUENCE FOR CREW NEEDING ASSISTANCE OR RESCUE ON THE LUNAR SURFACE

Marlei Walton[1], Jason Norcross[2], Robert Sanders[1], Storm Myers[1], Nathaniel Newby[2], Scott Ross[1]
[1]*NASA JSC, Houston, TX, USA;* [2]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Extravehicular activity (EVA) on the lunar surface presents unique risks to crew with possibility for injury. Without appropriate assistance or rescue capability, inability to nominally ambulate and return to a lander, especially during early Artemis missions, could have catastrophic consequences. Mapping likelihood and consequence safety risk associated with identified injury scenarios establishes a baseline from which to assess potential mitigation solutions to ensure crew health and safety. **METHODS:** Causes leading to the need for incapacitated crew rescue (ICR) during EVA on the lunar surface were previously identified and classified using an ICR/Acute Injury scenario spectrum. Severe scenarios are those when the affected astronaut requires either partial or full continuous assistance from the rescuer. Evaluation of these continual reliance conditions included calculating event probabilities (likelihoods) associated with an early Artemis mission and mapping them to established Exploration System Directorate (ESD) probability thresholds; safety consequences were analyzed and correlated to defined ESD personnel safety categories. These resulting likelihood and consequence values served as a baseline for assessing risk reduction of three mitigation capabilities: crew assistance (rescuer crew) only, walking assist devices, and a wheeled transport device. **RESULTS:** Of the twenty-five continual reliance conditions, ten were evaluated as "catastrophic" (Level 5, loss of life) during EVA on the lunar surface with probabilities ranging from moderate to very low during an early Artemis mission. Crew assistance only and walking assist devices showed similar potential for risk reduction, with four of the ten causes decreasing to Level 4. A wheeled transport device further increased risk reduction with six of the ten conditions decreasing to Level 4. **DISCUSSION:** Given the catastrophic consequence of several identified conditions, assessments should be performed to determine the feasibility of mitigation capabilities. It is currently unknown whether a rescuer astronaut could effectively provide continuous assistance to enable both crew to return safely to the lander from the standpoint of both suit geometry and human performance. Although resulting in an increase in resources, providing a wheeled transport provides the highest risk reduction potential, and walking assist devices may have prevention as well as mitigation benefits.

Learning Objectives

1. Learn about continual reliance medical conditions that lead to possible catastrophic consequence during an early Artemis EVA on the lunar surface.
2. Learn about consequence risk reduction associated with three potential mitigation capabilities during an early Artemis EVA on the lunar surface.

[448] USING VIRTUAL REALITY AS A COUNTERMEASURE FOR ASTRONAUT MOTION SICKNESS AND SENSORIMOTOR IMPAIRMENT IN POST-FLIGHT WATER LANDINGS.

Taylor Lonner, Aaron Allred, Aadhit Gopinath, Luca Bonarrigo, Torin Clark
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: Prolonged microgravity exposure results in motion sickness and impaired sensorimotor function in astronauts returning to Earth. This is caused by the reinterpretation of vestibular cues while in microgravity which produces "sensory conflicts" upon re-exposure to Earth gravity. During water landings, symptoms of motion sickness (e.g. nausea and vertigo) may become more severe when astronauts awaiting recovery are subjected to ocean wave motion in their capsule. This impairment poses increased operational risk, a decreased ability to perform tasks, and crew discomfort. Certain pharmacological countermeasures have proven effective in reducing motion sickness severity, but they have undesirable side effects such as drowsiness. This study explored the efficacy of using virtual reality (VR) to reduce motion sickness and sensorimotor impairment, relevant for post-flight water landings. **METHODS:** Gravity transitions were simulated using the "sickness induced by centrifugation" paradigm wherein subjects were exposed to 2G's in the body-centered –x-axis for one hour. The centrifuge used for this study was the Human Eccentric Rotator Device (HERD) from U of Colorado-Boulder. Following centrifugation, subjects were transferred into the Tilt-Translation Sled (TTS) where they experienced wave-like motion for up to an hour. Following centrifugation, motion sickness was quantified using the Motion Sickness Questionnaire (MSQ) in five-minute intervals, and a modified Romberg balance test was used to assess sensorimotor impairment before centrifugation (baseline), following wave-like motion, and after an hour of recovery. During wave-like motion, both experimental groups wore a VR headset. The countermeasure group (N = 4, female = 2, age = 25 ± 4.97) was shown an Earth-fixed visual scene with congruent cues of self-motion. The control group (N = 4, female = 1, age = 23.5 ± 5.74) was shown a non-moving white fixation point on a black background with no cues of self-motion. **RESULTS:** Peak motion sickness was higher in the control group (MSQ = 14.5 ± 9.15) than the countermeasure group (MSQ = 12.75 ± 5.31), and following wave-like motion, balance was worse in the control group (Pass% = 0.72) than the countermeasure group (Pass% = 0.97). **DISCUSSION:** These results suggest providing congruent visual cues of self-motion in VR can help reduce sensory conflict, mitigating motion sickness and sensorimotor impairment during post-flight water landings.

Learning Objectives

1. Understand how the sensory conflict theory relates to motion sickness in astronauts during post-flight water landings.
2. Learn how virtual reality can be used to combat motion sickness caused by sensory conflict and improve sensorimotor function after gravity transitions.
3. Consider how ground-based analogs can be used to simulate the experiences of astronauts in microgravity.

[449] ORION LIGHTING WORKAROUND FOR MAINTAINING CREW CIRCADIAN ENTRAINMENT

Matthew Lindsey[1], Carlos Dostal[2]
[1]*Naval Aerospace Medical Institute, Pensacola, FL, United States;* [2]*UTMB, Galveston, TX, United States*

(Education - Program/Process Review)

INTRODUCTION: Light is the primary environmental time cue of our endogenous circadian pacemaker. Suboptimal crew circadian entrainment (CCE) is common and associated with acute and chronic medical symptoms. Additionally, fatigue from suboptimal CCE promotes use of countermeasures such as sleep medications. The Orion Cabin Lighting System (OCLS) consists of monochromatic light-emitting diode (LED) lamps. However, light is a powerful suppressor of melatonin, and it is a disruptor of CCE if used at incorrect times. A commercial off the shelf (COTS) dynamic lighting system (COTS-DLS) is a potential workaround for maintaining CCE. **METHODS:** A literature review aided selection of appropriate COTS-DLS for maintaining CCE. Our team conducted preliminary testing utilizing COTS lighting and developed recommended concept of operations for COTS implementation. **RESULTS:** A tunable and dimmable COTS-DLS can reduce 480 nm light peak wavelength and alter lighting temperature and intensity close to desired pre-sleep lighting specifications. **CONCEPT OF OPERATIONS:** Three concept of operations were recommended based on existing studies suggesting 3 hours of pre-sleep is desired. **DISCUSSION:** COTS-DLS is a potential workaround to maintaining CCE. However, implementation requires formal testing to ensure illumination goals are met while achieving optimal lighting design and placement within operational demands. Power capability with power utility panels (PUPs) must be achieved, and PUP use must be weighed against other competing power needs to meet operational requirements. Further testing in visual performance/color discrimination, flammability, frangibility, and off-gassing must be achieved. **RECOMMENDATION:** Concept of operations 1, providing 3-hours of pre-sleep lighting with automated COTS-DLS, is recommended for optimal crew circadian entrainment due to terrestrial studies that indicate capture of the entire wake maintenance zone.

Learning Objectives

1. To consider three concepts of operations for use of commercial off the shelf lighting onboard the Orion capsule for optimal crew circadian entrainment.
2. To consider advantages and disadvantages for use of commercial off the shelf lighting onboard the Orion capsule for optimal crew circadian entrainment.

[450] DEVELOPMENT OF A DIRECTED ACYCLIC GRAPH FOR VENOUS THROMBOEMBOLISM DURING SPACEFLIGHT

Alexander Svoronos[1], Travis Lambert[2], Robert Reynolds[3], Karina Marshall-Goebel[3], Erik Antonsen[4]
[1]*University of California-San Diego, San Diego, CA, United States;* [2]*Montefiore Medical Center, Albert Einstein College of Medicine, Bronx, NY, United States;* [3]*KBR, Houston, TX, United States;* [4]*Baylor College of Medicine, Houston, TX, United States*

(Original Research)

INTRODUCTION: Recent studies have reported the development of venous blood flow stasis in astronauts along with a case of occlusive venous thrombosis during spaceflight. Subsequent investigations revealed approximately one-quarter of surveilled crew members had some degree of blood flow stasis in the left internal jugular vein. Therefore, NASA's Human System Risk Board now formally tracks venous thromboembolism (VTE) as a "concern" for human spaceflight. To investigate potential mechanisms by which exposures concomitant with spaceflight (e.g., microgravity, radiation) may contribute to VTE, we developed a causal diagram in the form of a directed acyclic graph (DAG). **METHODS:** The mechanisms by which spaceflight exposures may elevate the risk of VTE and the downstream effects on mission outcomes were critically analyzed, taking into account scientific literature and subject matter expertise consultation, and a DAG was generated. A Level-of-Evidence score for each causal relationship was assigned based on assessing the literature against a set of criteria derived from the A. Bradford Hill Causal Guidelines. **RESULTS:** The set of three main factors that predispose people to VTE (hypercoagulability, endothelial damage, and blood stasis) is known as Virchow's Triad. In constructing the DAG for VTE we articulated various mechanisms by which the principal spaceflight hazards (microgravity, radiation, closed hostile environment, isolation and confinement, distance from Earth) are thought to interact with or cause the components in Virchow's triad. We found sufficient evidence to at least speculate that fluid shifts from microgravity, compensatory alterations in hematologic indices, spaceflight atmospheric conditions, and oxidative stress/inflammation from radiation may be potential contributors to VTE development. **DISCUSSION:** Developing the DAG entailed a systematic and repeatable approach for visualizing relationships between contributing factors that may lead to VTE in spaceflight. Articulating pathways linking spaceflight exposures to VTE

risk factors and possible VTE development enables subject matter experts from different domains to construct a shared mental model. Assignment of levels of evidence scores to the relationships helps identify knowledge and capability gaps that should be considered for further investigation. Furthermore, the DAG highlights modifiable variables and may therefore facilitate the development of new VTE risk mitigation strategies.

Learning Objectives

1. The audience will gain an understanding of how exposures concomitant with spaceflight (e.g., microgravity, radiation, spaceflight atmospheric conditions) might influence the risk for venous thromboembolism.
2. The audience will gain an understanding of what directed acyclic graphs are and their utility in the assessment of spaceflight-associated risks.
3. The audience will be shown how the process of constructing a directed acyclic graph and assessing levels of evidence within the graph fosters critical insights that may reveal otherwise unrecognized mechanisms contributing to a spaceflight risk, along with knowledge and capability gaps, and Earth-based analogs for their assessment.

Thursday, 05/25/2023 ***1:30 PM***
Napoleon Ballroom A1-B3

[S-81]: PANEL: EXTENDED REALITY APPLIED TO AEROSPACE MEDICINE AND HUMAN PERFORMANCE

Chair: Brennan Cox

PANEL OVERVIEW: *The next generation eligible for careers in aviation and aerospace medicine will have grown up during a period in which immersive digital technologies transitioned from "pie-in-the-sky" concepts to commercially available, household staples. With dozens of eXtended Reality (XR) devices on the market, current and future users are busily exploring the realm of possibilities offered through Augmented, Virtual and Mixed Reality (AR/VR/MR). As the name implies, XR effectively extends reality by blending real world and computer-generated experiences, most readily with head-mounted devices. These tools are not just for entertainment, but also hold great promise for reshaping how we plan, execute, and understand the nature of complex tasks. As such, they are already being employed across aerospace, military, and medical environments for training, logistics, situation awareness, and human performance enhancement, among other applications. This invited panel provides five presentations on research and practical considerations of XR in areas of aerospace medicine and human performance. Using a human systems integration framework, panelists will incorporate the domains of human factors engineering, personnel, training, safety, and habitability in their discussions. The first presentation introduces XR devices, their unique characteristics and features, and how users should evaluate their overall utility. The second presentation gives insights on the use of XR for assessing individual differences and performance constructs that are difficult (if not impossible) to measure through traditional means, with applications to personnel selection and classification. The third and fourth presentations will focus on the training domain, to include meta-analytic evidence supporting transfer of training, as well as a case study on the operational use of XR for training student naval aviators. The final presentation will explore how XR can inform and enhance aviation safety and mishap investigations. This panel will conclude with audience discussion on the current state and future use of these technologies, with an eye toward the next generation.*

[451] EVALUATING EXTENDED REALITY DEVICES

Mike Lowe
Naval School of Aviation Safety, Pensacola, FL, United States

(Education - Tutorial/Review)

INTRODUCTION: This presentation will provide an overview of extended reality (XR) and a multifaceted approach to evaluating XR systems. Specifically, this lecture will identify technological components, system requirements, and Human Factors (HF) considerations that support successful employment of XR systems. **TOPIC:** Technological advances in virtual, augmented, and mixed reality (VR, AR, MR) has led to significantly more powerful, affordable, and lighter systems. As these technologies have matured, the term extended reality (XR) has become the nomenclature used to refer to any combination of VR, AR, and MR. These developments have led to XR being an increasingly attractive tool to support tasks such planning, training, rehearsing, and the conduct of operations. From aviation to maintenance to health care, XR has the potential to meet a variety of needs. To determine if XR is appropriate to meet these needs, it is critical that practitioners understand the technological and human centric requirements for assessing XR capabilities. **APPLICATION:** As the confluence of the real and synthetic environments, the application of XR is dependent on users' ability to understand and operate in this blended space. While technological assessments within prescribed engineering specifications are relatively straightforward, HF considerations present challenges to the acceptance and utilization of many systems. XR is not immune. For example, it can be difficult to define and assess the immersion and presence required to facilitate the accurate perception and understanding of information presented in XR. Further, assessment of the performance of actions in a naturalistic manner in XR can be complicated and subjective. Ultimately, the successful evaluation of XR requires an interdisciplinary understanding and approach. The lecture presented here provides a framework that describes the unique characteristics and features of XR technology, and the HF considerations needed for comprehensive evaluations. From a technological perspective, the framework identifies capabilities such as tracking, controls, interactivity, design, and display requirements. From the HF perspective, the framework introduces concepts that explain physiological, psychophysiological, perceptual, cognitive, and user acceptance considerations. Using both perspectives, the framework offers an actionable methodology to examine XR systems for a wide range of applications.

Learning Objectives

1. Participants will learn about specific technological requirements for XR systems.
2. Participants will learn about Human Factors and Human Computer Interaction considerations that must considered when evaluating extended reality technologies.

[452] ASSESSING INDIVIDUAL DIFFERENCES AND PERFORMANCE IN VIRTUAL REALITY: APPLICATIONS FOR PILOT AND PERSONNEL SELECTION

Alexandra Kaplan, Brennan Cox
Naval Medical Research Unit-Dayton, Dayton, OH, United States

(Education - Program/Process Review)

BACKGROUND: Virtual Reality (VR) has the ability to evoke and measure human behaviors in ways that traditional assessments cannot. This is due to the immersive nature of VR as well as the ability to incorporate physiological measures directly into VR-based scenarios. The next generation eligible for careers in aviation and aerospace medicine has grown up in an era during which VR devices have expanded use beyond entertainment, to include use in organizational business practices. One particular area in which VR holds practical utility is personnel selection, as VR provides a mechanism through which candidates can be exposed to job-relevant scenarios while both active and passive assessments of individual differences and performance may be obtained. **DESCRIPTION:** VR provides a modality for measuring constructs that underly the decision process behind a person's behaviors and responses. For instance, many VR devices include eye tracking capability, thereby enabling pupillometry assessments of gaze, scan, fixation, workload, and even stress state, with eye tracking data indicating which elements within the VR environment the person attends to, skips over or returns to, or outright ignores. These data can better inform personnel experts of candidates' decision-making processes, to include how easy or difficult

it was for them to arrive a decision/response. Such assessments would be especially useful in aviation, where success relies on skills involving psychological constructs that cannot be directly measured, such as fuzzy decision-making skills, prioritization strategies, and spatial reasoning. The more precise and scientific we are about measuring what *is* observable (e.g., time-to-decision, eye movements, pupillometry, hesitation, answer choices), the more inferences we can make about constructs that are *not* technically observable (e.g., decision-making strategies, stress-related performance decline) but give rise to observable behavior. **DISCUSSION:** A shortcoming of traditional testing methods is that the final answer does not reveal the person's decision-making process. Researchers in the assessment domain are rapidly investigating how psychological constructs such as testing strategy can be elicited via VR. This presentation will discuss published and ongoing research efforts and propose future directions for the use of VR as an assessment for pilot and personnel selection.

Learning Objectives

1. Participants will learn about the psychological constructs that VR can evaluate in personnel selection assessments that are not currently fully captured in traditional testing methods.
2. Participants will learn about physiological indicators that can be registered while a VR task is performed.

[453] THE USE OF XR-BASED TRAINING: META-ANALYTIC SUPPORT

Ben Sawyer[1], Alexandra Kaplan[2]
[1]*University of Central Florida, Orlando, FL, United States;* [2]*Naval Medical Research Unit-Dayton, Dayton, OH, United States*

(Education - Program/Process Review)

BACKGROUND: The value of Extended Reality (XR) as a training tool has been fiercely debated. While its benefits are numerous, the integration into existing training pipelines is sometimes questioned due to the possibility of negative transfer. Due to the training taking place in a different (virtual) environment compared to the eventual real-world performance, both the principles of encoding specificity and state-dependent learning indicate that training transfer may be impacted. However, recent meta-analytic efforts have shown that training transfer from XR is, on average, no lower than training transfer from other, more traditional training methods. When studies, and fielded technologies, underperform new research calls out the vital need for training in XR use, and human-centered design of XR technologies and platforms. **DESCRIPTION:** Transfer of training can be measured through the Transfer Effectiveness Ratio (TER) which examines the efficiency of time spent training in a virtual environment. Additionally, training effectiveness is often measured in straightforward real-world performance outcomes. Performance outcomes was the focus of a recent meta-analysis that supported the integration of XR technologies into training pipelines as an addition to in-person training, or a replacement wherever the inclusion enhances safety, reduces time needed, or conserves resources. However, not all XR training is created equally, and up-front investments in training users on the XR equipment, and XR human-centered design, pay dividends in superior outcomes. **DISCUSSION:** It has been quantitatively shown that XR-based training does not differ from traditional training methods in terms of TER. Therefore, benefits such as safety, financial, and time savings can and should be taken into account when XR interventions are being considered. The technology is not a panacea, and as with tradition training, up-front consideration of the tools used is vital to outcomes.

Learning Objectives

1. Participants will learn about the barriers to, and benefits of, integrating XR into training programs.
2. Participants will learn about the measurement methods for determining efficacy of new, technologically advanced training interventions.

[454] NAVAL AVIATION TRAINING NEXT: INTEGRATING XR TECHNOLOGY TO ENHANCE STUDENT TRAINING

Michael Natali
Naval Air Warfare Center Training Systems Division, Orlando, FL, United States

(Education - Case Study)

INTRODUCTION: With growing pilot shortages, the United States Navy (USN) is exploring new technologies and re-imagining training methodologies to create more efficient and effective aviation training. The rapid advancements in capability, utility, and fidelity of extended reality (XR) technologies are facilitating this innovation by providing low cost and immersive environments for learning. Under the term "Naval Aviation Training Next (NATN)", the USN is integrating XR technologies across its aviation training via experimental syllabi designed to capitalize on the advantages provided by these new tools. **BACKGROUND**: While integrating XR within training, an adage was quickly adopted: "New technology added to old training methods only equals more expensive training; but new technology integrated into a new training method can achieve more efficient training." XR technologies offer new and exciting capabilities but they are not a "silver" bullet that will fix a training system – they have to be leveraged appropriately to optimize their strengths and recognize their weaknesses. **CASE PRESENTATION:** NATN redesigned training around psychology-based principles to integrate XR technology. These "3 ½ Guiding Principles" provide the foundation that allows XR to enhance training: 1. Competency-based Training – guiding students towards mastering skills instead of just performing them via: Focus on underlying behavioral skillsets, not just specific aircraft technical skills; Students progress as they display competence in a skill. 2. Cyclical Learning – providing practice throughout the syllabus, cycling back to previously learned skills for repetition across a wider variety of situations. 3. Cohesive Cohorts – students grouped into small, cohesive cohorts with structured characteristics. 3.5 Technology Updates – integrating XR systems. **DISCUSSION**: By adopting these principles, the Navy has been able to leverage benefits provided from XR such as tailored learning, higher repetition, greater training immersion, and improved skill mastery. Studying results of the operational use of the NATN methods with XR technology shows students are reaching equal or better performance in less time, with fewer flight hours, while attempting more difficult events, i.e., NATN training is more effective and efficient. These positive findings demonstrate that by integrating new technologies with new methods, the Navy is now producing better aviators.

Learning Objectives

1. Participants will learn about the development and need of new methods based in psychology-based learning principles for leveraging extended reality benefits for training.
2. Participants will learn about how extended reality has been adopted in aviation training and how it has affected student performance.

[455] THE USE OF EXTENDED REALITY TECHNOLOGY IN AVIATION MISHAP INVESTIGATIONS: CONCEPT IN PRACTICE AND TRAINING

Michael Lowe, Eric Carroll
Naval School of Aviation Safety, Pensacola, FL, United States

(Education - Program/Process Review)

BACKGROUND: The Naval School of Aviation Safety (SAS) is an echelon three command under the Naval Safety Command and is the training command for educating Aviation Safety Officers (ASO) and leaders in several areas of safety, including hazard identification, risk management, mishap investigations, reporting and how to develop the Safety Management System in their squadron or wing. A key

function that SAS serves is with fleet support regarding all aviation safety matters. A necessary, though unfortunate, portion of SAS's instructional time is on the mishap and its immediate aftermath. With the maturing of extended reality technology, two areas that could lend itself quite efficiently when focusing on aviation mishaps will be discussed. **OVERVIEW:** Extended reality can enhance Aviation Safety directly in two ways. The first way is the investigation of mishaps. Often, a limited number of officials are allowed at mishap sites due to a variety of reasons, such as safety and inaccessibility. In those cases, the members of the Aviation Mishap Board (AMB) are relegated to photos and videos of the crash site as the only means to visualize and develop a mental model of what occurred. The second way comes once we achieve this capability. Previous mishaps can be fully utilized when training our ASOs in-house. SAS already has a physical "crash lab" where students can walk around previous mishaps, gaining insight on a factor or series of factors leading to the mishap. But benefit is limited as the mishap is a recreation in a sterile hanger environment. **DISCUSSION**: Recent mishaps have demonstrated the usefulness of drones to collect key and vital information regarding the mishaps and can even help inform the timeline immediately before the mishap. With this data becoming more readily available and combining it with other data, such as the flight data recorder and other aircraft performance measures, the natural next step would be to create a virtual environment where the AMB member can step immersively into the scene. With the enhancement that the various extended reality capabilities can offer, these educational opportunities can be fully maximized, producing better trained and prepared safety professionals.

Learning Objectives

1. Participants will learn about the conceptual use of Extended Reality in Aviation Mishap Investigations.
2. Participants will learn about the potential use of Extended Reality in the education and training domain for Aviation Safety Officer Certification in the Safety Management

Thursday, 05/25/2023 ***1:30 PM***
Nottoway & Oak Alley

[S-82]: POSTERS: SPACE MEDICINE POSTERS 2

[456] FLIGHT SURGEON SURVEY RESULTS REVIEW: LONG-DURATION ARTEMIS MEDICAL SYSTEM CONOPS

Takuma Ishibashi[1], Andrew Bushong[2], James Locke[3], Christopher Haas[3]
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(Education - Program/Process Review)

BACKGROUND: The Artemis Mission Functional Medical Concept of Operation (ConOp) is an operational document that describes the functional medical capabilities and concept of operations for early Artemis missions of around 30 days duration. It is currently under revision for longer missions (180+ days), aiming to build a foundational diagnostic and treatment capabilities list considering mission parameters, crew selection and training, and mass/volume constraints. An interview of NASA operational flight surgeons was completed to start the revision of the medical ConOp. **METHODS:** In the survey, 20 experienced NASA flight surgeons responded to 57 standardized questions covering 17 categories, 22 questions of which were covered in this analysis including 4 categories: Cardiovascular, Catastrophic Situations, Pulmonary, and Respiratory/O2 Support. These results were categorized into recommendations and observations. The recommendations were used to objectively quantify the responses to look for consensus, differences and uncertainty among responses. The observations remain important but were not included in this review. **ANALYSIS:** Regarding questions related to changes in medical conditions treated for long-duration missions, percentage of "No Change" responses varied from 20% to 75%. In the "Change" treatment plan responses, a variety of recommendations were made, which were further analyzed through graphical analysis. Additionally, recommendations on capability questions in multiple systems were visualized within one product. **DISCUSSION:** This work demonstrates the importance of collaboration and thorough analysis amongst experienced NASA flight surgeons to help establish medical systems and contributing to the likelihood of mission success during Artemis long-duration missions. Through this review analysis, we were able to identify some positive attributes and areas for improvement, which will facilitate further discussions.

Learning Objectives

1. The audience will learn about collaborative and comprehensive approach for helping establish medical systems during Artemis long-duration missions.
2. The participant will be able to understand the importance of a systematic approach to objectively quantify NASA flight surgeon interview responses to look for consensus, differences and uncertainty.

[457] PERCUTANEOUS CHOLECYSTOSTOMY TUBES AND LONG DURATION SPACEFLIGHT

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(Original Research)

INTRODUCTION: Cholecystitis is one of the most common surgical pathologies, with an incidence of 1 in 10 people presenting with an infected gallbladder in their lifetime. Cholecystectomy is the mainstay treatment. However, modalities such as antibiotics and percutaneous cholecystostomy tube placement have been proposed as definitive alternatives in environments where surgery maybe limited, such as space travel. We reviewed the outcomes of percutaneous cholecystostomy tube (PCT) placement to assess the utility of the procedure during spaceflight. **METHODS**: A literature review involving 30 peer reviewed articles was completed to describe the use of PCT, its efficacy, and patient outcomes following procedure. We evaluated benefits, or lack thereof, for PCT during space flight. **RESULTS**: Terrestrially, the main indication for PCT placement is inability to tolerate cholecystectomy. Symptoms usually resolve within 4 days following placement, with concomitant antibiotic administration. Mean tube indwelling time was approximately 71 days. Cholecystitis recurrence rate was 15% at 2 months following PCT placement. Complication such as mortality from sepsis, hemoperitoneum, and tube malfunction ranged 39-46%. There is no consensus on optimal timing of tube placement. On average, 32.9% of patients required cholecystectomy. **DISCUSSION**: Long term success rates of PCT for cholecystitis is poor, as patients continued to require antibiotics and the high rates of recurrence without subsequent cholecystectomy. In cislunar space, the return to Earth for definitive procedure maybe achieved even prior to completion of required antibiotics dosage needed with PCT. However, with missions to Mars, PCT is most likely inadequate. Surgical capabilities and expertise should be seriously considered for long duration spaceflight.

Learning Objectives

1. The audience will understand the utility of percutaneous cholecystostomy tubes and outcomes associated with its placement.
2. The audience will understand the benefits of cholecystectomy over percutaneous cholecystostomy tubes during spaceflight.

[458] EVA DATA AND ASSOCIATED MEDICAL EVENTS IN THE PUBLIC DOMAIN

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(Original Research)

INTRODUCTION: Since 1965, NASA has conducted Extravehicular Activities (EVA) in Earth's orbit, transEarth, and on the lunar surface. Astronaut medical events are commonly caused due to activities performed during an EVA and the EVA suit itself. Currently, no comprehensive database is dedicated exclusively to EVA-related medical events, but information exists in other sources. **METHODS:** Study data were collected from publicly available sources including: NASA Historical Archives, Existing Databases, Publications, Oral histories, Astronaut Biographies and Astronaut Debriefs. To address credibility, we created a 4-question credibility tool to assess the quality of sources used in this study. This tool was modified from existing DISCERN and Stanford Credibility tools. and produces a credibility score ranging from 1 (low credibility) to 3 (highly credible). **RESULTS:** EVA medical information from the Gemini, Apollo, and Skylab missions were found using public domain sources. We identified 23 medical events during these three eras. Resources such as the NSSDCA were scored at a 3 (high reliability), while other sources, such as Spaceflight Now or Space.com, were ranked as a 2 and 1 (low reliability), respectively. EVA medical sources such as Scheuring et al., Diaz et al., and Ramachandran et al. ranked at 2.5. Overall sources used had a combined mean rank of 2.7. MSK injuries are the most common and frequently reported issues. Injuries were predominantly on the hands, feet, shoulders and arms. Lunar surface medical events were predominantly MSK in nature, but instances of tachycardia, and tachypnea were also reported during lunar excursion. The incidence rate of MSK injuries from 1965 to 2009 was 0.26 injuries per EVA, with the EVA suit being the second most common cause on injury. **DISCUSSION:** Initial data is comprehensive, but questions remain on data validity due to the relationship between astronauts and flight surgeons. Astronauts may withhold information for fear of putting flight status in jeopardy. This is evidenced by recorded instances of crewmembers experiencing in-flight medical events but not disclosing these instances until retirement. Following Skylab, EVA medical information, was much more challenging to obtain likely due to federal protections of medical information, such as The Privacy Act of 1974 and the Health Insurance Portability and Accountability Act of 1996. However, these laws do not protect deceased astronauts.

Learning Objectives

1. The audience will learn about common medical events experienced by astronauts during extra vehicular activity.
2. The participant will be able to understand the risks associated with future lunar excursion events and possible mitigation strategies.

[459] SPACE RADIATION INDUCED CARDIOVASCULAR INFLAMMATION & COAGULATION VIA PROTEOMIC ALTERATIONS

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(Original Research)

INTRODUCTION: The exact health implications of prolonged exposure to space radiation, known as Galactic Cosmic Rays (GCRs) is largely unknown in humans. Previous studies utilizing mono-energetic components of GCRs displayed minimal cardiovascular degeneration in mouse models long-term. Efforts in future investigations to mimic the space radiation environment through exposure to sequential GCR components resulted in increased damage to the cardiovascular system than individual components. This study exposed healthy mice to simplified $GCR_{5\text{-}ion}$, and aims to acquire a mechanistic understanding of how space radiation alters cellular processes that may result in cardiovascular inflammation & ultimately coagulation via proteomic alterations in the plasma of experimental mice. **METHODS:** The plasma of male C57BL6 mice that were exposed to 150cGys of $GCR_{5\text{-}ion}$ at the NASA Space Radiation Laboratory (NSRL) at Brookhaven National Laboratories were analyzed at 8 months post radiation by quantitative mass spectrometry (n=10) and compared to the plasma of sham-irradiated mice. Differentially Expressed Proteins (DEPs) were identified, filtered for significance, and then analyzed based on fold change (FC). **RESULTS:** In the plasma, 456 proteins were identified, and 4 of those proteins were perturbed to a level of statistical significance using an adjusted p-value. The proteins with a FC ≥ 2 were Major Urinary Protein 20 (MUP20), Serum Amyloid A-1 (SAA1), and Glutathione S-transferase theta-3 (GSTT3). Proteins perturbed to a level of statistical significance using an unadjusted p-value with a FC ≥ 2 were various immunoglobulin components and enzymes that function in numerous metabolic pathways. **DISCUSSION:** Upregulation of SAA1, an acute phase reactant that is a known biomarker in inflammation, may indicate chronic inflammation in the vasculature. Perturbed enzymes that function as mediators within the citric acid cycle, fatty acid synthesis, xenobiotic metabolism, and inflammatory processes may indicate oxidative stress and activation of various defense mechanisms. These findings allude to irreversible alterations in the vasculature after $GCR_{5\text{-}ion}$ exposure that may increase risk of thrombus development, and may provide clarity on the health risks of prolonged exposure to space radiation in humans.

Learning Objectives

1. The audience will understand and be able to identify key cardiovascular protein groups and pathways that are perturbed in the plasma after exposure to space radiation.
2. The participant will be able to understand the potential cardiovascular risks posed to humans after exposure to space radiation.

[460] VALIDATION OF AN AUTOMATED PUPILLOMETRY DEVICE IN A MICROGRAVITY ENVIRONMENT

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(Original Research)

INTRODUCTION: Quantitative pupillometry examining pupillary constriction velocity and pupillary light reflex is emerging as a rapid, non-invasive, easy-to-use, and reliable marker of increased intracranial pressure. Automated pupillometry allows reliable and quantifiable assessment of pupillary function which may allow rapid diagnosis of intracranial pathology that affects clinical decision making. The Spaceflight Associated Neuro-ocular Syndrome (SANS) is a constellation of findings affecting intraocular pressure, intracranial pressure (ICP), optic disc edema, globe shape, and more. Per our review, automated pupillometry has been suggested, but not yet deployed in spaceflight as a surrogate measure for ICP. It is hypothesized that daily pupillometry measurements pre and in- and post-flight might serve as an early surrogate of SANS-related changes in spaceflight, and might aid in the development of future countermeasures in the management of SANS. In this study, we demonstrate the first-ever deployment and validation of the Neuroptic(™) handheld pupillometer in the microgravity environment during parabolic flight as a first step, with follow-on plans for deployment in commercial orbital spaceflight. **METHODS:** The automated pupillometer underwent standard payload integration, hazards analysis and modification so as to be compatible within the microgravity environment. The crew underwent ground testing as to obtaining measurements in the 1g environment, and was then briefed as to the parabolic flight pupillometer procedure for retrieval, power-on, positioning, measurement, power-down and

stowage. The crew then performed the pupillometry procedure in flight. **RESULTS:** The pupillometer was successfully deployed within the microgravity environment during parabolic flight. Pupillometry measurements were successfully obtained. Debris shedding from foam and plastic material from the device was not an issue. **DISCUSSION:** Based on the results of this demonstration, the NPi-300 pupillometer can successfully be used within the microgravity environment to obtain measurements in pupillary latency. The pupillometer will be deployed on upcoming commercial orbital flights to obtain regular pupillometric measurements to serve as a surrogate marker of ICP changes pre, during, and post-flight.

Learning Objectives

1. To educate the audience about the value of automated pupillometry as a potential tool for intracranial pressure (ICP) monitoring during spaceflight as a surrogate marker for the Spaceflight Associated Neuro-Ocular Syndrome (SANS).
2. To educate the audience as to the results of the first deployment and validation of an automated pupillometer in a microgravity environment.
3. To educate the audience as to next steps for deploying pupillometry during orbital spaceflight as a potential monitor for ICP and SANS-related changes during spaceflight.

[461] LSAH EVIDENCE FOR THE TREATMENT AND PREVENTION OF SPACE MOTION SICKNESS

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(Original Research)

INTRODUCTION: On average, 84% of astronauts report experiencing symptoms of space motion sickness. These symptoms are most prevalent in the first 72 hours after a transition in gravity. Symptoms commonly include nausea and vomiting (86%), anorexia and poor appetite (78%), headache (64%), stomach awareness (61%), and malaise (58%). To date, there have not been any standardized agency guidelines on the treatment of space motion sickness (SMS), or for its prophylaxis, despite its prevalence in space travel and its risk towards mission and crew. **METHODS:** De-identified data from the Lifetime Surveillance of Astronaut Health database was compiled for all astronauts comprising shuttle and ISS crews. This data was analyzed for symptoms of space motion sickness, which medications were used for treatment, how effective those medications were at symptom relief, and what, if anything, was given for prophylaxis. **RESULTS:** Of 8449 LSAH entries of space motion sickness symptoms between ISS and Shuttle missions, 79% of astronauts were either treated for SMS symptoms or were given prophylactic medications to prevent symptoms. A total of 102 astronauts (15% of the total) were considered repeat fliers, with 45 (44%) of the 102 reporting less significant SMS symptoms on their second flights compared to their first. Effectiveness was judged on a spectrum that included very effective, effective, moderately effective, somewhat effective, not effective, and unknown. Medication effectiveness for treatment of SMS symptoms and prophylaxis against SMS symptoms were compared based on the percentage of their total doses given that were each level of effectiveness. Phen/Dex 50mg/5mg, and Ondansetron all had 100% of their given doses leading to very effective prophylaxis, with Meclizine having 59.3% of its doses leading to very effective prophylaxis. However, Meclizine represented the highest percent of all very effective prophylactic medications at 39%. For treatment, Phen/Dex 12.5mg/2.5mg and Scopolamine 0.4mg were both very effective with 100% of their doses. Meclizine was very effective with 43.8% of all its given treatment doses. **CONCLUSION:** Based on these findings, Meclizine may be the most effective medication for preventing space motion sickness symptoms, while Promethazine was most effective at treating already present symptoms. However, Promethazine can lead to mission-impacting side effects that are best mitigated by combining Promethazine with Dexamphetamine in combination.

Learning Objectives

1. Treatment for space motion sickness in astronauts based on efficacy of prior treatment in Shuttle and ISS astronauts.
2. Prophylaxis space motion sickness in astronauts based on efficacy of prior treatment in Shuttle and ISS astronauts.
3. Background information on prior research regarding space motion sickness, including causes, on-Earth analogues and treatments.

[462] VENOUS GAS EMBOLISM: REVIEW TO QUANTIFY A SAFE VOLUME OF AIR IN INTRAVENOUS FLUIDS BAGS FOR SPACEFLIGHT APPLICATIONS

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(Original Research)

INTRODUCTION: The ability to create intravenous fluids (IVF) in-situ from the potable water supply of a spaceflight vehicle or habitat is a desired capability for an exploration medical system. In order to define an acceptable volume of air in IVF bags, an understanding of the volume of venous gas embolism as it relates to negative outcomes is needed. The purpose of this study is to review the literature to determine if there is a known minimum volume of gas that contributes to mortality and/or morbidity that could be used to define requirements for rapid IVF infusion in microgravity. **METHODS:** A literature review was conducted of the PubMed database using the syntax: (Venous) AND (Gas OR Air) AND (Embolism) AND (Morbidity) AND (Mortality) AND (Volume) as well as manual review of references from relevant articles. 151 articles were screened excluding partial text and pediatric articles. Studies were reviewed for identification of volume of venous gas embolism associated with morbidity and/or mortality, which identified 27 articles. **RESULTS:** Reviewed literature included animal studies, case reports, and review articles. A high variation of proposed volumes contributing to mortality was reported. The limited human data values ranged from 20 ml to 200 ml of infused air with mortality estimated to be 48 – 80%[3,4,5]. No studies evaluated human morbidity in any capacity. **DISCUSSION:** The lack of consensus on the safe volume of infused air has potential ramifications for IVF use in spaceflight as current technologies to create IVF from potable water may introduce air in IVF bags. While current microgravity infusion protocols call for the use of inline air removal filters, commercially available options have flow rate limitations that preclude rapid infusion in a resuscitation scenario. Such filters may be used in parallel to increase flow rate, but the time required to set up such a system may exclude its use during a medical emergency. Additionally, these consumable filters drive up the overall mass and volume of the medical system. Identification of a safe volume of air threshold in IVF would allow for guidelines for the in-situ production of IVF in future spaceflight vehicles/habitats.

Learning Objectives

1. The audience will understand the current limitation in fundamental understanding of air embolism during IVF infusion in spaceflight.
2. To promote study of mortality AND morbidity as it relates to volume of venous gas embolism as it will have considerable impact on resuscitation protocol in future spaceflight.

[463] 3D-PRINTED, NEGATIVE-PRESSURE NASAL GUARD TO CAPTURE AEROSOLS GENERATED DURING IN-FLIGHT NASAL SINUS AND SKULL BASE SURGERIES

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(Original Research)

INTRODUCTION: Body fluid containment presents a challenge in microgravity. Immune dysregulation, compact co-habitation and reduced clearance of environmental aerosols complicate the risk of infectious transmission during in-flight surgery, especially in the setting of aerosol-producing procedures. A number of surgical adjuvant devices has been proposed to contain body fluid from injuries or procedures with open body cavities, including the Aqueous Immersion Surgical System. However, head and neck surgery presents additional challenges given its proximity to the airway. We have designed a 3D-printed, negative-pressure device that affixes over the nose to capture aerosols generated during nasal sinus and skull base surgeries. **METHODS:** The device was designed using Solidworks modeling software and subsequently 3D-printed in durable resin. The ergonomics of the device were improved through iterative design with qualitative feedback from surgeons. The efficacy of aerosol capture was interrogated *in silica* through a Solidworks Flow Simulator model. The particles were simulated as 5 µm water droplets in air with a forward velocity of 4.5 m/s and a vacuum pressure of 16 kPa. The device was also tested in real-world, terrestrial conditions where aerosolized water was generated in the oropharynx of a mannequin and forced through the forward openings at speeds mimicking off-shoot from surgical debridement. The mass flux of aerosol escape from the device was measured using high-speed particle velocimetry. **RESULTS:** The device consists of two parts: a rigid, resin-based shell with an internal vacuum chamber encircling forward-facing instrument ports and a moldable, silicone gasket to form a seal against a patient's face. Particle velocimetry demonstrated near undetectable levels of mass flux from the forward opening when the vacuum was on compared to the control condition with the device off. The *in silica* simulation agreed with the real-world test. **DISCUSSION:** The device is a promising, low-cost intervention that works at the source to reduce the amount of aerosol released into the environment during in-flight head and neck surgery. Future work includes cadaver-based testing with device-naïve surgeons for more formalized ergonomic assessment and higher-fidelity simulation using actual debridement and drilling to generate aerosols. Future testing in parabolic flight could provide insight into the effects of microgravity currently explored only by simulation.

Learning Objectives

1. The viewers will be able to understand the challenge of body fluid containment in microgravity and the risk of infectious transmission via aerosols.
2. The audience will be able to describe a novel device to reduce the amount of aerosol emission generated by in-flight nasal sinus and skull base surgery.

[464] SIMULATING SPACE RADIATION-INDUCED CHANGES IN CARDIOVASCULAR BLOOD FLOW

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(Original Research)

INTRODUCTION: Participants in space flight missions are exposed to significantly higher doses of ionizing radiation than on Earth, damaging vascular endothelial cells and leading to cardiovascular diseases. The effects of radiation on blood vessels can be analyzed through computational modeling. Previous vascular simulations are limited in size or neglect integral components such as radiation damage and blood flow. We have developed a multi-scale methodology to model structural changes to vessels in the human heart after whole-body irradiation. **METHODS:** The vascular geometry is constructed by a fractal algorithm to generate 3-dimensional scalable vessel networks. Radiation transport is simulated with an amorphous track-structure method to model dose deposition from protons and secondary particles, mimicking the space radiation environment. The biological response of the vessels is modeled to fit experimental data. The resulting changes in blood flow are then calculated utilizing a special case of the Navier-Stokes equations, known as the Poiseuille equation. **RESULTS:** Preliminary results from our laboratory have shown the computational feasibility of calculating blood flow in a network of 17 billion vessels, approximately the size of the human body. We have also shown the feasibility of demonstrating injury in single organ systems from 2 million protons, and the relative changes in blood flow. Changes in vessel radii varied from a 5% increase to complete closure, leading to large blood flow changes in the entire network. Computations in a 128-node high performance computer cluster has an execution time of 87-CPU hours. **DISCUSSION:** Our preliminary results have shown the feasibility of demonstrating radiogenic changes in cardiovascular models. The systemic flow disruptions from small vessel injury indicates the significance of blood flow on radiation-induced cardiovascular response. Building on our current model, we plan to integrate dynamic time scales and non-local continuum methods to further analyze the effects of space radiation damage on the vascular system. Future studies in this line of research can help to understand and even prevent deleterious results of space radiation, such as coronary artery disease, atherosclerosis, and ischemic heart disease.

Learning Objectives

1. The audience will be able to understand the effects of space radiation damage on cardiovascular blood flow.
2. The audience will learn about biophysical modeling and radiation transport simulations.
3. The audience will learn about the radiobiological response of blood vessels in the space radiation environment.

[465] SURGICAL DISCIPLINES IN LONG-TERM SPACE FLIGHT

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(Education - Program/Process Review)

BACKGROUND: The new paradigm of long-term space flight rendered surgical capabilities ever more important. The goal is to go beyond the Lunar Gateway, explore outer space and make humanity a multi-planetary race by reaching Mars. During deep space travel, several factors will affect crew health, therefore mission success. Both surgical necessities and capabilities will differ from LEO (Low Earth Orbit). In addition to the microgravity encountered in LEO, long-term missions will pose the challenges of sustained radiation, and the lack of available support and equipment. **OVERVIEW:** A survey of the existing scientific literature considering the potential medical conditions that are likely requiring surgical care was conducted to estimate the relevance of surgical disciplines in preparation for future long-duration missions and to develop an integrated surgical model. Due to the long-term exposure of pathological extraterrestrial environments and factors like microgravity or radiation, a great variability of medical cases may be presented, involving a broad spectrum of surgical disciplines. Based on the severity of the manifestation, adequate conservative care may be a curative solution, however some of these conditions can develop alarming, life-threatening symptoms that will require surgical intervention either under local or general anesthesia in order to reduce morbidity or even mortality. **DISCUSSION:** This individual thorough survey of the relevant published papers to state diversification of potential on-board operative or non-operative surgical conditions from 2004 - 2022; 48 potential surgical conditions were identified: 13 cases general surgery (27.08%), 9 cases trauma-orthopedic surgery (18.75%), 5 cardiac surgery (10.41%), 3 thoracic surgery (6.25%) and other disciplines: 19 cases. Consequently, the importance of well-trained surgical specialists during long-term space flight is a crucial part of the mission. As long as robot assisted telesurgery is unavailable in space, –based on our analysis–, 4 out of the top 5 surgical conditions that are most common and most likely to occur in space (cholecystitis, appendicitis, cataract, breast lesions and abdominal wall hernia), can be treated by a general surgeon. Onboard surgical expertise will be an absolute necessity for the improved safety of future deep space missions.

Learning Objectives

1. The audience will learn about the great variety of the potential surgical cases, their pathophysiology and the surgical disciplines that may be needed for adequate medical care.
2. The listener will be able to gain a broader understanding on potential surgical specialties/knowledge necessary on a long-term mission and the surgical disciplines most needed to reduce morbidity and mortality.
3. The participant will learn about a proposed training curriculum/disciplines necessary for the potential specialty of Aerospace Surgery.

[466] INFLUENCE OF THE ACTN3 GENE ON MUSCLE HEALTH AND PHYSICAL FITNESS TO INFORM FUTURE INTERVENTIONS IN SPACEFLIGHT MISSIONS

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(Education - Tutorial/Review)

INTRODUCTION: Exposure to reduced gravity environments leads to diminished muscle size, strength, and endurance. Preservation of physical fitness is critical for mission essential tasks such as extravehicular activities, adaptation to changes in gravity loads, and crew egress from spacecraft. Current countermeasures to maintain ISS astronauts' muscle mass and fitness include dedicated time for a combination of cardiovascular exercise and resistance training. Countermeasure effectiveness is monitored before, during, and after missions. It is important to understand both environmental and genetic contributors to astronaut physical fitness. Multiple genes, including ACTN3, are known to correlate with exercise phenotypes and have the potential to help personalize countermeasures based on an astronaut's genotypic makeup. **TOPIC**: The ACTN3 gene encodes a protein expressed only in fast-twitch muscles and correlates with sprint and power phenotypes. A common polymorphism in ACTN3 gene is R577X (rs1815739), produced by a C–to–T base substitution, resulting in a nonsense mutation from arginine (R) to a premature stop codon (X) present in approximately 18% of the population. This polymorphism causes an absence of α–actinin–3 in type II muscle fibers but does not lead to a disease phenotype. The RR genotype is associated with elite athletes, especially in sprint and power sports. The XX genotype is believed to be more common in endurance athletes. The ACTN3 gene also has potential associations with training adaptation, post-exercise recovery, and exercise-associated injuries. **APPLICATION**: Understanding how ACTN3 and other genetic determinates of fitness phenotypes affect astronaut physical performance can inform personalized exercise and recovery prescriptions. For example, individuals with the RR or RX genotype may respond better to high-load and low repetition exercise, while XX may benefit from high repetition with low weight exercise. Since the wild-type protein may confer more resistance to muscle damage, those individuals with the RR or RX genotype may benefit from high intensity interval training for improved VO_2 max, whereas those with an XX genotype may benefit from low intensity, high volume endurance activity. Additionally, omics data related to health and performance could be used as biomarkers to monitor astronaut fitness and the effectiveness of training regimens during a mission.

Learning Objectives

1. Learn about the phenotypic effects on muscle function and fitness secondary to R577X mutation in the ACTN3 gene.
2. Learn how mutations in the ACTN3 gene may inform future countermeasures for future spaceflight missions.

[467] DOES SKELETAL DEVELOPMENT DURING SPACEFLIGHT RESULT IN LONGER BONES?

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(Original Research)

INTRODUCTION: Endochondral ossification is an important biological process in determining the size, shape, and mechanical strength of adult long bones that is affected by mechanical loading[1]. However, how unloading could alter the development of long bones is unclear. The purpose of this study was to determine the potential effects of long bone development of growing rodents experiencing unloading from spaceflight. The primary hypothesis of this study was that spaceflight animals would have longer bones as compared to their age and sex matched ground controls. **METHODS:** Male Sprague Dawley rats were exposed either to ground or spaceflight conditions during STS-40 and STS-58 missions for 9 and 14 days respectfully. At the time of launch, the rats were aged 8 weeks and 5 weeks old respectfully. Rodent bones were harvested postflight and length of humeri, femora, and tibae was determined by caliper. Groups were compared using a student's t-test. An average, standard deviation, and percent difference was also calculated. **RESULTS:** No significant differences were found between the length of humeri, femora, and tibae of spaceflight animals as compared to ground control animals. On average the bones of the spaceflight group were longer than the ground controls. The percent difference of the spaceflight group ranged from +1.2 to +2.1% as compared to the ground control group. **DISCUSSION:** The primary hypothesis of this study was not supported as the spaceflight animals did not have statistically significant longer bones as compared to their age and sex match ground controls. Despite of this, the finding that the spaceflight animals consistently had longer bones from a relatively short exposure to unloading may mean that longer durations would demonstrate an appreciable difference. Future work should examine not only length but other osteologic parameters.

Learning Objectives

1. How the skeleton may develop differently during spaceflight conditions at different periods of life (before vs after skeletal maturity)
2. Using NASA's Life Science Data Archive (LDSA) to conduct space medicine research

[468] CONSIDERATIONS FOR PNEUMOTHORAX MANAGEMENT IN EXPLORATION SPACEFLIGHT

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(Original Research)

INTRODUCTION: On the spectrum of chest injury that could occur during human spaceflight, pneumothorax is a serious but potentially treatable condition. Pneumothorax can be diagnosed with high fidelity using ultrasound, an imaging modality anticipated to be available on a remote exploration mission such as to Mars. Treatment strategies for this condition have been outlined for low Earth orbit and lunar platforms, but there are additional challenges presented by the resource and communication limitations of an exploration mission. **METHODS:** Terrestrial standards of care for traumatic and spontaneous pneumothorax were reviewed including the utilization of imaging for diagnosis and treatment. Reports of diagnosis and treatment of pneumothorax in austere environments were additionally considered. Available versions of International Space Station (ISS) Integrated Medical Group (IMG) Medical Checklist were evaluated for relevance of treatment plans for low Earth orbit to exploration missions. **RESULTS:** The likelihood of traumatic pneumothorax is low but increases with time of mission and potentially with the introduction of partial gravity. Primary spontaneous pneumothorax is generally thought to be of low incidence among a highly screened crew. Observation for small pneumothorax, followed by needle aspiration for large or symptomatic pneumothorax, remains a viable strategy for treatment of this condition in human spaceflight. Adjuncts for larger pneumothorax or in the case of persistent or rapid reaccumulation of air must be considered against mass and volume restrictions of the medical system. There is some evidence that ultrasound is well equipped to determine not only presence or absence of pneumothorax but also

reliably predict volume of lung collapse. **DISCUSSION:** The increasing constraints of mass and volume on an exploration mission significantly impact how far treatment options will deviate from terrestrial standard of care. Further characterizing the capabilities of ultrasound to reliably indicate the degree of lung collapse would be worthwhile as this could increase likelihood to observe and may assist with surveillance of known pneumothorax.

Learning Objectives

1. Understand how limitations in the medical system influence the pneumothorax management in human spaceflight, especially with regards to exploration missions.
2. Appreciate the gaps in knowledge that if filled would improve planning for management of pneumothorax on exploration missions.

[469] THE UNIVERSITY OF MINHO'S SPACE MEDICINE COURSE - LESSONS AND OUTCOMES

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(Education - Program/Process Review)

BACKGROUND: The future of Space Medicine will encompass a set of new challenges that we have not yet faced in these 60 plus years of human spaceflight, from the increase in accessibility that comes with commercial spaceflight to the exploration of deep space. There is a need for the development of this field, not only to address these challenges, but also to its relevance for life on Earth. This can be exemplified by the transversality of medical knowledge between the space context and intensive care patients, the use of spinoffs in our daily life, and space technologies and data for health and humanitarian purposes, to name a few. There is no denying that a try for space medicine research translates into benefits for a variety of different fields. In an effort to tackle these issues, a strive for the younger generations must be undertaken, in order to provide the needed critical mass that pushes for new initiatives and attracts funding. **DESCRIPTION:** The School of Medicine of the University of Minho's Space Medicine Short-Course (EM-UM SMSC) was created with the aim of providing students with the fundamental medical knowledge applied to the (aero)space context, as well as the impact and usefulness of Space Exploration to the life and health on Earth. The overall structure of the course consists of one week of concept introduction, composed of 45-60 minutes classes, culminating in an evaluation at the end of the week, followed by three weeks dedicated to the ideation of an academic and/or entrepreneurial group project, culminating in a presentation of the work before a jury. **DISCUSSION:** The first edition of the EM-UM SMSC was implemented between the 14th of November and the 9th of December of 2022. With this presentation, we describe the intricacies of the course, the challenges that our team faced, what went well and where there is room for improvement, as well as some of the projects thought-out by our students, detailing the different stages of development achieved.

Learning Objectives

1. The audience will learn about the Space Medicine Education efforts being undertaken in Portugal and at the University of Minho.
2. Participants will have the change to understand some of the challenges that come with implementing such a program.
3. The audience will have the chance to learn about some of the project thought out by our students.

[470] OTOLITH FUNCTION AND COGNITIVE PERFORMANCE IN COMMERCIAL SPACEFLIGHT

Victor Yang[1], Jamie Perin[2], Nabila Ali[1], Michael Schubert[1], Mathias Basner[3], Mark Shelhamer[1]
[1]*Johns Hopkins University School of Medicine, Baltimore, MD, United States;* [2]*Johns Hopkins University Bloomberg School of Public Health, Baltimore, MD, United States;* [3]*University of Pennsylvania Perelman School of Medicine, Philadelphia, PA, United States*

(Original Research)

INTRODUCTION: Human spaceflight involves the simultaneous response to multiple stressors. Astronauts are often the subjects of biomedical studies, but these are rarely examined for synergies reflecting the interaction of various adaptive processes. **METHODS**: Two sets of studies, Ocular Alignment and Cognition, were performed by 4 civilian astronauts on the Inspiration4 mission before and after spaceflight. Ocular Alignment, a measure of otolith asymmetry, is assessed with perceptual nulling to determine vertical and torsional skew. Cognition is a battery of 10 tests spanning cognitive functions including risk-taking, emotion recognition, memory, spatial orientation, vigilant attention, and abstract reasoning. We performed mixed-effects analyses of the relationships between Cognition and Ocular Alignment scores, response times, score shifts pre- to post-flight, and space motion sickness (SMS). **RESULTS**: Spaceflight and SMS were significantly associated with performance changes from pre- to post-flight on a combined 8 of 12 Alignment and Cognition tests. Similar measures of relative spatial orientation from Alignment and Cognition yielded different outcomes: while spaceflight reduced (improved) torsional misalignment by 0.31 degree (p=0.017), it decreased performance in the Cognition test of Line Orientation (0.95 StD decline, p=0.014). Directly comparing Alignment and Cognition, each degree of increased vertical skew from pre to post flight was associated with a decrease in time to complete individual Cognition tests by 0.92 StD (p=0.056). Furthermore, each degree of increased vertical skew was associated with an increase in individual Cognition test accuracy of 1.15 StD when looking at all 4 astronauts (p=0.030). This effect was driven by those with SMS (1.23 StD increase for vertical skew (p=0.050), 1.55 for torsional (p=0.050)) rather than those without. **DISCUSSION**: While SMS and spaceflight are associated with changes in Ocular Alignment and Cognition performance, comparisons between tests are important to validate results when measuring similar outcomes especially given the small sample size of astronaut studies. We find that change in ocular skew from pre- to post-flight is associated with improved Cognition performance and hypothesize that larger changes in ocular skew reflect greater vestibular adaptation to spaceflight. Further testing is needed to elucidate SMS associations with vestibular adaptation, ocular skew, and Cognition performance.

Learning Objectives

1. The participant will learn about the importance of adequate vestibular adaptation in spaceflight for cognitive functioning in commercial astronauts.
2. The participant will learn about the cognitive and vestibular health of astronauts before and after the Inspiration 4 flight.
3. The participant will be able to appreciate the synergies across astronaut biomedical studies that reveal more information than any one study alone.

[471] GALVANIC VESTIBULAR STIMULATION POSTFLIGHT SENSORIMOTOR TRAINING

Caroline Austin, Chris Yan, Torin Clark
University of Colorado-Boulder, Boulder, CO, United States

(Original Research)

INTRODUCTION: The peripheral vestibular system and central interpretation undergo changes when exposed to microgravity and must readapt when returning to a gravitational environment. During this readaptation period, astronauts experience illusory vestibular sensations of self-motion. Specifically, head tilts are perceived as larger than they actually are and can result in a sense of translation. Such illusions can lead to increased risk of spatial disorientation while in or operating a landing vehicle and can lead to degraded performance of functional tasks. This decreased performance poses a serious risk for emergency procedures and may limit astronauts' performance on the Moon following extended microgravity exposure. Previous studies have shown that the application of electrical stimulation to

the mastoids can stimulate the vestibular system and alter perception; however, it is unclear how well galvanic vestibular stimulation (GVS) can mimic the orientation misperceptions that astronauts experience post-spaceflight. **METHODS:** The study uses the Tilt Translation Sled to subject participants to a series of tilt sequences with varying roll angle and velocity GVS proportionality schemes. Electrodes are attached to the subject's (n=10, 3 F) left and right mastoids and up to 2mA of current is applied, which is coupled to the roll tilt motion. The participant's sense of orientation is reported using a subjective haptic horizontal task. This study was approved by the University of Colorado Boulder's Institutional Review Board. **RESULTS:** Preliminary results indicate that bi-lateral current can produce alterations to tilt perception during static roll head tilts. By coupling current to the amount of roll head tilt, the perception of tilt can be exaggerated, similar to the illusions experienced by astronauts post-flight. The altered perceptions of tilt appear proportional to the current applied and fairly consistent across individuals. **DISCUSSION:** The tilt overestimation induced by bi-lateral GVS is consistent with astronaut post-flight illusions, and presents a promising opportunity to develop a training tool to prepare astronauts for the illusory vestibular sensations they will feel post-spaceflight. This was the first in a series of experiments designed to inform the development of such a tool that can use IMU data to provide GVS cue stimulation in real-time and accurately recreate post-flight vestibular illusions.

Learning Objectives

1. Determine whether bi-lateral GVS can be used to reproduce roll tilt-gain illusions.
2. Gain understanding of the perceptual effects of GVS when current is proportional to roll angle and/or velocity.

Thursday, 05/25/2023 ***3:30 PM***
Grand Ballroom A-B-C

[S-83]: SLIDES: GRAVITY, IT'S THE LAW

Chair: Tom Hoffman
Co-Chair: James Elliott

[472] ACUTE DOSE-RESPONSE OF THE INTERNAL JUGULAR VEIN TO GRADED HEAD UP AND HEAD DOWN TILT

Richard S. Whittle, Bonnie J. Dunbar, Ana Diaz-Artiles
Texas A&M University, College Station, TX, United States

(Original Research)

INTRODUCTION: Microgravity induced cephalad fluid shift has recently been associated with altered jugular venous flow, including flow stasis and reversal. On long-duration missions, it has been hypothesized that this altered flow could lead to increased thrombogenicity, with a resultant elevated embolic risk. The aim of this study is to generate gravitational dose-response curves of the common carotid artery (CCA) and the internal jugular vein (IJV) hemodynamic responses using a tilt paradigm. This investigation will improve the understanding of the vascular response to altered-gravity and provide a baseline that can be used to compare the magnitude of these changes during spaceflight, as well as the efficacy of measures to counteract altered blood flow in the neck. **METHODS:** Twelve male subjects (age 27.2±2.7 years, height 179.0±8.3 cm, weight 84.7±18.7 kg) were subjected to graded tilt from 45° head-up through to 45° head-down in 15° increments, in both supine (face up) and prone (face down) positions. Ultrasonography of the left and right CCAs and IJVs, and jugular venous pressures (P_{IJV}) were recorded at each tilt angle. **RESULTS:** The cross-sectional area of the CCA, A_{CCA}, did not significantly change with tilt (p=0.262) or position (p=0.361), and there was no significant difference between the left and right sides (p=0.849). In contrast, IJV cross-sectional area, A_{IJV}, and pressure, P_{IJV}, were both highly dependent on tilt in a non-linear fashion (p<0.001 in both). Further, the right IJV was significantly larger than the left IJV (p<0.001) and expanded more rapidly with tilt than its left counterpart. P_{IJV} was equivalent in the left and right sides (p=0.775) but was significantly higher in the prone position (p<0.001). **DISCUSSION:** Gravitational dose-response models quantifying the expansion and increase in pressure of the IJV in tilt were constructed using generalized additive mixed-effects models. These dose-response curves were compared with existing data from parabolic flight and spaceflight studies, showing good agreement on an acute timescale. The quantification of fluid shift in altered-gravity informs the understanding of the pathogenesis of spaceflight-induced venous thromboembolic risk. Future investigations will collect similar data in female subjects and will compare these dose-response curves to interventions focused on reducing cephalad fluid shift, such as lower body negative pressure and short-radius centrifugation.

Learning Objectives

1. The audience will learn about quantitative changes in the common carotid artery and internal jugular veins due to altered-gravity environments.
2. The audience will learn about the relationship between spaceflight induced cephalad fluid shift and increased risk of venous thromboembolism events.

[473] AN EXPLORATION OF LOWER BODY NEGATIVE PRESSURE'S POTENTIAL APPLICATION MITIGATING SPACEFLIGHT'S EFFECTS ON MUSCULOSKELETAL AND NEURO-OCULAR SYSTEMS

Michael Gallagher[1], Jamila Siamwala[2], Sunny Narayanan[3], David Wassell[2], Erik LeRoy[4]
[1]*University of British Columbia, Victoria, BC, Canada;* [2]*Association of Spaceflight Professionals, Inc., St. Petersburg, FL, United States;* [3]*Florida State University, Tallahassee, FL, United States;* [4]*NYU Grossman School of Medicine, Manhattan, NY, United States*

(Education - Tutorial/Review)

INTRODUCTION: Lower body negative pressure (LBNP), originally designed as a cardiovascular spaceflight countermeasure, shows promise mitigating additional human spaceflight risks. This session will explore evidence for this. **TOPIC:** Bone loss in astronauts during spaceflight occurs quickly without effective countermeasures. Much lost bone mass is often not recoverable postflight. Terrestrial animal studies in which venous tourniquets were applied to the limbs of subjects demonstrated increased bone formation distal to these tourniquets, suggesting increased venous pressure could cause bone formation. Moreover, skulls of humans and other animals gain mass in space, which could be correlated with fluid shifts towards the head in space. Given these effects of fluid pressure on bone, LBNP might also help mitigate microgravity-induced bone loss by counteracting the fluid shift. Astronauts have a greater than 400% increased risk of spinal disc herniation one year after spaceflight compared with commercial and military pilots. Results of a study involving simultaneous use of LBNP and a treadmill showed reduced spinal intervertebral disc changes in astronauts, which may reduce spinal disc herniation in these individuals. In human subjects in a head down tilt position, LBNP reduced intraocular pressure back down to levels observed when they were seated. Should elevated intraocular and intracranial pressure play a key role in SANS pathology, LBNP could help mitigate this condition. Anecdotal use of LBNP on Earth also raises questions worth answering scientifically. Some athletes use LBNP in combination with compression therapy to improve post-exercise muscle recovery, though higher quality studies regarding its effectiveness are needed. Should LBNP have beneficial effects on muscles of athletes on Earth, investigating its ability to mitigate muscle loss in astronauts in space could be worthwhile. **APPLICATION:** More studies on a broader range of physiologic systems, including the musculoskeletal and visual systems, of astronauts wearing LBNP devices during space missions are warranted to clarify if LBNP can help counteract the negative effects of spaceflight on these systems. Should LBNP have a significant, positive effect on mitigating bone loss in space, it may also be effective in treating osteoporosis on Earth, which exists in a significant proportion of the elderly.

Learning Objectives

1. Participants will gain knowledge about animal studies illustrating the effects of venous pressure on bone and how this might apply to lower body negative pressure (LBNP) as a countermeasure in space.
2. Participants will learn about the potential application of lower body negative pressure to mitigate spaceflight-associated neuro-ocular syndrome (SANS).
3. The audience will gain an understanding of other ways lower body negative pressure (LBNP) is being studied scientifically and used by athletes on Earth.

[474] CHARACTERIZATION OF JUGULAR VENOUS BLOOD FLOW DURING ACUTE FLUID SHIFTS

Karina Marshall-Goebel[1], Jason Lytle[2], David Martin[2], Steven Laurie[2], Christopher Miller[2], Stuart Lee[2], Millennia Young[1], Brandon Macias[1]

[1]*NASA JSC, Houston, TX, United States;* [2]*KBR, Houston, TX, United States*

(Original Research)

INTRODUCTION: Recently, altered internal jugular vein (IJV) blood flow dynamics, including stasis and retrograde flow, were reported during long-duration spaceflight. These findings may contribute to various risks of spaceflight, including thrombosis or other risks affected by cerebral venous blood flow. To date, our understanding of cerebral venous outflow dynamics in weightlessness is limited to ~50 and ~150 days into spaceflight, and therefore, it is unknown how quickly the alterations in venous blood flow dynamics change as a result of weightlessness. The purpose of this study was to characterize the immediate effects of weightlessness on bilateral IJV structure and blood flow. **METHODS:** We investigated the effects of acute weightlessness during parabolic flight on the right and left IJV in 13 healthy subjects (7 male, 6 female, mean height: 174 ± 10 cm). Baseline ultrasound images were obtained on the ground (1G) in the seated and supine postures and during 0G parabolic flight. We used 2D ultrasound to measure IJV cross-sectional area and Doppler ultrasound to characterize venous blood flow patterns in the IJVs. **RESULTS:** There appeared to be a similar pattern of response in the left and right IJV cross-sectional area across postures and G-levels. IJV area increased from seated to supine by 0.74 mm^2 (95% CI: 0.56 to 0.91 mm^2, p<.001) and increased further during weightlessness by 0.29 mm^2 (95% CI: 0.11 to 0.47 mm^2, p=.0015). IJV Doppler images revealed stagnant flow in the left IJV in one subject during 0G exposure that was not present during on the ground in the seated or supine posture; the subject's right IJV maintained pulsatile, normal flow patterns in 0G. **CONCLUSIONS:** This study characterized the immediate effect of the weightlessness-induced headward fluid shift on venous parameters in the left and right IJV. The left IJV appears to be more susceptible to flow alterations, including stagnant flow, during both short and long-duration exposure to weightlessness that may contribute to the risk of thrombosis inflight.

Learning Objectives

1. The audience will learn about changes in venous hemodynamics during acute exposure to weightlessness.
2. The audience will learn about the significance of stagnant blood flow in the spaceflight environment.

[475] MITIGATING THE EFFECTS OF PUSH-PULL ACCELERATION IN COMMERCIAL SUBORBITAL SPACEFLIGHT

Lauren Church[1], Eleonor Frost[2], Maia Gummer[3], Chloe Mohanadass[4], Nina Purvis[5]

[1]*King's College Hospital NHS Trust, London, United Kingdom;* [2]*Aberdeen School of Medicine, Aberdeen, United Kingdom;* [3]*University College London, London, United Kingdom;* [4]*Barts Health NHS Trust, London, United Kingdom;* [5]*Queen Mary University of London, London, United Kingdom*

(Original Research)

INTRODUCTION: The push-pull effect describes blunted or altered physiological response to hyper-G following a period of <1G. This effect is well documented in aviation, particularly high performance aerobatics. There is currently little documentation with regard to its effect in commercial suborbital spaceflight, despite flight profiles suggesting a period of microgravity immediately preceding an increased-G re-entry phase. **METHODS:** A thorough literature search was conducted to review the push-pull effect in healthy physiology and pathophysiological states, which might affect an individual's experience of the effect. These literature reviews were used to form the basis of a protocol of medical screening for commercial spaceflight participants (CSPs) and a novel seat design for CSPs on board, in combination with open access documents from spaceflight providers Virgin Galactic and Blue Origin, provided by the Student Aerospace Challenge. **RESULTS:** Literature showed that the push-pull effect has been implicated in aviation safety concerns for many years. There are several disease states discovered which might limit either a CSP's +Gz tolerance (such as cardiovascular complications), or impair mitigation strategies such as anti-G straining manoeuvres (which can be affected by any neurological condition which limits movement or control of the lower limbs).It was established in the literature search that +Gx is generally better tolerated than +Gz in untrained individuals. This was integrated into the novel seat design, having CSPs seated horizontally so that +Gx was experienced on re-entry. This however was deemed implausible in crew, and therefore other mitigation strategies have been suggested. **DISCUSSION:** It is evident that the push-pull effect is not yet thoroughly documented in commercial suborbital spaceflight; this is likely due to the lack of data available given the small number of flights that have yet taken place. The integration of physiological monitoring to standard training protocols for such flights will allow a greater volume of data to be collected, further informing on the consequences of push-pull acceleration and the efficacy of any mitigations put in place.

Learning Objectives

1. For participants to understand the impact of push-pull acceleration on normal human physiology and pathophysiological states.
2. Participants to identify mitigation strategies appropriate for commercial spaceflight participants and safety-critical crew roles used in commercial spaceflight to prevent incidents directly relating to push-pull acceleration.

[476] THE EFFECT OF MICROGRAVITY ON THE HEPATOBILIARY SYSTEM AND IMPLICATIONS FOR LONG DURATION SPACE TRAVEL

Lisa Brown[1], Danielle Carroll[2], Benjamin Thomson[3-4], Jonathan Koea[5-6], Anthony Phillips[6]

[1]*New Zealand Space Health Research Center, Auckland, New Zealand;* [2]*University of Colorado-Boulder, Boulder, CO, United States;* [3]*University of Melbourne, Melbourne, Australia;* [4]*Royal Melbourne Hospital, Melbourne, Australia;* [5]*Waitemata District Health Board, Auckland, New Zealand;* [6]*University of Auckland, Auckland, New Zealand*

(Original Research)

INTRODUCTION: Microgravity induces changes to the nature of fluid flow and biochemistry within the body. The changes to the hepato-biliary system are less known but have significant implications for long duration space flight in the effort to maintain healthy human physiology. This literature review aims to highlight the research undertaken of the hepatobiliary system in microgravity and identify the implications for long duration space flight and where potential mitigation strategies could be developed. **METHODS:** A literature review was performed of medical, engineering and physical sciences databases (PubMed, Embase, Medline, Google Scholar) using search terms of 'Microgravity, Biliary, Liver, Pancreas.' **RESULTS:** A total of 63 articles were included

in the final review (N=6 human, N=39 animal, N=15 cell culture, N=2 review), including a combination of space flight studies (shuttle, ISS and satellite), bed rest, tilt table and simulated microgravity cell culture experiments. Biochemical changes within cell culture and animal studies found: significant changes of cholestasis within the liver with activation of lipotoxic pathways; reduction in hepatocyte metabolic activity; increase in ALT and AST and reduction in Kupffer cell population. These changes can be seen after just 13 days. Human bed rest studies have shown a decrease in gallbladder excretion and reduction in blood flow through the liver. The findings show reversibility after return to a gravity state. **DISCUSSION:** With the advent of long duration space flight, the implications of the changes in the hepatobiliary system is paramount in terms of considering prophylactic intervention and having strategies on board for flight. The changes in fluid flow, lipid absorption, immunotherapy changes – all can lead to an increased risk of hepatobiliary diseases in space flight including the formation of gallstones, cholecystitis, risk of pancreatitis and an increase in non-alcoholic fatty liver disease (NAFLD). Consideration needs to be given to diet modification with reduced fat during flight as well as technology available to deal with complications of biliary disease such as ultrasound training for Astronauts of the biliary tree and availability of percutaneous drains to treat septic complications.

Learning Objectives

1. The audience will learn about the effect of microgravity on the hepatobiliary system.
2. The audience will be able to consider mitigation strategies to reduce the occurrence of pathology in the hepatobiliary system during long-duration spaceflight.

[477] THE EFFECT OF SHORT DURATION BED REST ON POPLITEAL ARTERY STRUCTURE, FUNCTION, AND FLOW-MEDIATED DILATION IN OLDER ADULTS WITH TYPE 2 DIABETES

Kseniya Masterova[1], Jiefei Wang[1], Tatiana Moro[2], Elena Volpi[1]
[1]*UTMB, Galveston, TX, United States;* [2]*University of Padova, Padua, Italy*

(Original Research)

INTRODUCTION: As spaceflight becomes commercialized, those of older age and with common health conditions such as diabetes will be flying, creating unprecedented challenges in space health. Type 2 diabetes mellitus (T2DM) and inactivity individually accelerate changes related to vascular aging. These changes increase cardiovascular risk and contribute to morbidity and mortality in the elderly. It is unknown if T2DM and bed rest have an additive, deleterious effect on vascular structure and function in older adults. The objective of this study is to determine the magnitude of the effect of bed rest on vascular structure and function in older adults with T2DM compared to healthy controls and determine if resistance exercise is protective of this effect. **METHODS**: So far, we have recruited T2DM (n=11) and healthy control (n=18) subjects (age: 67.4 ± 5.6 years) to undergo five days of bed rest. During bed rest, subjects were randomized to receive intensive bedside resistance exercise physical therapy or standard of care in-bed passive physical therapy. On bed rest days 1 and 5, popliteal artery diameter, blood velocity, blood flow, and flow-mediated dilation were measured using Doppler ultrasonography. **RESULTS**: Our preliminary data shows decreased popliteal artery diameter in all groups. Resistance exercise did not prevent artery size changes in controls nor diabetics. Resistance exercise showed a trend in preventing blood velocity and blood flow reduction in both diabetic and control groups. **DISCUSSION:** This preliminary data suggests that older adults with T2DM show similar arterial structure responses to healthy controls. Resistance exercise appears to help maintain blood flow by maintaining/increasing popliteal artery blood velocity, not size.

Learning Objectives

1. Participants will be able to describe how bed rest inactivity in the older adult and diabetic population may affect vascular structure and function.
2. Participants will be able to describe mechanisms by which resistance exercise may be preventative of vascular changes due to inactivity.

Thursday, 05/25/2023 ***3:30 PM***

Grand Ballroom D-E

[S-84]: PANEL: AEROSPACE AND THE NEXT GENERATION OF CARDIAC TECHNOLOGY - USING NEW TECHNIQUES AND KNOWLEDGE TO SUPPORT AVIATION

Chair: Joanna d'Arcy
Co-Chair: Eddie Davenport

PANEL OVERVIEW: *This panel will look at new techniques and knowledge in the field of cardiology which offer opportunities to improve the care and support of aviators. The field of clinical medicine is constantly evolving, and as new technologies and practices emerge, they may offer the potential to alter the way in which aircrew are treated for their condition. Whether it is offering a new treatment option that makes a return to the cockpit possible for the first time or providing an alternative way to risk stratify aircrew to enhance flight safety, these are all exciting additions to the armament of aviation medicine. Also, as new techniques are adopted in wider clinical medicine, we must carefully consider whether there is enough evidence to support their use in aviators, or whether we cannot yet consider them suitable for a return to the cockpit. This panel will look at how new techniques and technology may support decision making and treatment for aircrew with a range of cardiac conditions. Trans-catheter techniques for valve disease present different considerations in aircrew, compared with other methods of valve intervention. Valve surgery has also continued to evolve, and the emergence of new technologies that might be more suited to aviation and space than previously is a very exciting proposition. Assessing our aviators using newer techniques will also be discussed, highlighting how they can be used to aid decision-making by AMEs and specialists alike. They may offer the potential to keep aviators flying for longer without compromising flight safety, whilst increasing our confidence that we will correctly identify those at greatest risk. This international panel of aviation-orientated cardiologists will discuss the next generation of cardiology in aerospace medicine, and how it offers the potential to open up new avenues of treatment and assessment for our aircrew.*

[478] AEROSPACE CARDIOLOGY BREAKTHROUGHS FOR THE NEXT GENERATION

Eddie Davenport[1], Norbert Guttler[2], Thomas Syburra[3], Olivier Manen[4], Dennis Bron[5], Lysette Broekhuizen[6], David Holdsworth[7-8], Joanna d'Arcy[8]
[1]*U.S. Air Force, Wright-Patterson AFB, OH, United States;* [2]*German Air Force, Cologne, Germany;* [3]*Switzerland Air Force, Luzem, Switzerland;* [4]*French Air Force, Paris, France;* [5]*Switzerland Air Force, Dubendorf, Switzerland;* [6]*Netherlands Air Force, Ultrecht, Netherlands;* [7]*Royal Army, Henlow, United Kingdom;* [8]*RAF, Henlow, United Kingdom*

(Education - Program/Process Review)

BACKGROUND: Prior to the year 2003 there was not a single military pilot flying with known coronary artery disease, bicuspid aortic valve, mitral valve prolapse, atrial fibrillation, or congenital heart disease. However, thanks to surgical and medical advances along with evidence-based data, in the year 2023, we now have pilots flying after coronary revascularization, valve repairs/replacements, pacemakers, and even congenital heart disease. **OVERVIEW:** Recent breakthroughs in aerospace cardiology have paved the way for evidence based aeromedical disposition. This collaborative effort has allowed more aircrew than ever back to flying while increasing the safety of flight. Advances in all three realms of

cardiology will be discussed to include electrical, structural, and vascular heart disease. Specific examples include atrial fibrillation, mitral valve repair, aortic valve replacement, multiple repaired congenital defects, and obstructive coronary artery disease returned to high-performance flight. **DISCUSSION:** Using aerospace cardiology as a guide, we can increase return to flight in all areas of the aerospace environment. With ongoing international collaboration between the military and civilian institutions and evidence-based practices, the future is very bright for future generations of aerospace medicine.

Learning Objectives

1. Understand the history and advancement of cardiology disposition in aircrew.
2. Learn to apply evidence-based principles in all areas of aeromedical disposition.
3. Promote and develop a sense of collaboration between aircrew and the AME/flight surgeon and medical specialist to allow return to flight for aircrew using evidence-based medicine principles.

[479] BREAKING NEWS FROM THE CARDIAC SURGERY THEATRE: THE BIONIC PILOT AND THE HOLY GRAIL IN VALVE SURGERY

Thomas Syburra[1], Eddie Davenport[2], Norbert Güttler[3], David Holdsworth[4], Denis Bron[5], Olivier Manen[6], Lysette Broekhuizen[7], Joanna D'Arcy[4]

[1]*Luzerner Kantonsspital and Swiss Air Force, Luzern, Switzerland;* [2]*U.S. Air Force, Wright-Patterson AFB, OH, United States;* [3]*German Air Force, Cologne, Germany;* [4]*RAF, Oxford, United Kingdom;* [5]*Swiss Air Force, Dübendorf, Switzerland;* [6]*French Air Force, Paris, France;* [7]*Dutch Air Force, Amsterdam, Netherlands*

(Education - Tutorial/Review)

Is cardiac surgery the death knell for aircrew's career? As we learnt during the past meetings, it is not. Still, limitations will apply. Why so often, why so many: more often than not, we just don't really know at the level of evidence-based science. Thus, the principles of precaution apply and consequently we may end up banning aircrew from flying on a rather eminence-based ponderation. Fortunately, cardiac surgery does not stand still, nor do the aircrafts, the envelopes of deployment, the flight crew licensing regulations, and the occupational profiles. More evidence is gathered after revascularization of coronary artery disease, using preferably total arterial grafting. Minimal invasive direct coronary artery bypass (MIDCAB) surgery does not require a full sternotomy anymore, therefore not impairing the stability of the thorax more than a chest tube insertion. Mitral valve repair, in trained hands, has a repair rate above 80% with outstanding long-term results, including the exclusion of the left atrial appendage at the same time, opening the doors to unrestricted licensing. Mini-thoracotomy is increasingly the standard-of-care in most cardiothoracic units for mitral valve repair. Fully implantable wireless batteryless vascular electronics with printed soft sensors for multiplex sensing of hemodynamics are tested today in USA laboratories, a promising way of obtaining real-time telemetry data from blood flow, oxygenation, and pressure [1]. We had ECG and EEG for our astronauts and aircrew in the past, we will tomorrow gather the whole cardiovascular online telemetry data, biochemical markers and many more included. Aircrew needing an aortic valve operation had the choice of aortic valve repair (in few ideal cases, in few ideal hands). For aortic valve replacement we only had mechanical prostheses (lifelong longevity but Warfarin dependent) in young age, or tissue prostheses (no Warfarin but limited longevity). Two sub-optimal options indeed, despite the latest progresses in prostheses' construction and preservation. Finally comes the Holy Grail in aortic valve surgery: the prosthesis that shall last for ever without need for oral anticoagulation. Sievers' novel trileaflet mechanical heart valve developed at Lübeck University shows ideal hemodynamics, no hemolysis at all and a thrombotic rate well below the 1% safety rule [2]. Do we stand at the doors of a game changer in cardiothoracic surgery? Future will certainly tell!

Learning Objectives

1. Understand the feasibility of established key cardiac surgery procedures in the light of flight crew licensing.
2. Learn about the latest developments in cardiac surgery and their novel lesser impact on flight crew licensing limitations.

[480] FLYING AFTER TRANSCATHETER AORTIC VALVE REPLACEMENT – CURRENT POSITION AND FUTURE PERSPECTIVES

Norbert Guettler[1], Eddie Davenport[2], Lysette Broekhuizen[3], Thomas Syburra[4], Denis Bron[5], Olivier Manen[6], David Holdsworth[7], Joanna d´Arcy[7]

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(Education - Tutorial/Review)

INTRODUCTION: Surgical aortic valve replacement (SAVR) has been an established procedure for those with severe aortic stenosis for decades and flying after SAVR is accepted by licensing authorities in Northern America and Europe. About twenty years ago, transcatheter aortic valve replacement (TAVR), also called transcatheter aortic valve implantation (TAVI), has been developed, originally for inoperable patients with high periprocedural risk. As the indication for TAVR has now expanded to intermediate- and lower-risk patients, it is discussed whether TAVR could be a suitable method for pilots and if flying after TAVR could be possible in the future. **TOPIC:** TAVR is a minimally invasive procedure, during which a new valve is inserted without removing the old, damaged valve. Mostly, a transfemoral access is used, a transapical access is also possible. **APPLICATION:** TAVR is not yet mentioned in the European aeromedical regulations. But according to the current Guide for Aviation Medical Examiners by the Federal Aviation Administration, TAVR may be considered for any flying class. It has to be specifically explained by the cardiologist why this procedure was chosen. First- and second-class applicants may be reviewed by the Federal Air Surgeon´s Cardiology Panel or Consultant after a 6-month recovery period. Randomized trials have shown noninferiority in high- and intermediate risk patients, and more recently even in low-risk patients (PARTNER 3 and EVOLUT Low Risk trials) compared with SAVR. But there are still some open questions to be answered. There are no long-term data about the durability of the prosthetic material used for TAVR. Typical unresolved issues of TAVR are paravalvular leakage and permanent pacemaker implantation. Patients with bicuspid aortic valves have been excluded from most trials. Currently, TAVR is usually recommended according to US Guidelines for patients over 65 years of age, according to European Guidelines it is recommended over 75 years of age. Between 70 and 75 years of age, TAVR can be recommended individually by the Heart Team. Although the average age of pilots has increased, TAVR is currently not the appropriate procedure for most of them. But this may change in the future, when better protheses and more data about their durability will be available.

Learning Objectives

1. Learn that novel cardiac devices which are primarily incompatible with flying may be considered for aircrew in the future, when safety and complication rates have improved, and indications have broadened.
2. Learn that the indication for transcatheter aortic valve replacement has extended to intermediate and low-risk patients.
3. Learn that transcatheter aortic valve replacement is currently recommended for older people.

[481] CORONARY CT ANGIOGRAPHY (CCTA) FOR CARDIOVASCULAR RISK ASSESSMENT IN AIRCREW

Lysette Broekhuizen[1], Joanna d' Arcy[2], David Holdsworth[2], Norbert Guttler[3], Thomas Syburra[4], Olivier Manen[5], Denis Bron[6], Eddie Davenport[7]

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(Education - Tutorial/Review)

INTRODUCTION: Screening for cardiovascular disease is of great importance in aircrew personnel and knowledge about the latest developments and recommendations on this topic is necessary for a good evaluation. CCTA has a high accuracy for the assessment of coronary artery disease (CAD) and is emerging as a valuable technique for cardiovascular risk assessment. **TOPIC:** Adverse cardiac events related to CAD can cause sudden in-flight incapacitation of aircrew which can result in extensive consequences. Therefor clarity about health hazards is desirable in aeromedicine. As CCTA has a high negative predictive value for CAD in low-risk populations this imaging technique can be used to determine who is at increased risk even before clinical suspicion arises. The predictive value for CAD of CCTA in this population is superior compared to exercise testing. The latter is no longer recommended as a diagnostic tool for CAD in the guidelines for cardiologists but data in aircrew is lacking. Exercise testing is often still used in periodic cardiac screening of aircrew despite of the low pre-test probability in this group. The ACC/AHA guidelines does recommend screening with invasive coronary angiography (CAG) in asymptomatic individuals in case of multiple cardiovascular risk factors or a borderline abnormal stress test results when performing in high risk occupations. Of course, CCTA has the benefit of a very low complication rate and can often be done with limited exposure to radiation. In recent years, the Royal Netherlands Air Force (RNLAF) has experienced a higher demand for additional screening in pilots who are older or have cardiovascular risk factors. Therefore the RNLAF is investigating whether the use of CCTA as a primary screening modality for military aircrew is more suitable then the current approach using only exercise testing (SUSPECT trial). **APPLICATION:** CCTA should be easily accessible in air crew personnel for cardiovascular risk assessment, especially if they are older (men ≥40 years) or have risk factors for cardiovascular disease (including family history). Early detection of atherosclerosis can improve individual prevention strategies.

Learning Objectives

1. Diagnostic benefits and draw backs of CCTA compared to other screening modalities.
2. When to use CCTA for primary screening purposes in aircrew, which is a population at low risk for cardiovascular disease.
3. Value of CCTA for improving preventive measures

[482] GREY ZONE APPEARANCE OF THE HEART – SUPERFIT OR PORTENT OF DISASTER?

David Holdsworth[1], Lysette Broekhuizen[2], Norbert Güttler[3], Thomas Syburra[4], Denis Bron[5], Olivier Manen[6], Eddie Davenport[7], Joanna d'Arcy[8]

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(Education - Tutorial/Review)

INTRODUCTION: Currently, there is no accepted clinical method to differentiate early heart muscle disease (dilated cardiomyopathy (DCM)) from athletic adaptation when anatomical imaging of the heart reveals borderline dilatation or borderline reduced contractile function (ejection fraction). **TOPIC:** Periodic medical evaluation, typically including 12-lead ECG recording, is a common, routine part of safety assessment for aircrew and space crew. The finding of anomalies on 12-lead ECG, or of murmurs on physical examination, often leads to further cardiac investigation including echocardiography and sometimes cardiac MRI. When imaging demonstrates either that the cardiac chambers are mildly dilated or that the contractile function at rest is mildly reduced there are two possible diagnoses. This phenotype is seen in exercise adaptation[1] or in early heart muscle disease[2]. In UK military aviation practice, the only clinical cases to remain undiagnosed after cardiovascular assessment of >500 aircrew were all borderline dilated hearts with borderline reduced contractile function. This phenotype has been termed the 'grey zone'[3]. Surprisingly, there exists no reliable method to differentiate the two extremely different clinical entities. The only suggested technique to date is exercise echocardiography. An exercise induced increase of at least 12% in the left ventricle ejection fraction (LV EF) or reaching a peak exercise LV EF of >63% has been reported to provide 77-83% sensitivity respectively for identifying DCM[4]. **APPLICATION:** The UK military aviation medical service now routinely uses cardiopulmonary exercise testing as an integral part of cardiovascular assessment for grey zone cases. In this session, a summary of the clinical exercise test findings of the first consecutive 30 cases will be presented.

Learning Objectives

1. The audience will learn about the frequency and challenge of the 'grey zone' left ventricle finding in aircrew (borderline dilatation and reduced contractile function). This common problem currently leads to the occupational restriction of extremely fit pilots and non-pilot aircrew whose adaptation to exercise includes physiological cardiac enlargement.
2. The audience will learn about the current limitations to diagnosis in this common and challenging clinical scenario and some approaches of exercise-based clinical tests.
3. The audience will learn about the promising initial findings of UK Defence Aviation medicine clinicians performing cardiopulmonary exercise testing to discriminate early heart muscle disease from athletic adaptation.

[483] A HIGH-PERFORMANCE PILOT WITH AN INTERESTING ELECTROCARDIOGRAM

Denis Bron[1], Joanna d'Arcy[2], David Holdsworth[2], Norbert Güttler[3], Thomas Syburra[4], Olivier Manen[5], Eddie Davenport[6], Lysette Broekhuizen[7]

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(Education - Case Study)

INTRODUCTION: Aeromedical cardiology examination is a challenging process. New medical findings may play an important role in the relationship between the Aeromedical examiner und Aircrew member. **BACKGROUND:** In the routine annual medical examination process at the Swiss Air Force Aeromedical Centre in Duebendorf an ECG is required at regular intervals. **CASE PRESENTATION:** A 49-year-old F/A 18 pilot was found to have a new bifascicular block (left anterior hemi-block (LAHB) and Right Bundle Branch Block (RBBB) on screening ECG during an aeromedical examination in 2016. The previous medical history was

uneventful except for lumbar discal hernia. He did have history of G-lock with crash. The pilot was made temporarily unfit to fly while cardiac examination was done. Echocardiography demonstrated normal structure, function and ejection fraction. He had normal exercise ergometry and unremarkable cardiac MRI. Electrophysiological investigation showed discrete prolonged HV interval. The pilot also showed normal performance in the centrifuge with no cardiac abnormalities. After six months of temporary unfit, solo fitness to fly was granted with a waiver. No new cardiac abnormalities have been observed since 2016 during annual cardiac re-evaluations. **DISCUSSION:** Our case shows the alertness of the Aeromedical examiner in finding new ECG-abnormalities. Specific clinical warning symptoms were absent and further examinations could find any cause for a the bifascicular block. This case demonstrates another successful application of the risk calculation matrix used through the occupational cardiology working group NATO WG HFM-316.

Learning Objectives

1. Professional relation to Aircrew is an important factor for aeromedical examination.
2. Frequent ECG recording during aeromedical examination is necessary and useful.
3. Following procedures HFM-316 recommendation is useful.

Thursday, 05/25/2023 ***3:30 PM***
Napoleon Ballroom C1-C2

[S-85]: PANEL: CARDIAC ARREST IN THE AIR TRANSPORT ENVIRONMENT: WHAT'S NEW?

Sponsored by Aerospace Human Performance Committee

Chair: Keith Ruskin
Co-Chair: Carlos Salicrup

PANEL OVERVIEW: *Eight million passengers fly on a commercial airline flight every day, and approximately 130 will experience a cardiac arrest during that flight. Rapid recognition of the event and high-quality cardiopulmonary resuscitation (CPR) are critical to survival after cardiac arrest. Factors that can affect this outcome include the availability of rescuers, application of an automated external defibrillator, and possibly diversion after successful resuscitation to provide access to a higher level of care. In some cases, the first responders to in in-flight cardiac arrest may be a medical student or resident, and at least one study suggests that skills with a demonstrated impact on the survival, including depth of chest compressions, and performance of shocks using an AED were retained 42 months after CPR training. This educational panel will provide an overview of the management of in-flight cardiac arrest. After a review of the relevant physiology and the available resources, additional presentations will discuss the development of cognitive aids for volunteer rescuers, how medical students and residents can respond to a call for medical assistance, and offer insights into how flight crews respond to medical emergencies during flight. The panel will also discuss the incidence of cardiac arrest in airports and the use of automated external defibrillators in that environment.*

[484] A PASSENGER JUST ARRESTED! WHAT DO I DO?

Keith Ruskin
University of Chicago, Chicago, IL, United States

(Education - Tutorial/Review)

INTRODUCTION: The average incidence of out-of-hospital cardiac arrest (OHCA) among adults is 55 per 100,000 person-years. Although overall survival after OHCA is poor, early recognition, high quality CPR, and use of automated external defibrillators (AED) have improved survival and long-term outcomes. Although cardiac arrest during commercial airline flights is relatively uncommon, the unusual setting, limited resources, and variability of volunteer rescuers' skills present unique challenges. **TOPIC**: Volunteer rescuers and cabin crew should perform CPR in accordance with the most recent guidelines as published by the American Heart Association. Survival after a witnessed arrest with a shockable rhythm has improved in patients who are treated promptly. After starting CPR, an AED should therefore be applied as quickly as possible, and rescuers should follow the instructions given by the device. After return of spontaneous circulation (ROSC) is obtained, the AED should remain attached to the patient for the duration of flight to monitor the cardiac rhythm and to deliver additional shocks should another cardiac arrest occur. Because chest compressions cannot be continued during an emergency descent, AsMA guidelines recommend that the flight be continued until either ROSC has been obtained or attempts at resuscitation have been terminated. At least one study has shown that more effective chest compressions are delivered when volunteer rescuers breathe supplemental oxygen to mitigate hypoxia caused by reduced cabin pressure during cruise flight. Attempts at cardiac resuscitation should continue for as long as the AED detects a shockable rhythm or until the Universal Termination of Resuscitation Guidelines recommend discontinuation of CPR. **APPLICATION:** Early recognition and treatment of cardiac arrest during an in-flight cardiac arrest can improve the likelihood of survival. Successful resuscitation is possible if volunteer rescuers are flexible and can adapt to the unique environment and limited resources in a commercial airline cabin. **RESOURCES:** 1. Ruskin KJ, Ricaurte EM, Alves PM. Medical Guidelines for Airline Travel: Management of In-Flight Cardiac Arrest. *Aerosp Med Hum Perform*. 2018 Aug 1;89(8):754-759. 2. Clebone A, Reis K, Tung A, OConnor M, Ruskin KJ. Chest Compression Duration May Be Improved When Rescuers Breathe Supplemental Oxygen. *Aerosp Med Hum Perform*. 2020 Dec 1;91(12):918-922.

Learning Objectives

1. Participants will understand how the unique environment of a commercial aircraft cabin affects their ability to provide CPR during flight.
2. Participants will be able to make effective use of the resources on board a commercial aircraft when acting as a volunteer rescuer.
3. Participants will be able to educate and develop research projects on the topic of in-flight cardiac arrest for the next generation of aerospace professionals.

[485] COGNITIVE AIDS FOR VOLUNTEER RESCUERS IN THE NEXT GENERATION RESPONDING TO CRITICAL EVENTS

Anna Ruskin
University of Chicago, Chicago, IL, United States

(Education - Tutorial/Review)

INTRODUCTION: Cardiac arrest during commercial flight is a rare event that requires immediate intervention by cabin crew or volunteer rescuers. Because cardiac arrest is an extremely rare event and occurs suddenly, rescuers may not be cognitively prepared to manage it. After initiating CPR, the likelihood of successful resuscitation may be improved if the volunteer or cabin crew access a cognitive aid. **TOPIC:** Cognitive aids that use human factors principles may help rescuers to manage a passenger who suffers an in-flight cardiac arrest or other in-flight medical emergencies such as hypoglycemia, dehydration, or major cardiac events. Critical event cognitive aids must be carefully tailored, iteratively tested, and regularly reviewed to ensure that they are meeting the needs of the next generation. When creating a new cognitive aid for a critical event, the first step is to determine the 'scope' of the cognitive aid as specifically as possible. A cognitive aid designed for too broad of a scope will contain non-relevant information will take extra time and require a greater cognitive workload to use, especially in an emergency. The next step is to carefully look at the reasons why and timing with which the rescuers will access the aid. These factors must be kept in mind when designing the aid. Beta-testing of the aid should occur during mini-simulations with actual users. Finally, the aid must be tested in the real-world, and changed frequently to meet user needs. **APPLICATION:** The meeting attendees will be taken through a detailed, step-by-step discussion on

how to develop cognitive aids for an in-flight medical emergency. The framework of ensuring that the next generation of volunteer rescuers has human-factors informed cognitive aids for their use will be highlighted. **RESOURCES: 1.** Circulation. 2020;142(suppl 2):S580–S604. DOI: 10.1161/CIR.0000000000000899

Learning Objectives

1. To explore cognitive aids during in-flight cardiac arrest for volunteer rescuers in the next generation.
2. To look at ways to design cognitive aids for the future to meet the scope, environment, and user needs.

[486] IN-FLIGHT CARDIAC ARREST: THE FLIGHT CREW PERSPECTIVE

Carlos Salicrup
Medicina Aeroespacial, Mexico City, Mexico

(Education - Case Study)

We have in our flight plans en route alternate airports, largest length of time for an en route alternate is one hour from any critical point, for extended range flights varies from 2 to 4 hours. These "alternates" are normally used in case of a critical system failure that obligates to "land at the nearest suitable airport". These alternates comply with dispatch requirements, but in case of a medical emergency some of these may not be suitable for a passenger with a medical emergency needing a specific hospital treatment. Most of the flight crews are not aware about this situation. A medical deviation may mean to land the airplane in a non-familiarized airport, in limited or weather conditions and hitting unfamiliar approaches, factors that may lead to a mishap. For the passenger best outcome, medical deviation should be considered to places that along with meeting the technical requirements for "suitable airport" should have the best "suitable medical facility" for the type of illness. An inflight cardiac arrest is a challenge to the cabin and flight crew competencies (Communication, situational awareness, leadership, team work, workload managing, knowledge, etc…). Cabin crew with updated BLS training for these situations is a must, also AEDs/EDs with updated protocols software, and If you have the luck to find a medical volunteer on board, and if is trained and experienced managing these situations. Also if the equipment contained in the medical kits is at the minimum required (No IV lines, No IV fluids, No O2 meters, no Dextrose meters, etc.) the managing, outcome and need to deviate may be different when there's at least the minimum "goodies" that we use in EMS "attack kits" when we make first contact at the scene with a critical patient, by far-away the humanitarian and medical responsibility/quality Vs money savings for airlines haves to be considered. If as pilots, should we issue a MAYDAY (Emergency) or PANPAN (Urgency) for a medical emergency on board is also something that haves to be considered, since the safety of the airplane is not compromised but there's a life-threatening situation, acting quick but keeping the safety of all the other passengers and aircraft is always the priority. Training in mock-ups or in airplanes about how to extract an unresponsive passenger or crew member from their seat is also a must. We should have all the chance and training to offer the best medical and aviation practices to these passengers.

Learning Objectives

1. The attendee will learn about aviation alternate airports Vs Medical Alternates.
2. The attendee will learn about the implications of a medical deviation.
3. The attendee will learn about the importance of an appropriate medical kit.

[487] SHOULD MEDICAL STUDENTS AND RESIDENTS RESPOND TO AN IN-FLIGHT CALL FOR HELP?

Jaclyn Edelson
University of Chicago, Chicago, IL, United States

(Education - Tutorial/Review)

INTRODUCTION: High quality CPR and medical care in an emergency can save lives, especially when resources are limited, as during flight on a commercial airplane. This presentation will discuss who 'should' provide that care– specifically, this panel section will discuss the ethics, capability, and legal consequences of medical students and medical residents providing medical care on an airplane. **TOPIC:** During in-flight medical emergencies, resources including personnel, drugs, and equipment are limited. A medical student or resident may be the most qualified and knowledgeable person to offer assistance during an in-flight cardiac arrest. Acting as a sole provider on the ground would, however, generally be considered outside of their scope of practice, which typically requires direct supervision from a board-certified physician. This point will be explored further in consideration of the role of the ground-based medical consultation service, who may be able to supervise a medical trainee via telecommunication. The current generation of medical trainees is in a unique position to take advantage of the ground support physician because most have had formal training in and from telehealth due to the Covid-19 pandemic. Physicians-in-training may feel a personal, ethical obligation to help a fellow passenger in need, but later find that their actions are subject to legal consequences. The Aviation Medical Assistance Act of 1998 protects some healthcare professionals who volunteer to help a passenger during an in-flight medical emergency but does not protect them from the financial expense that may lead up to a 'not guilty' verdict. This point is especially relevant to medical residents/students who typically do not carry individual medical malpractice insurance and rely on their training institutions' policies. **APPLICATION:** This presentation will be directly applicable to the "Next Generation" of aerospace medicine physicians and will serve to spur discussion about medical students' and residents' roles in an in-flight cardiac arrest. **REFERENCES:** 1. Commercial Airline In-Flight Emergency: Medical Student Response and Review of Medicolegal Issues. J Emerg Med. 2016 Jan; 50(1):74-8. Bukowski JH, Richards JR. PMID: 26514306. 2. Davies M. How should I respond to an in-flight emergency? BMJ 2019; 364: j5151 doi:10.1136/sbmj.j5151

Learning Objectives

1. Debate medical student and residents' role in an in-flight emergency.
2. Examine changes in medical training due to the Covid-19 pandemic that could affect medical trainee response to an in-flight emergency; specifically changed expectations of responsibility and increased experience with telehealth.

[488] SUDDEN CARDIAC ARREST AND PUBLIC ACCESS DEFIBRILLATION AT COMMERCIAL AIRPORTS

Aditya Shekhar
Icahn School of Medicine at Mount Sinai, New York City, NY, United States

(Education - Tutorial/Review)

INTRODUCTION: Cardiac arrest results in fatal injury if effective resuscitation is not quickly initiated. Early defibrillation is associated with favorable outcomes and is uniformly emphasized in resuscitation guidelines. For many years, commercial airports have been models for public-access defibrillation and are associated with exemplary cardiac arrest outcomes when compared with other public venues. **TOPIC:** Key components of the "Chain of Survival" include timely recognition, early access to high quality CPR and defibrillation, and expedient arrival of professional rescuers. Public-access defibrillation with automated external defibrillators (AEDs) has been highly successful. Commercial airports have been described as "laboratories" for testing public health interventions designed to improve cardiac arrest survival. Airports with have been associated with significantly higher rates of bystander defibrillation and cardiac arrest survival when compared with other public venues. Other contributing factors for favorable cardiac arrest outcomes at airports include an improved likelihood of an arrest being witnessed, a large number of CPR-trained individuals willing to assist, and on-site public safety personnel and emergency medical services (EMS). **APPLICATION:** The efficacy of public access defibrillation has been validated in airports, and these lessons are currently being cross-applied to other public venues, including shopping malls and resorts. Improving access to AEDs and increasing rates of bystander AED use is a current focus of the resuscitation science community. **RESOURCES:** Shekhar AC, Ruskin KJ. Sudden cardiac

arrest in commercial airports: Incidence, responses, and implications. *Am J Emerg Med*. 2022 Sep; 59:118-120. doi: 10.1016/j.ajem.2022.07.006.

Learning Objectives

1. The participant will be able to describe the major components of the "Chain of Survival" in out-of-hospital cardiac arrest as applied to commercial airports.
2. The participant will be able to describe some of the unique factors that lead to favorable cardiac arrest outcomes at commercial airports.
3. The participant will be able to describe how airports have been used to validate public-access defibrillation for other public venues.

Thursday, 05/25/2023 ***3:30 PM***
Napoleon Ballroom D1-D2

[S-86]: PANEL: US AIR FORCE ACCESSION MEDICAL WAIVER DIVISION (AMWD) OUTCOMES EVIDENCE PANEL: US AIR FORCE SCHOOL OF AEROSPACE MEDICINE (USAFSAM) PILOT PROJECT

Chair: Ian Gregory

PANEL OVERVIEW: *Militaries over the millennia have had to determine who is "fit to serve." Military medical standards, even in antiquity, were controversial. Medical standards for entering the US military branches have been established for over two centuries. Medical standards manuals from WWII era stated that "to be effective in military service, an individual must have the capacity for sustained duty in the face of separation from home, regimentation, lack of privacy, extremes of climate, hunger, exhaustion, and threat of bodily harm." Today's Department of Defense Instruction (DODI) 6130.03 Volume 1 directs the principles behind current standards: free of contagious disease, minimal lost duty time or early separation, ability to complete military training, adaptable to all military environments worldwide, and ability to perform duties without worsening medical condition(s). The US Air Force (USAF) enlists and trains approximately 30,000 new airmen yearly. Each must meet Department of Defense medical standards, or receive a medical waiver, to attend Basic Military Training. Recruiting data indicate there are fewer qualified applicants currently present in the general US population, leading to pressure on the medical standards to meet force demands. Senior leaders want medical accession waiver staff to "take more risk" with incoming applicants. However, the level of risk currently being taken has not been fully quantified. Historically, standards have been "surrogates" for assessing health and performance. Usually, medical experience, prognosis and judgement were primary inputs to the conditions listed in the standards and waiver decisions. The Accession Medical Waiver Division (AMWD) has been focused on gaining more evidence from outcome data to inform waiver threshold determination and accession medical standards. The AMWD is also focused on quantifying the level of risk that fully qualified individuals bring to key operational measures versus those with medical waivers, utilizing data harvested from an expanding suite of outcome evidence. This 2023 panel will discuss AMWD's "pilot" project with the USAF School of Aerospace Medicine (USAFSAM) in baseline risk quantification for a first set of outcome measures, discuss the extent of the USAF's new Exception to Policy Process, and outline plans for future improvements and additions to the outcomes evidence portfolio.*

[489] DEPARTMENT OF THE AIR FORCE MEDICAL EXCEPTION TO POLICY PROCESS

Robert York, Christopher Grussendorf
U.S. Air Force, San Antonio, TX, United States

(Education - Program/Process Review)

BACKGROUND: The United States Air Force (USAF) assesses approximately 70% all applicants for accession as fully qualified and an additional 10% of all applicants as medically acceptable with waiver. Of the remaining population, 10% are medically disqualified, and 15% did not complete the application process. Despite not meeting medical standards, the line of the Air Force (i.e., non-medical senior leadership) is willing to accept additional risk in order to access exceptional individuals into the Air Force by selectively approving exceptions to policy (ETPs, specifically line exception to medical policy) requests. In 2020, the process for review of ETP requests was delegated by the Secretary of the Air Force for Manpower and Reserve Affairs (SAF/MR) to the Commander of the Air Force Air Education and Training Command, serving as the Air Force's Force Development Commander. Some ETP decision authority was also delegated to the AETC Commander; authority for some case types was retained to SAF/MR. **OVERVIEW:** The ETP board process is part of the Air Force's Talent Management process and operates to access or retain highly qualified and exceptional service members while minimizing the risk to mission and health. This session will discuss the history, authorities, current risk assessment process and known outcomes. Since the advent of the current ETP board process, 117 cases have been reviewed by the Air Education and Training Command (AETC) commander (AETC/CC). The most common case types include: vision, asthma, spinal, dermatologic, and mental health diagnoses. **DISCUSSION**: Medical standards are the intersection of evidence-based medicine and the risk tolerance of the line leadership. The ETP process allows the line of the Air Force to make decisions to access or continue service for certain exceptional service members. The current ETP board process involves dialogue about medical and operational risk, Air Force career field personnel requirements, and commander advocacy for members with desirable skills and leadership potential. The objective of these boards is to provide the AETC Commander with data and perspectives to render ETP decisions. Discussion and decisions from these boards fuel areas for future medical standards policy review, and with the increased awareness of line risk tolerance/acceptance, provide data for future medical standards decision making. Speakers on this panel will present further details on the AF ETP board process.

Learning Objectives

1. The Department of the Air Force has a process to access or continue service for aviators and others in special duties following medical disqualification. This includes review of medical risk to the mission and to the member.
2. ETP process data and trends in line of the Air Force senior leader assumption of risk is used to inform future reviews of medical standards policies.

[490] EVOLUTION OF US AIR FORCE ACCESSION MEDICAL WAIVER DIVISION DECISION MAKING PROCESSES.

Ian Gregory
U.S. Air Force, Joint Base San Antonio-Randolph, TX, United States

(Education - Program/Process Review)

BACKGROUND: The US Air Force Accession Medical Waiver Division (AMWD) was created to ensure consistent, timely, data driven accession and initial flying medical waiver decisions across the total force. For the AMWD to meet its mission, it needs to use updated data to base future decisions from. Specifically, data on the outcomes of prior waiver decisions will drive decision making for future waiver considerations. While the AMWD has always used up to date medical information to drive decisions, further understanding outcomes data will help improve the quality of occupational suitability decisions. **OVERVIEW:** The AMWD's mission is to "conduct comprehensive entrance and initial special duty occupational suitability analyses and rapidly deliver consistent evidence-based decisions to the Total Air and Space Force." The challenge presented to the AMWD so it can meet its mission while using outcomes data, is that the information systems that collect data on accession medical waivers do not naturally communicate with systems that collect outcomes data that is relevant to the operational Air Force. Desired operational outcomes include retention in the service for 1 operational tour, restrictions in ability to deploy, restrictions in ability to perform

one's job, utilization of medical care, and more. A contract was funded to get people to link the data within the different systems to analyze the likelihood of desired outcomes from those who started off with a medical waiver. **DISCUSSION:** Significant data is present showing the workload the AMWD has done over the past 3 years of its existence. Diagnoses, percent of waiver approvals, types of applicants are all well documented by the organization. Some changes in waiver practices have been made based off those numbers, and other influences. With the new information about operational outcomes from members who accessed with medical waivers, decisions can be made about future waiver practices. The project is early in the implementation phase, but increased fidelity when looking at the data will help to know if people with specific diagnoses are more or less likely to have specific outcomes that the US Air Force is interested in. Extending the project to include more outcomes and more years of cohort participants will ensure greater success moving forward.

Learning Objectives

1. Understand the mission and processes of the US Air Force Accession Medical Waiver Division when making occupational suitability decisions for members who do not meet accession and initial flying standards.
2. To learn about the different data the Accession Medical Waiver Division uses to track decisions and help inform future decisions.
3. Understand the fundamentals of incorporating operational outcome data to prior medical accession waiver decisions.

[491] OUTCOMES AND EVIDENCE – FUTURE INQUIRIES AND ANALYSES

Rodger Vanderbeek, Hernando Ortega
Accession Medical Waiver Division, Air Force Recruiting Service, Randolph AFB, TX, United States

(Education - Program/Process Review)

BACKGROUND: Occupational suitability assessments and subsequent decisions for entrance and initial special duty accessions depend upon predictive models of disease/injury progression, risk of recurrence or exacerbation, and response to occupational exposures. Suitability decisions further depend upon a robust understanding of the operational mission task requirements and environmental challenges, their performance requirements, and the required and desired human performance attributes and capabilities across the entire Air Force and Space Force Specialty Codes (AFSCs) spectrum. Gaps in knowledge across this entire spectrum remain. **OVERVIEW:** In pursuit of closing these knowledge gaps, the Accession Medical Waiver Division (AMWD) needs a larger suite of operational outcomes to accompany condition/disease outcomes, and then incorporate that larger outcome suite within ongoing studies and analyses. Evidence from those studies across a larger data set/larger outcome set will allow comparison of cohorts for both clinical outcomes of their waivered condition or disease and operational outcomes in the context of the cohort's condition/diagnoses. This larger body of outcomes (operational availability, human performance, and clinical) will provide an even larger critical evidence-base for deeper enlightenment of the impact of occupational suitability decisions across a larger number of occupations (AFSCs). **DISCUSSION:** Targeted future operational and human performance outcomes will be described along with presently utilized outcomes. Networks/data systems that are the home for some of these outcomes will be described. Ongoing work to establish new validated performance outcomes will be described. Future studies and analyses will be described along with their anticipated utilization in occupational suitability analysis and their potential to inform service and DoD policy for medical standards.

Learning Objectives

1. The audience will learn about potential operational human performance outcomes of interest to support evidence-based outcomes for occupational suitability determinations in USAF/USSF accession waivers.
2. The audience will learn about future cohorts to be submitted to an operational analysis agency for studies and analyses on those cohorts, to compare clinical, occupational and operational outcomes for cohorts and control populations.

[492] TITLE: OPERATIONAL OUTCOMES ANALYSIS: DIAGNOSTIC SUBGROUP ANALYSIS

Eduardo Rizo[1], Benjamin Clapp[2], Hernando Ortega[3], David Coulliette[4], Atheer Jaffar[4]
[1]*U.S. Air Force, San Antonio, TX, United States;* [2]*U.S. Air Force, Wright-Patterson AFB, OH, United States;* [3]*U.S. Air Force, Randolph AFB, TX, United States;* [4]*U.S. Air Force Materiel Command, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: USAFSAM Studies and Analysis pilot project proof of concept analysis linked qualified (QUAL) and waived (WAVR) enlisted accessions to outcomes of interest; 4-year retention (RET), mobility restrictions (MR), duty restrictions (DR) and medical visit counts (MVC). USAFSAM further stratified the WAVR cohort into diagnosis groups. **METHODS**: All active duty (AD) enlisted accessions from FY15 – FY18 and their waiver status, were cross referenced with AF personnel data and AF medical data to measure RET, DR, MR and medical utilization. The WAVR cohort was further divided, based on ICD code, into a MH group (ADHD, anxiety, and mood disorders), an Ophthalmic/Otic group (astigmatism, myopia, binocular vision disorders, and hearing loss), and an Atopic group (asthma, atopic dermatitis, and allergy or anaphylaxis). RET was measured at 1, 6, 12, 24, 36 and 48 months. DR were measured as days on profile and compared to total days in service, as were MR. MVC per Airman year calculated by sponsor identification divided by time in service. **RESULTS**: The 4-year QUAL group had 104,4970 individuals and had RET rates at 1, 6, 12,24, 36, and 72 months of 96.1%, 92.7%, 90.9%, 87.7%, 84.0%, and 72.1%. The WAVR subgroups ranged from 50 to just over 1250 individuals. All subgroups had unique RET rates that were equal to or greater than the QUAL group except for hearing loss (lower). MR for the QUAL group was 9.5% of time in service with a mean 35 days. Anxiety disorders and hearing loss subgroups had lower MR rates than the QUAL group; the rest were higher. DR days were 5.9% of time in service for the QUAL group. Anxiety disorders myopia astigmatism, and atopic dermatitis had lower DR rates. The QUAL cohort had an average of 12.8 MVC per year; all WAVR subgroups were higher in MVC except for hearing loss and atopic dermatitis. **DISCUSSION**: Mood disorders (207) the highest RET, 73% higher MR, 37% higher DR, 30% higher annual MVC. Anxiety disorders had 101 individuals but similar to the baseline QUAL population. ADHD (1,253) had increase of 15% for MR, 13.5% DR, and 3% for MVC. Astigmatism and binocular vision were similar to the QUAL baseline. Myopia had higher RET and had MR/DR rates similar to astigmatism. The allergy or anaphylaxis subgroup (628) had similar RET to the QUAL group but had 28% higher DR/MR rates and 20% increase in MVC. Atopic dermatitis had 13% lower DR and a 4% higher MR while asthma had a 20% increase DR and 16% increased MR.

Learning Objectives

1. Understand which conditions have represent higher medical risk and suggest the waiver threshold is appropriate.
2. Understand which conditions might be appropriate for accepting increased risk in waiver determination based on outcomes in the first term of service.

[493] OPERATIONAL OUTCOMES ANALYSIS: BASELINE FULLY QUALIFIED VS WAIVER

Benjamin Clapp[1], David Coulliette[2], Atheer Jaffar[2], Hernando Ortega[3], Rodger Vanderbeek[3], Eduardo Rizo[3]
[1]*USAFSAM, Wright-Patterson AFB, OH, United States;* [2]*U.S. Air Force, Dayton, OH, United States;* [3]*U.S. Air Force, San Antonio, TX, United States*

(Original Research)

INTRODUCTION: Medical standards have been "surrogates" for assessing health and performance. The medical literature has data on

medical outcomes. The Accession Medical Waiver Division has been focused on gaining more evidence from operational outcome data to inform waiver thresholds and accession medical standards. This proof of concept looks at an initial set of operational outcomes to establish baselines for the current application of DOD medical standards. **METHODS:** AMWD provided a list of active duty (AD) enlisted accessions from FY15 – FY18 and their medical waiver status, either qualified (without medical waiver or QUAL) or with medical waiver (WAVR). This list was cross referenced with AF personnel data and AF medical data to measure retention rate on AD, days on duty restrictions, days on mobility restrictions and medical service utilization. Retention was measured at 1, 6, 12, 24, 36 and 48 months. Duty restrictions (DR) and mobility restrictions (MR) measured as days on profile were compared to total days in service. Visits per Airman year were calculated by sponsor identification divided by time in service. **RESULTS:** The 4-year QUAL group had 104,4970 individuals while the WAVR cohort had 10,953. The QUAL cohort had retention rates at 1, 6, 12,24, 36, and 72 months of 96.1%, 92.7%, 90.9%, 87.7%, 84.0%, and 72.1%. The WAVR cohort retention rates were 96.7%, 93.9%, 92.2%, 89.2%, 85.8%, and 75.1% respectively. MR for the QUAL group was 9.5% of time in service with a mean 35 days while the WAVR group had 11.0% time on MR with a mean of 38 days. DR days were 5.9% of time in service (mean 21 days) for the QUAL group, and the WAVR group had DR days of 6.6% of time in service (mean 24 days). The QUAL cohort averaged 12.8 medical visits per year; WAVR was 13.7 visits per year. **DISCUSSION:** A baseline for these 4 outcomes was established for the QUAL cohort and compared to the WAVR cohort. WAVR had slightly higher retention rates across the board, slightly increasing over the 4-year study period. The QUAL had average MR rate, above the SECDEF goal of 95% deployability. The WAVR group was 22% higher at 11% overall MR. DR for the WAVR group were also higher than the QUAL group (17% increase). However, this study did not link waiver diagnosis to the diagnoses that produced MR or DR. The finding of 12.8 medical visits per airman per year was high for all airmen and should be further investigated, but the WAVR group had a 7% higher medical visit rate.

Learning Objectives

1. Know that observed retention rates are higher among the waivered than the unwaivered population.
2. Identify a significant (validated) concern with the admission of persons diagnosed with mood disorders prior to admission into the USAF.

Thursday, 05/25/2023 ***3:30 PM***
Napoleon C3

[S-87]: PANEL: AEROSPACE MEDICINE: ADAPT OR PERISH REDUX: CHALLENGES AND OPPORTUNITIES FOR THE AEROSPACE MEDICAL PROFESSIONAL IN THE NEXT DECADE

Chair: Stephen Altchuler
Co-Chairs: Gitika Gorthi, Paul Nelson

PANEL OVERVIEW: *This panel presents a series of views of where the practice of Aerospace Medicine is and where it is going. Much of this change is being driven external to the specialty of Aerospace Medicine, and the pressures driving change are accelerating. These include, but are not limited to, the advancement of operational missions supported, including enhanced focus on the Space Medicine mission; military and civilian. Concurrently, the practice of clinical medicine is rapidly evolving, and includes factors such as a demand for care anytime and anywhere, democratization of medical knowledge, emphasis on team collaboration, an enhanced role of precision medicine, artificial intelligence and biocybernetics, while experiencing a continued emphasis on cost containment. Additionally, the United States Military Health System (MHS) has long been the institution that disproportionately supported the specialty of Aerospace Medicine in the United States for both military and civilian domains. The MHS is undergoing the most dramatic realignment of medical support functions since the early 1950's as both operational missions and approaches to clinical medicine present increasing challenges. The profession of Aerospace Medicine must successfully demonstrate and communicate a clear Value Added Proposition (VAP) to policy makers in order compete successfully for increasingly scarce resources, regardless of whether in the military or civilian domains. This panel will review some of these challenges, suggest best practices, new models of engagement and education to maintain relevance, and describe what the requirements of the specialty will demand if we are to not only survive but to prosper. In keeping with the theme of this year's scientific program, the panel will close with a look to the future from those young people who will carry our specialty forward. The icons of Aerospace Medicine delivered to us a proud legacy to run our lap of a never ending race. The future will be built on a proud legacy of those who have come before us. As we hand off the baton to our emerging aerospace leaders, it is now up to us to engage with the remarkable young people who will soon take our place, helping set them up for success in creating an exciting future that few of us have even dreamed of.*

[494] THE FUTURE IS NOW: CHALLENGES AND CHANGES THAT WILL DRIVE CHANGES FOR THE AEROSPACE MEDICINE SPECIALISTS

Jacob Berry[1], Lawrence Steinkraus[2]
[1]*Harvard University, Cambridge, MA, United States;* [2]*Mayo Clinic (emeritus), Rochester, MN, United States*

(Original Research)

INTRODUCTION: Operations in the Air and Space domains drive support requirements, including requirements for Air and Space Medicine. Only by understanding where operations are today, and where they will be over the next several decades, can we position the specialty of Aerospace Medicine to meet the support demands of these rapidly changing air and space operations. **METHODS**: This panel will provide a review of trends in the air and space domains. It will cover current civilian and military operations, connecting policy, business trends, public and private investments, and forecasts predicting what operations may look like in the future. **DISCUSSION:** As supported operations in the air and space domains rapidly evolve, the requirements placed on aerospace medical professionals will change quickly too. Some things will change incrementally, such as the approach to aerospace medical standards or mitigation strategies for the traditionally stressors or air and space flight. Other changes will be more dramatic, including changes in health monitoring systems, biocybernetics, integration of artificial intelligence and machine learning into operational medical support, and the challenges of providing medical support for distant operations as complex networked operations drive missions far beyond the reach of traditional air and space medical support.

Learning Objectives

1. Understand some of the macro trends that will drive medical support for Air and Space Operations of the future.
2. Consider how some of the current and emerging technologies may change the way that medical support for Air and Space Operations are accomplished.

[495] RISK IDENTIFICATION, MANAGEMENT, COMMUNICATIONS: MULTI-DISCIPLINE AND MULTI-DOMAIN ENGAGEMENT DRIVE KEY AEROSPACE MEDICAL PROFESSIONAL PROFICIENCIES

Paul Nelson[1], Lawrence Steinkraus[2]
[1]*USAFSAM, Wright-Patterson AFB, OH, United States;* [2]*Mayo Clinic (emeritus), Rochester, MN, United States*

(Original Research)

INTRODUCTION: Complex systems, as discussed by Perrow, Reason, Dekker, and others, are often under-appreciated relative to

safety and mission success. To be effective, risk mitigation requires not only constant attention amidst real-world friction and demands, but also effective management and communication skills. While constructs such as the Human Factors Analysis Classification System (HFACS) aid in understanding error chains, they are insufficient in providing a global understanding of how to recognize and address complex systems prior to accidents, ensuring the pre-conditions for safer air and space operations. **METHODS**: The speakers will briefly review lessons from a high-profile failure costing many lives and millions of dollars. They will then integrate concepts such as High Reliability Organizations (HRO) theory and the Failure Mode Effect Analysis (FMEA) construct and propose a model for effective relationships and horizontal and vertical communication strategies to improve both safety and mission effectiveness. **DISCUSSION**: Many of the concepts proposed by the authors are familiar. However, as previous speakers have discussed, the domains within which the Aerospace Medicine Specialist will practice are rapidly changing. The proposed model for effective relationships and communication strategy will build upon concepts and practices that have worked well in the past but will incorporate requirements for the specialty to remain relevant and effective in the rapidly evolving future that is upon us. This talk will review options to enhance the Value-Added Proposition (VAP) for the next generation of Aerospace Medical Specialists leading and participating in a cross functional multidisciplinary team of specialists. These will drive requirements for education and training that are currently being set by the American Board of Preventive Medicine (ABPM).

Learning Objectives

1. Understand the concepts of the HRO and FMEA models, and how they may apply to the future practice of Aerospace Medicine.
2. Critically evaluate the model proposed by the authors to effectively engage with Air and Space Operations at all levels.
3. Understand that effectively communicating scientific recommendations as the Aerospace Medical Specialist will become far more challenging in an increasingly linked world where information is democratized.

[496] FOOTBALL OR FUTBOL? UPDATES FROM THE AIR UNIVERSITY: EDUCATING AN AIRMAN OR SPACE GUARDIAN FOR THE 21ST CENTURY

David Manrrique[1], Paul Nelson[2]
[1]*Air University, Maxwell AFB, AL, United States;* [2]*USAFSAM, Wright-Patterson AFB, OH, United States*

(Original Research)

INTRODUCTION: As Air and Space missions rapidly evolve, the Air University embarked upon a transformation effort in 2015 to ensure that the education system of the Air Force produced Airmen (and now Guardians) capable of leading in increasingly complex environments. Building upon educational theory, the authors will propose a sports analogy as a starting point to better understand the education requirements to produce such leaders. **METHODS:** This presentation is built upon several prior presentations delivered at the Aerospace Medical Association annual meeting on the rapid curriculum evolution at the Air University. These changes were necessary to keep pace with the requirements of producing professional Airmen and Space Guardians in the dynamic environment of the 21st century. The authors will review existing educational models including the Continuum of Learning and Bloom's taxonomy and describe recent significant changes to the curriculum at the Air University. Finally, the authors will propose an analogy of education and training requirements to build world class athletes in two quite different games, American and European Football (Soccer). **DISCUSSION:** Certainly, to become an elite athlete in either American or European football requires a basic athletic ability, discipline, intelligence, and a commitment to excellence. While the path to becoming an elite athlete in either sport requires a sustained commitment to excellence, the way the game is played and coached is different. Both are complex games to play, especially at the elite level, but the way players are developed before they reach the elite level shares both similarities and differences. The authors will describe recent experiences at the Air University with wargaming as an educational tool demonstrating the strengths, but also weaknesses of both types of education. They argue that the pathway for development of a professional relevant for the 21st century is more like European football/soccer and less like the development process for American football. They will discuss the implications of this model for the development of Aerospace Medical professionals.

Learning Objectives

1. Understand Bloom's taxonomy and the Continuum of Learning, two existing educational models employed by both civilian and military educators.
2. Integrate concepts and lessons from coaching and developing talent in professional athletes across two different sports into existing educational models.
3. Consider if these concepts may be relevant as we strive to develop Aerospace Medical professionals with the skills to effectively lead in the 21st century.

[497] THE FUTURE IS OURS: LET'S CREATE IT TOGETHER!

Gitika Gorthi
Columbia University, New York, NY, United States

(Original Research)

INTRODUCTION: The generations that gave us medical support for two world wars, the Cold War, the Apollo program, Precision and Stealth and now into a new frontier of Space will soon be led by a younger generation. Young people will create the future of the Aerospace Medicine Specialty, yet very few of these young people who will soon take our places are represented at this conference. Senior Aerospace Medical professionals must engage with the youth today that will soon be in charge to ensure viability for our profession for the future. **DISCUSSION:** The author will provide an overview of the macro-trends that are influencing a younger generation and fueling their passions, connecting the content with the material presented by the previous speakers on the panel. She will integrate her experiences creating an international community of young people connected with experienced and diverse professionals across the globe to provide clues for the audience to ensure that what is built today is not only sustainable and meets the needs of future operations but is accessible and engaging to attract and retain the talent that is necessary for the viability of our specialty going forward.

Learning Objectives

1. Understand some of the macro trends that are shaping the views of young people today.
2. Understand some of the factors that are driving interest in the specialty of Aerospace Medicine in young people today.

Thursday, 05/25/2023 ***3:30 PM***
Napoleon Ballroom A1-B3

[S-88]: PANEL: NAWCAD HUMAN SYSTEMS ENGINEERING UPDATES ON IMPROVING HUMAN PERFORMANCE AND PROTECTION

Chair: Micah Kinney
Co-Chair: Chris Foster

PANEL OVERVIEW*: *TITLE: *NAWCAD Human Systems Engineering Updates on Improving Human Performance and Protection BODY: This panel will present ongoing and future efforts in improving human performance*

and protection within the aviation environment from engineers and scientists at the Naval Air Warfare Center Aircraft Division (NAWCAD) Human Systems Engineering Department. The first presentation will discuss the development of a Naval Aviation Operational Injury Database (NAVOID) linking operational factors with aeromedical waivers. Second, a presentation on the need for meta-analysis and machine learning to identify future air platform physiological monitoring requirements. Third, a discussion on the ongoing efforts of technology test and evaluation to improve hearing protection and performance in flight. Finally, the fourth topic will discuss ongoing efforts in developing digital human models to predict and prevent injuries in aviation mishaps.

[498] DEVELOPMENT OF A NAVAL AVIATION OPERATIONAL INJURY DATABASE (NAVOID) GUIDING SOLUTIONS AND INTERVENTIONS TO ONGOING MUSCULOSKELETAL PAIN AND INJURY

Travis Doggett, Bethany Shivers, Juan Diaz-Rijos
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Education - Program/Process Review)

BACKGROUND: Musculoskeletal injuries associated with naval flight environment directly impact flight personnel, readiness, and cost. Acute and chronic injury data relative to operational exposures are critical to providing focused solutions to the fleet and is a well-established knowledge gap. Aeromedical researchers and human systems engineers, currently depend largely on survey data and anecdotal reports to identify relationships between aviation operational exposures and medical outcomes and/or waivers to develop and prioritize research and materiel/non-materiel solutions to commonly reported aircrew issues. These relationships lack verifiable supporting data or are limited in accuracy and application necessary for critical analysis of data and relationship determination. Access to individually-linked operational and medical data would allow researchers to identify exposure/outcome trends across a broad range of commonly reported issues such as neck and back pain/injury, better enabling focused solution development that can be rapidly implemented to the fleet. **OBJECTIVE:** 1. Demonstrate the critical capability provided by an aggregated database linking individual operational and medical readiness data providing data specificity critical to advancing aeromedical research efforts and solution development. 2. Develop a cost effective strategy to establish a full-scope aggregate operational and medical database as a core capability within NAWCAD. **APPROACH:** Aviation-specific operational and medical readiness data are reported independently removing the critical context needed to capture the full magnitude of the impact on readiness. The external databases identified for initial inclusion are the Navy's Sierra Hotel Aviation Readiness Program (SHARP) and Aeromedical Electronic Resource Office (AERO) flight waiver adjudication system. **OUTCOME:** Access to aggregated medical and operational data through a usable database will focus and define research of mitigation/prevention strategies, prediction tools, and treatment parameters. The result would be improved warfighter short/long-term health and medical readiness while decreasing chronic injury-related costs. Conducting a proof-of-concept data query and providing a cost-effective development strategy will strengthen appeals for program-level joint funding to support the immediately beneficial and broadly applicable capability provided by a full-scale aggregated operational and medical database.

Learning Objectives

1. Understand the critical need in linking operational exposures with medical conditions in order to streamline treatment and focus preventive research efforts.
2. Demonstrate SHARP and AERO as viable options for collecting data, aggregating, aligning, and collating into a centralize, queryable database discovering trends between operational factors and medical problems.

[499] USING MACHINE LEARNING TO IDENTIFY KEY PHYSIOLOGICAL MONITORING REQUIREMENTS FOR FLIGHT OPERATIONS

Travis Doggett, Micah Kinney
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Education - Program/Process Review)

BACKGROUND: The Department of Defense (DoD) has invested a significant resources into the investigation of unexplained physiological episodes within the flight environment. As part of this effort, devices to monitor the physiological state of aircrew during operational exposures have been tested in a variety of environments and in some cases in flight. Devices evaluated include functional near-infrared spectroscopy (fNIR), heartrate and respiratory sensors, eye-trackers, and electroencephalography. These studies have generated large data sets to better understand human physiology, validate hardware/sensors, and demonstrate how flight environments affect physiology. However, despite the large investment, there remains a significant knowledge gap in platform requirements and go/no-go criteria. **OBJECTIVE:** A systematic review will be conducted of existing DoD data obtained during validation of physiological hardware testing, human performance in environmental extremes, and investigations of individual differences on human physiology. Using these data sources will enable the use of machine learning algorithms to identify key physiological markers for impairment or reduced performance. With the identification of these key physiological markers, requirements for future aircraft platform integration of physiological monitoring hardware and command go/no-go criteria can be developed. **APPROACH:** NAWCAD and Naval Medical Research Unit-Dayton will perform a systematic literature review to identify relevant physiological monitoring efforts. Down-selection will guide machine learning "binning" including reduced oxygenation, impaired cognition, or elevated heart rate and allow meaningful connections of unrelated metrics. The Naval Air Warfare Center Training and Simulation Division recently developed machine learning algorithms to enhance aircraft maintenance. A multitude of sensors collecting data including gravitational forces and engine temperatures is collected as part of routine maintenance cycles. Employing machine learning and data analytics, potential failures of components can be identified beforehand. We propose using this approach with physiological data to identify deviations from baseline prior to impairment or loss of performance. We hypothesize that machine learning can be applied to the existing multi-variate data sets to identify key physiological measures, then validated and verified to ensure reasonable and intelligible outputs.

Learning Objectives

1. Understand the physiological endpoints of importance in monitoring aircrew during operations.
2. Understand the need for performing meta-analysis of physiological data in order to determine tolerance trends that can guide requirements on future aircraft design.

[500] EMERGING TECHNOLOGIES TO IMPROVE HEARING CONSERVATION MANAGEMENT AND ENHANCE WARFIGHTER PERFORMANCE

Kyle Shepard
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Education - Tutorial/Review)

Effective hearing and balance is imperative to mission success in all military operations. Situational awareness and communication capability are the most important mechanisms for military members to operate safely and competently as a team in dynamic environments. Temporary or permanent disruption to these abilities account for a large portion of physiologic events (PE's) throughout the Naval Aviation Enterprise. Disruptions can be caused by hazardous noise, vibration, pressure changes, significant motion and other factors. Unfortunately, these stressors are very common

throughout Naval Aviation. Fortunately, they can often be mitigated when properly understood and appropriate controls are applied. Audiologists are subject matter experts of the assessment and management of hearing and balance systems. Therefore, this specialty became a primary component of the new Aeromedical Monitoring and Analysis Branch of the Human Systems Engineering Department when it was created in 2021 at Naval Air Warfare Center Aircraft Division (NAWCAD) of NAVAR at Naval Air Station Patuxent River in Maryland. Operational Audiologists in the Navy offer clinical expertise in both hearing and balance, field knowledge of sustaining or enhancing these systems in unique environments and physiologic knowledge to be synergized with the wealth of engineering expertise already present at NAWCAD. This presentation is intended to discuss audiologic concepts and emerging technologies demonstrating promise to improve hearing conservation management and/or enhance warfighter performance in extreme environments.

Learning Objectives

1. Following participation in this session the learner will be able to name one of the primary facilities in the Navy that conducts research on current and emerging hearing protection and communication systems.
2. Following participation in this session the learner will be able to name at least 1 emerging technology that will impact hearing protection and communication systems in the future.
3. Following participation in this session the learner will be able to be able to describe the difference between talk through and active noise reduction technology.

[501] USING ANALYTICAL HUMAN MODELS FOR ACCURATE PREDITION OF INJURIES

Lindley Bark, Aamir Jafri
Naval Air Warfare Center Aircraft Division, Patuxent River, MD, United States

(Education - Program/Process Review)

INTRODUCTION: Human analytical models were developed two decades ago to assess injuries accurately. These models are regularly applied in modeling and simulation to analyze injuries in automobile accidents. The OEMs (Original Equipment Manufacturers) like Toyota, General Motors, Ford Motor Company etc., have led many of these developments. Presently, simulation of the kinematics of and prediction of injuries within the entire human body is possible including the brain and internal organs with and without muscle activation. Recently, NAWCAD acquired a set of models: Total Human Models for Safety (THUMS) from Toyota Labs. The purpose is for research toward reducing human harm in aviation mishaps. **TOPIC**: The THUMS model is currently used by NAWCAD to assess highly dynamic loading that naval personnel experience during aviation mishap events. It provides unprecedented fidelity with respect to potential injuries (including lower extremities) that are not fully captured by current physical or virtual anthropomorphic test devices (ATDs). Since each body organ and tissue model was developed using polygon scanner to capture accurate geometry along with verified/validated material properties with non-linear stress-strain curves, bone fracture, organ failures like bladder rupture, injury on the kidneys, liver, heart etc., can be determined. **APPLICATION:** The applications includes development of expanded injury criteria by comparing ATDs and THUMS in terms of predicted injury under specified dynamic conditions and identify how to bridge the standard ATDs with human body models. The return on investment is in allowing specific injury mechanisms to be investigated with countermeasures developed and assessed for efficacy. This enables targeting acute injuries for mitigation, injury criteria development, crashworthy system design and development, and rapid evaluation of airworthiness concerns. Internally, at NAWCAD, chronic injury prediction is underway to identify countermeasures. These models are also being adapted for conditions where warfighters experience mine blast or other transient dynamic events. The model results are accumulating into a database with spot tests against cadaveric testing or anecdotal mishap results are spot checked. Additional data from physical testing for different human specimen pertaining organs, tissues, muscle will be gathered and incorporated to the materials defined in these models.

Learning Objectives

1. Application of analytical human body models to injury prediction for aviation mishaps.
2. Correlation of human model vs. mechanical surrogate models for aviation mishap applications.
3. Potential used of analytical models to improve survivability in aviation mishaps.

Thursday, 05/25/2023 ***3:30 PM***
Nottoway & Oak Alley

[S-89]: POSTERS: HUMAN PERFORMANCE 2 AND OTHER POSTERS

[502] ESTABLISHING MECHANISMS THROUGH WHICH SYSTEMIC INFLAMMATORY PROCESSES NEGATIVELY IMPACT BRAIN STRUCTURE, FUNCTION, AND ULTIMATELY, AIRCREW READINESS

Koyal Ansingkar[1], Kui Xu[1], Joseph Piktel[1], Adrienne Dennis[2], Elizabeth Damato[1], Michael Decker[1]
[1]*Case Western Reserve University, Cleveland, OH, United States;* [2]*MetroHealth Medical Center, Cleveland, OH, United States*

(Original Research)

INTRODUCTION: Cognitive fatigue represents a constant threat to tactical aviator safety. We have recently found increased serum levels of proinflammatory cytokines are associated with fatigue in a cohort of T-6A instructor pilots. Hypobaria, ever present in tactical aviation, may be one contributor to the synthesis and release of those cytokines. We hypothesize exposure to proinflammatory cytokines perturbs levels of connexin-43, a key protein responsible for blood-brain barrier integrity, promoting the onset of neuroinflammation as cytokines leak into neuronal tissues. This manifests as cognitive fatigue. Our objective was to assess neuronal connexin-43 levels in a murine model following hypobaric exposure. **METHODS:** Following approval by the Institutional Animal Care and Use Committee, 15 C57BL/6J mice purchased from Jackson Labs were divided into three groups of five, each placed in a rodent hypobaric chamber at different altitudes to simulate different atmospheric pressures: 760 mmHg (sea level), 564 mmHg (8,000 feet of elevation), and 429 mmHg (15,000 feet of elevation). Each exposure consisted of an alternating cycle of 60 minutes at the experimental altitude followed by 60 minutes at sea level, three times per day over five consecutive days. Following all exposures, mice were sacrificed, and their brains extracted and preserved. The brains were processed for Western blot analysis to determine quantitative changes in connexin-43. **RESULTS:** Using Western blot analysis, connexin-43 protein levels were normalized to the total protein levels and calculated by dividing the target band signal by a determined lane normalization factor. This yielded normalized signals of 319092.7 ± 148238.1 (sea level n=3), 381111.9 ± 165984.5 (8,000 feet n=3), and 160805.1 ± 27104.5 (15,000 feet n=3). A relative decrease was observed in connexin-43 protein in the brains of mice exposed to 15,000 feet of altitude. **DISCUSSION:** The decrease in connexin-43 levels suggests an alteration in blood-brain barrier integrity following hypobaric exposure. Due to the small sample size in this preliminary study, statistical analyses could not achieve a minimum power of 0.80 at an alpha < 0.05. Experimental manipulations in upcoming months will include increasing sample sizes as well as the infusion of oxygen into the hypobaric chamber to maintain normoxia, similar to the cockpit environment experienced by tactical aviators.

Learning Objectives

1. Confirm a decrease in connexin-43 expression in the brain following exposure to hypobaria.
2. Isolate hypobaria from hypobaric hypoxia through infusion of oxygen into the hypobaric chamber to determine whether the decrease in

connexin-43 expression in brains is due to hypobaria alone or hypobaric hypoxia.
3. Understand whether hyperoxia, through excess infusion of oxygen into the hypobaric chamber, exacerbates the decrease in connexin-43 expression after exposure to hypobaria.

[503] INFLUENCE OF BAROMETRIC PRESSURE ON CARBON DIOXIDE ELIMINATION DURING NORMOXIC VOLUNTARY HYPERVENTILATION

Victoria Edwards, Alec Stevenson, Henry Tank, Rachel Firth, Vivienne Lee, Des Connolly
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(Original Research)

INTRODUCTION: Aircrew are trained to recognise in-flight symptoms of hypoxia. However similar symptoms may result from hypocapnia due to hyperventilation in the absence of underlying hypoxia. Reports suggest that ambient pressure influences carbon dioxide elimination, therefore this study aimed to determine whether hyperventilation in the absence of hypoxia is more or less likely to occur at altitude than at ground level. **METHODS:** Fourteen participants undertook 15 minutes of normal restful breathing followed by 15 minutes of controlled voluntary hyperventilation (lowering end-tidal partial pressure of carbon dioxide to ~21 mmHg) in a hypobaric chamber. This was repeated on separate occasions at ground level (GL) and at 17,000 ft pressure altitude (PA). Cardio-respiratory data were analysed using two-way ANOVA to evaluate the influence of *Altitude* (GL vs PA) and hyperventilation *Duration* (5, 10, 15 minutes). **RESULTS:** *Altitude* influenced baseline restful breathing such that minute ventilation increased at PA (9.1 ± 2.1 vs. 10.3 ± 1.9 $L{\cdot}min^{-1}$, p=0.001), however there was no difference in *Altitude* on minute ventilation during hyperventilation (21.5 ± 4.0 vs 22.4 ± 3.4 $L{\cdot}min^{-1}$, p=0.219). There was no effect of *Altitude* on any measures during hyperventilation (p>0.05), however *Duration* from five to 15 minutes influenced minute ventilation (26.1 ± 3.5 to 20.0 ± 3.1 $L{\cdot}min^{-1}$, p=0.001), respiratory exchange ratio (1.10 ± 0.31 to 0.82 ± 0.17, p<0.001) and heart rate (87 ± 14 to 76 ± 10 bpm, p<0.001), which all decreased over the 15-minute period. Brain blood flow velocity was initially decreased with hyperventilation by 35% but increased over the 15-minute period (35.8 ± 8.7 to 40.6 ± 9.8 cm s^{-1}, p=0.001). There were no differences in physiological or subjective measures during hyperventilation conducted at PA relative to GL. **CONCLUSION:** Under normoxic conditions, decreased ambient pressure does not predispose towards hyperventilation. The difference in ventilation during restful breathing likely resulted from the Haldane effect due to the requirement for the participant to breathe hyperoxic gas (43% oxygen) prior to ascent. In fast jet aircraft the breathing gas is often hyperoxic as a precaution against hypoxia, which could explain a tendency towards increased ventilation during fast jet flight at routine cabin altitudes.

Learning Objectives
1. The audience will understand the influence hyperventilation has on physiological variables at altitude compared to ground level.
2. The audience will learn if there is any difference in the lung ventilation required at altitude and at ground level to achieve an equivalent severity of hypocapnia.

[504] EFFECTS OF HYPOCAPNIA ON POSTURAL STANDING BALANCE MEAUSRED BY SHARPENED ROMBERG TESTING (SRT) IN HEALTHY SUBJECTS

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(Original Research)

INTRODUCTION: The effects of hypocapnia on the postural system have not previously been adequately investigated. The specific aim of this study is to evaluate the effects of hypocapnia on postural standing balance using the sharpened Romberg test (SRT). Hypocapnia arises in many significant and common clinical conditions affecting ventilation such as bronchial asthma, high progesterone states, sepsis and more. We hypothesized that participants would have decreased time to step out on SRT in the hypocapnic condition. **METHODS**: 22 healthy subjects (7 M, 15 F) at 500m elevation were timed on SRT before and after they deliberately lowered their carbon dioxide levels by increased ventilation over 2min. End-tidal CO_2 ($ETCO_2$) measured by an EMMA capnometer was used to approximate the blood carbon dioxide level during the experimental procedures. The standing times were then compared to the baseline pre-hypocapnic SRT using a one-tailed, paired-samples t-test in order to assess how hypocapnia affects standing balance. The participants subsequently returned to normocapnic status through regular, quiet breathing and CO_2 supplementation. After returning to subjective normocapnia, the participant performed the SRT once more, followed by a final measurement of $ETCO_2$. Approval for human subjects research was granted by the Mayo Clinic Institutional Review Board and Ethics Committee for Human Studies. **RESULTS**: Mean times to step out on SRT were 101.324 ± 116.52 seconds at baseline $ETCO_2$, 47.67 ± 68.03 seconds post-maximum voluntary ventilation for 2 min, and 120.553 ± 132.09 seconds post-normocapnic recovery. Statistical tests comparing baseline SRT to post-hyperventilation SRT was p = .0128 indicating rejection of the null hypothesis. When comparing post-hyperventilation SRT to post-normocapnic recovery SRT p = .0002, again indicating a rejection of the null hypothesis. **DISCUSSION**: Our findings demonstrate that hypocapnia at 500m altitude is sufficient to cause clinically and statistically significant decreases in time to step out on SRT. These results in normobaric settings reveal that carbon dioxide homeostasis is integral to cerebral functioning that governs postural control. Thus, clinical assessment of capnic status is important in the evaluation of altitude-related illnesses, notably when trying to differentiate acute mountain sickness (AMS) and high altitude cerebral edema (HACE) as the latter is clinically associated with truncal ataxia.

Learning Objectives
1. The participant will learn about the effect of hypocapnia on postural standing balance in normobaric conditions at 500m elevation (equivalent to barometric pressure of 716 mm Hg or .94 atm).
2. The participant will appreciate the importance of capnic status assessment in the differentiation of acute mountain sickness and high altitude cerebral edema.

[505] A PILOT-STUDY TO INVESTIGATE NON-INVASIVE POSITIVE PRESSURE VENTILATION ON OXYGEN SATURATIONS WITHOUT SUPPLEMENTAL OXYGEN AT ALTITUDE

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(Original Research)

INTRODUCTION: Flying between 12,500 feet mean sea level (MSL) and 14,000 feet (MSL) for more than 30 minutes or any duration above 14,000 feet (MSL) requires the use of supplemental oxygen per the Federal Aviation Administration (FAA), however hypoxia can develop in pilots of general aviation (GA) aircraft below these levels. In an effort to offer an alternative method to supplemental oxygen for hypoxia prevention and increase safety of GA, we hypothesized that the use of noninvasive positive pressure ventilation (NIPPV) in the form of bilevel positive airway pressure (BPAP) would improve subjective overall well-being and cognition while at altitude. **METHODS:** Five males and five females between the ages of 18 to 89 with experience flying at 8,000 feet (MSL) or higher were recruited for a standardized flight profile consisting of four 15 minute segments, two at 8,000 feet (MSL) and two at 12,500 feet (MSL). The participants were randomly assigned

to either BPAP or ambient air and switched halfway. Environmental conditions during the two-day experiment were consistent. The Lake Louise scoring system for acute mountain sickness and a questionnaire were used to assess participant outcomes. Cohen's D for effect size and Wilcoxon Signed-Ranks tests were computed. All subjects participated voluntarily without compensation and written informed consent was obtained. The study was approved by the Mayo Clinic Institutional Review Board (protocol number 22-003189). **RESULTS:** We safely collected data on physiologic changes in subjects while on BPAP as compared to baseline ambient air. There were no injuries or acute medical complications. The majority of subjects felt that BPAP had a positive impact on their high altitude experience. Cohen's D = 1.1 suggestive of a large effect size was computed. Owing to small sample size and self-reported nature of this data, these effects are presented descriptively. Our study demonstrates subjective improvement both overall well-being and cognitive abilities while utilizing BPAP. **DISCUSSION:** Our focus was to prevent potentially dangerous effects of hypoxemia. The results from this study suggest that the use of BPAP subjectively improves well-being and cognitive abilities at and above 8,000 feet (MSL), as reported by the majority of our participants. Further research into the use of BPAP as an alternative to supplemental oxygen for the GA community is warranted.

Learning Objectives

1. The feasibility and practicality of inflight human research in general aviation.
2. The effectiveness of noninvasive positive pressure to alleviate symptoms of hypoxia.

[506] A CASE OF HYPERCAPNIA UNDER CONDITIONS REPRESENTATIVE OF FLIGHT

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(Original Research)

INTRODUCTION: Unexplained physiological impairment is a leading safety concern among tactical aircrew. Hyper- or hypocapnia have been proposed as potential causal factors for some physiological symptoms, but no in-flight data exist to evaluate such hypotheses. The present case report describes an instance of hypercapnia in a single study participant for whom the breathing circuit was fully monitored. **CASE PRESENTATION:** This event occurred during a study evaluating effects of repeated activations of an automated backup oxygen system (ABOS). The research participant was a 35y/o male active-duty United States Air Force Medical Technician with approximately 100 hours of hypobaric chamber experience. The participant experienced the following profile in a hypobaric chamber: 15 min at ground level with three simulated ABOS activations, followed by ascent to 9,000 feet for 45 min. Gas was supplied through a CRU-103 regulator and MBU-23/P flight mask. Delivered oxygen was 50% at ground level, 100% during simulated ABOS activations, and 95% at 9,000 feet. Beginning 32 minutes into the profile, the participant reported sudden severe symptoms, including tingling in his fingers, heart palpitations/increased heart rate, anxiety, sweating, and lightheadedness. The experimenter monitoring the signals in real time noted that the end-tidal CO_2 was just below the hypercapnic abort level of 65 torr. The profile was aborted, and the participant was given 100% O_2 for 25 min with no benefit. He was evaluated at the emergency room, discharged, and reported feeling better the next day. Subsequent data examination confirmed end-tidal CO_2 levels fluctuating around 9%. There was no evidence of equipment malfunction, and no indication of rebreathing expired gas. The participant's minute ventilation was noted to be approximately 23% less than his previous visits for the study. We hypothesize that the elevated oxygen suppressed the participant's carotid body CO_2 receptors while he was breathing on a somewhat resistive circuit, leading to lower minute ventilation. **DISCUSSION:** Physiological symptoms may occur in the absence of any fault or irregularity in the breathing system. One potential cause is acute hypercapnia, possibly influenced by the hyperoxic cockpit environment. In cases of hypercapnia, the standard response to in-flight events of activating an emergency supply of 100% oxygen may be counterproductive.

Learning Objectives

1. Describe possible causes of physiological symptoms in a cockpit environment.
2. Identify possible issues with using 100% oxygen as a default countermeasure.

[507] HYPOXIA AWARENESS TRAINING: PILOTS' EXPERIENCE OF HYPOXIA PARTICIPATING IN FIVE AVIATION PHYSIOLOGY COURSES OVER A TIME PERIOD OF 16 YEARS

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(Original Research)

INTRODUCTION: The German Air Force Centre of Aerospace Medicine provides Hypoxia Awareness Training for flight personnel in a hypobaric chamber at intervals of four years. Refresher training in aviation medicine is required throughout the careers of the flight personnel. This raises the question whether these personal hypoxia experiences have changed over time. **METHODS:** 70 male military aircrews attended five aviation medicine training courses every four years between 2002 (age 33 +/-4 yr.) and 2019. Each pilot underwent 5 exposures to reduced pressure in a hypobaric chamber to a simulated altitude of 25,000 feet to experience change of pressure and hypoxia (hypoxia recognition training). Heart frequency, oxygen saturation, hypoxia recognition time (HRT) and hypoxia symptoms were recorded. After a modification of the hypobaric chamber a remote controlled oxygen -separation was introduced in 2003. **RESULTS:** There was a significant difference regarding the hypoxia recognition time in the first and the following courses. In the first course the students disconnect themselves from 100% oxygen and the HRT was 72 sec. After the modification in 2003 the students were disconnected unperceivedly by the instructor from outside the chamber. The HRT under this condition were at least 99 sec (99 sec – 104 sec). The oxygen saturation when feeling the first hypoxia symptom averaged to 87%. The students reconnect to 100% oxygen at an average oxygen saturation of 70%. The most frequent 1st symptom was sensation of heat (44%) followed by dizziness (18%). Only 8 pilots (11%) had the same first symptom during all five courses. 13 (19%) aircrews didn't experience any hypoxia symptoms at least one time during the aeromedical training courses and 2 aircrews didn't feel any symptoms during three hypoxia demonstrations. **DISCUSSION:** The difference regarding the HRT between the first and the other courses could be an effect of the different disconnection methods from 100% oxygen. In the first course the disconnection from oxygen was conducted by the students but not in the following courses. So this could be the explanation why they felt the hypoxia symptoms 27 sec earlier. The recognition of hypoxia symptoms is not very reliable and therefore it makes sense to train it during a pilot's career. Medical monitoring is helpful for the safety crew to realize health problems of trainees in time and enables students to compare subjective feelings with objective data.

Learning Objectives

1. To understand the benefit of hypoxia training in a hypobaric chamber.
2. to understand the most frequent hypoxia symptoms and the benefit of medical monitoring.

[508] RELIABILITY OF TWO CLINICALLY ORIENTED EYE TRACKING PROTOCOLS

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(Original Research)

INTRODUCTION: Smooth pursuit eye movements, when the eyes continuously track a moving target, can be used to quantify an individual's general oculomotor and neurological health. Two commercially available eye tracking systems, the neuroFit ONE and RightEye Sensorimotor, measure smooth pursuit as a predictor of operational or athletic performance and biomarker of neurological health. However, to be useful for either, the same individual should score similarly on successive iterations of the same test. This study evaluates the test-retest reliability of both systems and their usefulness in aeromedical screening applications. **METHODS:** Intrasession test- retest data were collected from 43 participants (34.5 ± 7.8 years). Each session included the neuroFit ONE protocol, which consists of a radial Rashbass step-ramp smooth pursuit task, and the RightEye horizontal and vertical smooth pursuit protocols, which consist of a sinusoidal tracking task. Participants ran each protocol twice within the same session. Bland-Altman analyses were used to assess the repeatability of reported output metrics. Metrics from both devices were considered reliable if internal variance (95% limits of agreement) was less than external variance (95% range). **RESULTS:** Five of the neuroFit ONE metrics had acceptable test-retest reliability: latency (ms): mean difference = +2.05 (95% LOA: +10.28 to +15.82); response acceleration (deg*s^{-2}): mean difference = -5.45 (95% LOA: +35.33 to +65.73); direction noise (deg): mean difference = +0.68 (95% LOA: +4.33 to +7.77); smooth pursuit gain: mean difference = +0.00 (95% LOA: +0.24 to +0.16); and smooth pursuit proportion: mean difference = –0.01 (95% LOA: +0.13 to +0.20). The RightEye produced 8 different metrics of interest for each smooth pursuit direction, many of which were found to be reliable metrics, including horizontal disconjugacy, saccade percentage, and smooth pursuit gain. **DISCUSSION:** These results suggest several quantifiable components of smooth pursuit tasks can be measured reliably with commercial protocols. For the neuroFit ONE, metrics such as saccadic latency, response acceleration, direction noise, steady-state tracking gain and smooth pursuit proportion showed adequate test-retest reliability. Likewise, for the RightEye Sensorimotor, disconjugacy, gain, and saccade percentage demonstrated reliability. Some (but not all) elements of both devices could therefore be used in further studies to investigate aeromedical applications.

Learning Objectives

1. The audience will understand the reliability of two commercially available eye tracking systems, the neuroFit ONE and RightEye Sensorimotor.
2. The audience will understand which metrics produced by the neuroFit ONE and RightEye Sensorimotor could be used for further aeromedical testing.

[509] AN EYE-OPENING OUTCOME AFTER ROUTINE VISUAL ACUITY ASSESSMENT

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(Education - Case Study)

INTRODUCTION: This case report describes a 43-year-old military helicopter pilot who was found to have bilateral posterior subcapsular (PSC) cataracts. **BACKGROUND:** Ensuring excellent visual acuity is critical to flight safety. Changes in vision may occur imperceptibly or very rapidly, and any change in a pilot's visual acuity must be thoroughly evaluated. **CASE PRESENTATION:** A 43-year-old United States Air Force (USAF) helicopter pilot was noted to have 20/30 visual acuity bilaterally on annual flight physical. While considered near-normal vision, he did not meet the 20/20 visual acuity standard for required for USAF pilots. Ophthalmologic evaluation revealed decreased visual acuity (20/50 on the right eye and 20/40 on the left eye), and bilateral opacities just in front of the posterior lens capsule consistent with PSC (2-3 mm PSC on the right eye and a 1- 2mm PSC on the left eye). He underwent surgical correction with implantation of a monovision synthetic intraocular lens with resolution of his right-sided functional vision, and is pending left-sided surgery in the future. **DISCUSSION:** Cataracts are the leading cause of vision loss in the US, with an estimated 24.4 million adults aged 40 years and older having one or both eyes affected. However, the prevalence rate increase with increasing age, affecting only 2.5% of individuals aged 40-49 years. Of the 3 morphological types of cataracts, PSC is the rarest form, comprising only 2.2% of all cataract cases globally. PSC is fast-growing, can progress rapidly, and typically affects individuals at an earlier age than the other types. Most cases occur in people over 60 years old but can occur in younger patients with diabetes mellitus, chronic use of steroids, ocular disease such as retinitis pigmentosa, or a history of eye trauma. Symptoms primarily affect one's reading and night vision, creating halo effects and glare around lights. Regardless of vision correction to 20/20, cataracts pose a significant risk to flight safety. However, visual effects of cataracts can be successfully treated with surgical correction and pilots can return to flying once vision standards are met. PSC should be considered in the differential diagnosis for decreased visual acuity even in young pilots with subtle visual changes.

Learning Objectives

1. The audience will understand the signs and symptoms of posterior subcapsular cataracts.
2. The audience will understand the risk factors for developing posterior subcapsular cataracts.

[510] COOLING OF HELICOPTER FLIGHT CREWS AND GROUND HANDLING PERSONNEL DURING MISSIONS IN COLD REGIONS

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(Original Research)

INTRODUCTION: Military operations can occur worldwide, in all dimensions (land, air, and maritime) and at any time of the year. Often missions arise in extreme environments, including all combinations of heat, cold, wind, precipitation, etc. The acra are most affected in cold weather, so this is where the focus of damage is initially seen. There is always a disparity between optimum cold protection and enough movement as well as comfort to perform operational tasks. Crews in a helicopter with open side door or ramp are particularly affected on the different workstations. Low temperatures, cold wind, and moisture can affect crew members up to hypothermia, local cold injury and permanent tissue damage. **METHODS:** During a 3-week helicopter winter operation in Sweden, flying and ground personnel were examined with the mobPhysioLab® configured precisely to the required physiological parameters during the respective missions. The skin temperatures (T_{skin}) of the fingers and wrists, toes and ankles, as well as in the face (cheekbone) and the neck were considered. In addition, the core body temperature (CBT), as well as the heart (Hf) and respiratory rate (Bf), were synchronized recorded additionally with the environmental parameters (T, Hum, $Pres_{Envir}$) in real flight. **RESULTS:** The ground-bound outside temperatures were $Av\Delta T_{Envir}$ -10°C (range: -3 to -25°C) by in-flight activities. From 14 soldiers, 46 records could be generated and evaluated. Of these, 5 were in the cockpit, 24 were on the open side door in flight, and 17 were on the ground personnel during activities at the flying helicopter (e.g., downwash). All in all, a continuous cooling of the T_{skin} fingers (AvΔT -10°C, range -3 to -18°C) and T_{skin} toe (AvΔT -17°C, range -10 to -27°C) could be obtained during flight time only up to 50min. **CONCLUSIONS:** Strong cooling of the extremities means a reduction in blood circulation, leading to a stagnancy. Through this protective mechanism of centralization, the extremities are virtually abandoned in favor of the organism's survival. Depending on the exposure time and the depth of the cold, damage up to necrosis occurs. In parallel, the functionality is increasingly restricted, which means the loss of dexterity when the T_{skin} hand falls below 15°C.; at 8°C, a nerve block is formed (loss of function). The preliminary results

of this study show that despite protection, skin temperatures continuously drop to a critical threshold in a short period of time.

Learning Objectives

1. Cold can affect the extremities of a person extremely quickly and prevent their function, up to irrevocable damage
2. Low protection from the cold can severely affect the person in the military operationality and severely affect the flight safety of all.
3. It is of considerable importance that soldiers on deployment in cold climates are especially protected from the cold so that they can fulfill their mission and return from deployment without suffering personal harm

[511] CARBOHYDRATE INGESTION ATTENUATES COGNITIVE DYSFUNCTION FOLLOWING LONG-DURATION PASSIVE HEAT STRESS IN HUMANS

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WITHDRAWN

[512] EVALUATION OF MORE THAN 20 YEARS AEROMEDICAL EVACUATION – LESSONS LEARNED FOR THE FUTURE BASED ON 2060 TRANSPORTED PATIENTS

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(Original Research)

INTRODUCTION: During military operations abroad, serious illnesses and injuries can occur with the consequence that soldiers have to be flown out to their home countries by fixed-wing aircraft for further medical care. These special equipped aircrafts are also often used for evacuation in the context of humanitarian missions. An ongoing scientific analysis is necessary to improve the medical treatment before, during and after the aeromedical evacuation (AE) flights. **METHODS:** A retrospective analysis of 612 AE-flights of the German Air Force since 2002 were conducted. In total 2,060 patients were evacuated by fixed-wing military aircraft to Germany. 1,337 (65%) of these patients were soldiers, 723 (35%) have been flown as part of humanitarian aid missions. The analysis based on an evaluation of the intensive care transport records used during flight with additional data (patient movement request, clinical data, written report). In 1875 cases (91%) the transport protocol was available. **RESULTS:** In median the age was 34.3 years (min: 4.6, max: 101.0). Patients flown as part of humanitarian aid missions were significantly older than evacuated soldiers (40.4 vs. 32.4 years, $p < 0.001$). 1,641 (80.0%) patients were males, 227 (11.0%) females and in 192 (9.3%) cases the sex/gender was not documented. Most patients (n = 909, 44.1%) have been flown due to underlying traumatological/surgical conditions, 732 (35.5%) patients have had an internal medicine underlying disease. This was significantly different between humanitarian missions, where traumatic and surgical reasons were predominated, and evacuated soldiers with internal medicine reasons. Complications requiring invasive measures only occurred in a small number of patients: three (0.2%) patients required a chest drain, four (0.2%) patients had to be intubated, and three (0.2%) patients received a new central venous catheter. **CONCLUSIONS:** AE flights are an integral part of the rescue chain and essential for high-quality medical care for soldiers deployed abroad. Underlying diseases vary significantly between soldiers and patients transported for humanitarian aid missions. However, serious complications are rare. This shows, based on more than 20 years of experience, that the procedures during AE flights have been standardized and integrated into medical care in an optimized manner.

Learning Objectives

1. The audience will learn that the patients transported by aeromedical evacuation differ between evacuation from military mission abroad and humanitarian aid missions.
2. The audience will learn that traumatic/surgical and internal medicine diseases are the most common reason for the need of aeromedical evacuation.
3. The audience will learn that there can be found a broad range of age especially when patients from humanitarian aid missions are transported, this must be taken into consideration when an aeromedical evacuation team plans a flight.

[513] ACUTE CHANGES IN RAT TISSUE AND BLOOD GENE EXPRESSION FOLLOWING EXPOSURE TO FLIGHT-RELEVANT HYPOBARIA

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(Original Research)

INTRODUCTION: Exposure of humans and lab animals to high altitude, e.g. >10,000 ft, results in changes in gene expression in tissues and blood cells that may mediate adaptation to altitude or contribute to altitude sickness. This study tested the hypothesis that exposure of healthy rats to flight-relevant hypobaria (4000-8000 ft) and/or different O_2 concentrations causes acute genotypic changes in the blood, lungs, heart, and brain that help explain the effects of moderate hypobaria on both normal and injured animals. **METHODS:** The protocol was reviewed and approved by the UMB IACUC (1217007) and the U.S. Air Force Surgeon General's Office of Research Oversight and Compliance (FWR-2018-0001A). These studies were conducted in a facility accredited by AAALAC, in accordance with the Guide for the Care and Use of Laboratory Animals (NRC, 2011) and were performed in compliance with DODI 3216.1. Adult male Sprague-Dawley rats were exposed to the "flight" conditions for 5 or 10 hours, after which the rats were euthanized and tissues were flash frozen. RNA was subsequently isolated and used for microarray measurements of differential gene expression (≥ 1.5-fold change, $p < 0.1$) across 9 experimental groups compared to control animals which were maintained at sea level pressure under room air. **RESULTS:** Microarray analysis detected several hundred differentially expressed transcripts, including several at 4000 ft for only 5 hours. Blood showed the greatest change in gene expression while cardiac tissue showed the least. Canonical pathway enrichment identified several genetic pathways of interest for each tissue, including antioxidant gene expression in the lung, and iron homeostasis in the heart, lung, and brain. **DISCUSSION:** Exposure of rats to mild hypobaria and/or hyperoxia results in acute changes in gene expression in blood and vital organs. Some pathways showed trends over the two treatment durations, such as Nrf2-mediated gene expression in response to 8000 ft hypobaria in the lung. Although no mechanism was identified as a cause of flight-related secondary injury, this study provides a strong foundation for the analysis of gene expression changes after flight in normal animals and eventually in those subjected to trauma. The views expressed are those of the authors and do not reflect the official guidance or position of the United States Government, the Department of Defense or of the United States Air Force. Supported by US Air Force FA8650-18-2-6H15.

Learning Objectives

1. The audience will learn about gene expression changes brought on by aeromedical-evacuation relevant levels of hypobaria. They will see that relatively short exposures to moderate hypobaria and/or hyperoxia significantly affect the expression of many gene transcripts in multiple tissues, which may play a role in precipitating secondary injury.
2. The audience will learn which genetic pathways are most affected by aeromedical-evacuation relevant levels of hypobaria and/or hyperoxia in healthy rats. They will see this as a solid foundation in order to examine the differences in the gene expression between healthy and injured rats when exposed to moderate hypobaria.

[514] LOW OXYGEN TENSION DOWNREGULATES VIRAL ENTRY GENE EXPRESSION AND UPREGULATES THE TLR-IL33-NFκB PATHWAY IN HUMAN BRONCHIAL EPITHELIAL CELLS

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(Original Research)

INTRODUCTION: Given that hypobaric hypoxia and normobaric reoxygenation are commonly associated with air traveling and landing, while ischemia/hypoxia-reperfusion and hypoxemia are both associated with lung transplantation and chronic obstructive pulmonary disease (COPD), it is an interdisciplinary research topic of interest for both epidemics and aerospace medicine to investigate whether exposure to consecutive hypoxia or intermittent hypoxia-reoxygenation may influence the viral transmissibility, antiviral activity and innate immune and inflammatory response of human bronchial epithelial (HBE) cells. **METHODS:** Normal (NHBE) and COPD-diseased (DHBE) human bronchial epithelial cells derived from Caucasian age-matched donors were obtained from Lonza Biotechnology Company and cultured under normoxia (21% O_2) for consecutively 6 days, or cultured under 24/24-hour cycles of H/R (i.e., 1% O_2 and 21% O_2 alternately) for 6 days in total, or cultured under 1% O_2 for consecutively 3 days followed by 21% O_2 for consecutively another 3 days. Total mRNAs were then extracted followed by quantitative real-time PCR analyses. **RESULTS:** Consecutive hypoxia significantly decreased expression of the coronaviral entry genes *ANPEP*, *DPP4* and *TMPRSS2* as well as the influenza viral receptor gene *ST3GAL4* in both NHBE and DHBE cells, whereas intermittent H/R significantly decreased only *ANPEP* and *DPP4* but not *TMPRSS2* and *ST3GAL4* expression in the DHBE cells. Interestingly, both intermittent H/R and consecutive hypoxia significantly increased phospho-NF-kB nuclear localization and expression of the pro-inflammatory cytokine genes *IL6*, *IL8* (*CXCL8*) and *IL33*, and significantly decreased expression of the anti-inflammatory cytokine gene *IL11* in both NHBE and DHBE cells, while consecutive hypoxia significantly decreased expression of the anti-inflammatory *IL4* gene and intermittent H/R significantly increased expression of the pro-inflammatory *IL1B* (IL-1b) gene in both NHBE and DHBE cells. **CONCLUSION:** Taken together, our results demonstrate that 1) decreased viral transmissibility may not be associated with decreased cytokine storm; 2) increased nuclear localization of NF-kB is associated with increased expression of pro-inflammatory cytokine genes and increased nuclear localization of the hypoxia-inducible transcription factor HIF1a; 3) whether the *CGRP* expression levels are correlated with the *IL33* mRNA levels still awaits future studies.

Learning Objectives

1. To understand that Low oxygen tension downregulates viral entry gene expression and upregluates the TLR-IL33-NFkB pathway in human bronchial epitheial cells
2. To understand that Consecutive Hypoxia And Intermittent Hypoxia-Reoxygenation Downregulate Expression of Viral Entry Genes And Upregulate The TLR-IL33-NFκB Pathway And Pro-inflammatory Interleukin Genes in Human Bronchial Epithelial Cells
3. 1. Viral transmissibility may not be associated with the cytokine storm 2. Increased nuclear localization of NF-kB is associated with increased expression of pro-inflammatory cytokines and increased nuclear HIF-1a 3. It remains to be studied whether CGRP expression is correlated with the IL-33 mRNA levels

[515] DEVELOPMENT AND FLIGHT TESTING OF PRESSURE BREATHING OXYGEN EQUIPMENT DURING WORLD WAR II BY U. S. ARMY AIR FORCE (USAAF) PHYSIOLOGISTS

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WITHDRAWN

[516] HISTORICAL CASE STUDY: FATAL CRASH OF GEMINI ASTRONAUTS

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University of Vermont, Burlington, VT, United States

(Education - Case Study)

INTRODUCTION: In 1966, two NASA astronauts died in a T-38 crash on the way to train for their upcoming Gemini mission. This historical case study will provide a summary of the accident, the findings of NASA's review board, and conclude by looking at the crash through a modern lens of human factors and aviation safety. **BACKGROUND:** On February 28, 1966, Gemini astronauts Elliot See and Charles Bassett were killed when their T-38 jet, NASA 901, crashed in St. Louis. Thick clouds and poor visibility caused them to take an instrument landing approach. When they flew below the clouds, they were going too fast to make the runway, so See chose to take a visual circling approach. By the time See realized he was heading toward a building, it was too late. Both astronauts were killed on impact within 500 feet of the Gemini IX spacecraft they would have flown into orbit. **CASE PRESENTATION:** The crash was deemed to be caused by pilot error, which was not unusual at the time. However, See's personality and background were different than the other Gemini astronauts, which served to shift blame on him instead of focusing on the wider safety and culture of NASA. Flight Crew Operations chief Deke Slayton later disparaged his flying skills and said it was a "bad call" putting him in command. This tendency to blame the pilot for a crash is contrary to our current approach to aviation safety. Crew Resource Management (CRM) was developed in the 1970s in response to airline crashes in which human error was blamed, rather than getting to the root cause of the system. **DISCUSSION:** The early years of NASA's astronaut corps were idealized in *The Right Stuff* as a "combination of high technical competence, a very rugged individualism, and a very high level of competitiveness". Bob Helmreich, who helped develop CRM, described how this individualism and competitiveness can be destructive to teamwork and a culture of safety, concluding that this may be the "wrong stuff" for aviation safety. Rather than blame individual pilots for error, we should look at the larger system. Viewed this way, there were organizational influences that contributed to the high-risk culture of the astronaut corps. This crash could have been a moment of self-reflection for NASA on lessons learned, instead of blaming See and moving on as if nothing had happened. The crash of NASA 901 serves as a powerful reminder of the importance of developing a culture of safety with implications for aviation and medicine.

Learning Objectives

1. The audience will learn about the fatal crash of NASA 901 in 1966.
2. The audience will learn about the findings of the accident investigation and how blame was placed on an individual's personality and perceived skills rather than on the larger system.
3. The audience will learn about how human factors and crew resource management evolved over the years and how this case may be viewed differently based on our current approach to accident investigation.

[517] A REVIEW OF EVIDENCE-BASED DIVERSITY INITIATIVES IN MEDICAL EDUCATION AND THEIR APPLICABILITY TO TRAINING IN AEROSPACE MEDICINE

Andrew Lam[1], Curran Varma[2]
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(Education - Tutorial/Review)

INTRODUCTION: The Accreditation Council for Graduate Medical Education (ACGME) specifies the following Core Requirement for residency and fellowship programs: "The program… must engage in practices that focus on mission-driven, ongoing, systematic recruitment and retention of a diverse and inclusive workforce of residents, fellows, faculty members, senior administrative staff members, and other

relevant members of its academic community." Research has begun to identify approaches that are effective for the recruitment, retention, and development of medical students and residents from underrepresented in medicine (URM) backgrounds. This presentation introduces such strategies and discusses how they might translate to the training of aerospace medicine practitioners in particular. **TOPIC:** Producing a skilled physician is a longitudinal process that begins with early childhood education and continues indefinitely during practice as an attending. While the first years of life are instrumental in shaping the trajectory of one's future, the preponderance of research on diversity in medical education has focused on training from the pre-medical years to the end of residency. One promising intervention is the "diversity pipeline," a type of mentorship program that prepares learners from underrepresented demographic groups for a career in medicine. The literature reports many pipelines in which a majority of participants, whether high school, college, or medical students, have successfully advanced to the next stage of education. Complementing these outreach-based approaches are steps to directly mitigate unconscious biases in medical school and graduate medical education admissions procedures, some of which have resulted in significantly increased matriculation of URMs. Finally, graduate programs built around diversity go on to generate diverse leaders for the wider medical profession, as evidenced by certain residency programs that have become models for increasing representation in their respective disciplines. **APPLICATION:** Promoting diversity should be a priority for aerospace medicine education not only because it is an accreditation requirement but also because doing so equips our specialty to better serve an increasingly diverse flying population. Pipeline programs, vetted admissions procedures, and structural representation in graduate-level training are examples of evidence-based methods that have the potential to enrich the aerospace medicine community.

Learning Objectives

1. Learn various evidence-based approaches for improving diversity in medical training programs.
2. Understand how such strategies may be adapted to aerospace medicine training programs.

[518] EFFECTIVENESS OF ROUTINE CARDIAC CATHETERIZATION ON AVIATORS WITH KNOWN CORONARY ARTERY

Maryrose Chuidian[1], W. Taylor Timberlake[1], Edward Davenport[1], Caleb James[2], Timothy Crawford[1]

[1]*Wright-Patterson AFB, OH, United States;* [2]*5th Bomber Wing, Minot AFB, ND, United States*

(Original Research)

BACKGROUND: There are no universal guidelines recommending coronary angiography in the routine evaluation of asymptomatic military aviators with a history of coronary artery disease (CAD). The purpose of the study was to analyze the efficacy of periodic evaluation of CAD using coronary angiography. Specific timeframes from diagnosis included six months to a year, one to five years, five to ten years, and cumulative time in study. **METHODS:** A retrospective cohort study was conducted on 289 military aviators between 1986 to 2021. These aviators were referred to the Air Force Aeromedical Consultation Service (ACS) for their history of CAD. Each record was reviewed to identify the development of a significant event secondary to their CAD. An event was defined as either death, myocardial infarction, repeat revascularization or disqualification from flight status. Aviators were followed through to that event or the entire length of time within the ACS. Kaplan-Meier curve was constructed to show mean time to event among aviators in the study. Additionally, Chi-Square testing and Cox proportion hazard models were used to analyze the data. **RESULTS:** A total of 50 events were captured during the study, with 72% of the events occurring within the first year of follow-up while 28% occurred during the remaining time period. Additionally, an association was seen between history of a myocardial infarction or being a current smoker and developing a significant event. **CONCLUSION**: Significant cardiovascular events were detected among asymptomatic aviators using catheterization as a primary means of evaluation. Given the risk associated with flying aircraft and participating in military operations, this study supports the recommendation of periodic angiography in asymptomatic aircrew for evaluation of worsening CAD.

Learning Objectives

1. Analyze the effectiveness of periodic angiography studies in asymptomatic aviators
2. Stratify potential of secondary cardiac event in aviators with known CAD

[519] PROCESS FOR AN USN/USMC AIRCREW ANTHROPOMETRIC SURVEY

Lori Basham[1], Andrew Koch[1], Ashley Wheeler[1], Brian Corner[4], Bethany Shivers[1], Travis Doggett[1]

[1]*Naval Air Warfare Center Aviation Division, Patuxent River, MD, United States;* [4]*Corner3D LLC, Bedford, VA, United States*

(Education - Program/Process Review)

BACKGROUND: The USN/USMC Aircrew Anthropometric Survey is the first aircrew survey since the mid-1960s, and the first that includes female aircrew. Fleet and industry feedback indicates that addressing this data gap is long overdue. This project provides an opportunity to develop and populate a high-quality database and summary report at a much lower cost than previous military surveys through the use of new 3D scanning technology and analysis methods. **OVERVIEW:** This project is projected to take 2 years to complete, with data collection beginning in FY23. Power analysis and aircrew demographics yielded a sample size of 3765 as a goal. Survey sampling, manually collected measurements, and data analytics are standardized per 2012 US Army Anthropometric Survey and the 2010 USMC Anthropometric Survey. Collaborators include Senior Research Anthropologists and Anthropometrists from across the DOD and University of Michigan Transportation Research Institute (UMTRI). 3D scans are being collected with the UMTRI developed PassFit Body Scanner, Artec Leo (face/neck and hands), and Aetrex Albert II foot scanner. The PassFit system extracts DOD standardized anthropometry from the body scans. Fifteen manual measurements are also be collected. Optionally, range of motion data may be collected with a FaroArm coordinate measuring machine, and/or range-of-motion devices as appropriate. Application of parametric head and hand models that are currently in development for the face/neck and hand scans to create aircrew specific databases will be part of a future effort. **DISCUSSION:** The survey will address several current warfighting needs, including: 1) the creation of properly fitting equipment through accurate size design; 2) ensure that the necessary sizes/quantities of personal protective equipment are available in supply through accurate size tariffing; 3) facilitate the development of advanced mission equipment that relies upon accurate conformal fit, e.g., body armor, strength-augmenting or weight-offloading exoskeletons, and physiological monitoring garments; and 4) facilitate appropriate cockpit/workstation layout and seating design. The USN/USMC aircrew survey process can potentially be applied to other US military populations as well. It allows an opportunity for affordable and timely database generation that is beneficial across the DOD and industry.

Learning Objectives

1. Fleet demand signals indicate the need for improved fit, tariffing, and the need to address mission performance and endurance issues. The audience will learn that anthropometry appropriately characterizing the USN/USMC aircrew population is urgently needed and critical to modern aircrew systems design and qualification.
2. The audience will learn that new scanning technology, analysis methods, and survey processes are available to characterize military populations in a timely and affordable manner.

[520] CORONARY ARTERY AGGREGATE STENOSIS FOR CORONARY ARTERY DISEASE RISK STRATIFICATION IN AVIATORS WITH KNOWN DISEASE – CAN WE BROADEN RISK CATEGORIES?

William Timberlake[1], Maryrose Chuidian[1], Caleb James[2], Timothy Crawford[3], Eddie Davenport[1]

[1]*USAFSAM, Wright-Patterson AFB, OH, United States;* [2]*5th Bomb Wing, Minot, ND, United States;* [3]*Wright State University, Fairborn, OH, United States*

(Original Research)

BACKGROUND. Cardiovascular disease is a leading cause of morbidity and mortality among the general population as well as aviators. Annualized risk is a stalwart of aerospace medicine, and the traditionally accepted level is less than 1% per year. More recent analysis in asymptomatic aircrew suggests that new, expanded cutoffs for aggregate stenosis can be applied to annualized risk categories. The purpose of this study was to evaluate the new cutoffs, in a study population with symptomatic disease to determine if the cutoffs meet an acceptable level of risk for aviators to maintain flying privileges. **METHODS.** Aggregate stenosis was obtained via heart catheterization and reviewed via database search resulting in 384 military aviators between 1986 and 2021. Individuals were followed to event (cardiac death, repeat myocardial infarction or revascularization, or waiver denial) or study drop out. Analysis for cutoffs was performed utilizing a ROC curve and cumulative incidence graphs. ANOVA, chi-square, and Cox regression hazard ratio were used for additional analyses. **RESULTS.** Annualized risk of cardiac event for the experimental groups was (Group 0, 0% stenosis) 0.09%, (Group I, 1-95% aggregate stenosis) 0.67%, (Group II, >95% aggregate stenosis) 22.8%, and (Group III, Single Vessel Stenosis ≥70%) 3.42%. Revascularization was the event that drove the increased risk of Group II. Groups II, III, and BMI were independent risk factors for cardiac event risk. As aggregate stenosis increased, age, systolic blood pressure, blood glucose did as well. **CONCLUSIONS.** Mild-risk population cutoffs can be broadened without increasing risk of cardiac event above previous established cutoffs among symptomatic aviators. Future evaluation to better define a moderate-risk group may be warranted for those with known coronary artery disease.

Learning Objectives

1. Understand the risk of cardiac event associated with aggregate stenosis groupings in those with previously known disease.
2. Identify and stratify aviators at-risk for cardiac event in clinical practice.

Index of Abstract Authors (with abstract numbers) and Session Chairs (with session numbers designated by S-01 through S-89)

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Abridged Minutes of the 92nd Annual Business Meeting

Tuesday, May 24, 2022, Peppermill Resort & Casino, Reno, NV

(Full minutes can be accessed in the Members Section of the AsMA website: www.asma.org. You must log in to access.)

DeVoll

Sventek

Call to Order (James Devoll): A quorum of more than 100 members in attendance was met and the meeting started at 12:00 pm PDT on Tuesday, May 24, 2022.

In Memoriam (DeVoll): The president asked attendees to pause to remember those members who passed away this year.

Recognition of Past Presidents (DeVoll): Dr. DeVoll invited the Past Presidents of AsMA to rise and be recognized.

Report of the President (DeVoll): Welcome to everyone and thank you for being here today. This in person meeting in Reno during our usual May time frame has been a long time coming. A typical governance year would have only two Council meetings, but this year we are having three: August in Denver, our usual mid-year meeting in November, and now. This is a breath of fresh air to communicate with people in person. We are returning to normalcy.

AsMA has continued to support the work of CAPSCA as part of ICAO and the efforts to improve aviation safety in the era of COVID and beyond. Dr. Kris Belland serves as AsMA representative to CAPSCA and continues to do an outstanding job. In January, AsMA representatives (Drs. Salicrup, Schroeder, Wilkinson, and Blocker) provided commentary on a proposed Electronic Bulletin regarding the return to duty, fitness to fly, and/or control post COVID infection. This has been an important effort highlighting the contributions of AsMA to the international aviation industry.

The Home Office staff has continued to be fantastic throughout a hectic year of unique challenges, not to mention the additional planning and coordination challenges of the joint meeting with the Undersea & Hyperbaric Medical Society.

In the February 2022 Newsletter, Pam Day laid out the approved change in the Journal previously approved: the online version will be the primary member benefit starting in July, with an added benefit of greatly reduced cost for color images.

ACGME: The movement to provide definition and separation between the three preventive medicine specialties has certainly been tortuous but we are continuing to see progress. Comments were due to ACGME by Mar 30. [Ed. Note: This was approved in June.]

ACOEM has proposed hosting two virtual roundtables (each 1.5 to 2 hours in length) and an online survey to explore the impact of obesity in the aerospace and defense industry, provide awareness of programs to fight obesity, and identify the feasibility of implementing a comprehensive obesity benefit for employees in this industry. Among other meetings, we are planning a meeting with the Indian Society of Aerospace Medicine this week.

Future issues: A review and update of our dues structure.

Report of the Executive Director (Sventek): Mister President, officers, and members of the Aerospace Medical Association, I am happy to report that the Aerospace Medical Association is slowly recovering the negative impact of the COVID-19 pandemic. Organizations around the world were negatively impacted by this deadly virus; AsMA was equipped, organized, and operating remotely for several years. The AsMA HQ team business model included working in the AsMA office building 3 days each week and remotely 2 days per week. When government agencies recommended a shelter in place prevention plan, Gisselle Vargas and I built a schedule that required one AsMA employee in the office in the morning, one morning per week. The AsMA employee would arrive at normal opening time and work in the office until the mail was delivered. The employee would sort the mail and distribute appropriately. Once completed, the AsMA employee would then return home and work the remainder of the week safely from home. We are continuing this work schedule until it is clear the virus is completely under control. It should be noted that all AsMA Staff members are full vaccinated against the COVID-19 virus and all of us have received the recommended booster shots as well. I would like to publicly thank the incredible AsMA Staff and our Journal independent contractors for their strong work during the pandemic.

The work of the Association also continued during the pandemic through the efforts of the AsMA Council and AsMA volunteers. I want to thank all who volunteered this past two plus years to help move the Association forward. Thank you for your continued strong support of the Aerospace Medical Association.

AsMA membership dropped during the pandemic but has recovered to around 2,000 active and paying members. As of this report, AsMA membership totals 1,999. We believe part of the reason for the drop in membership was due to not being able to host an in-person Annual Scientific Meeting in 2020 and a mostly U.S. attended meeting in August 2021 in Denver, CO. Many of our members take the opportunity to renew their memberships during the Annual Scientific Meeting and even though our AsMA Staff sent out dues renewal notifications, many members may have waited to renew, hoping an in-person Annual Scientific Meeting would happen. Thanks to all who renewed when notified by the AsMA Staff. We will continue to work toward getting our membership back to the 2,100 number we had prior to the COVID-19 pandemic.

To offer our membership Continuing Education opportunities, AsMA continues to offer virtual continuing education via webinars. AsMA, in collaboration the International Academy of Aviation and Space Medicine (IAASM), hosted a total of three webinars in 2021. Those webinars offered participants updates on the impact of COVID 19 on aviation and space operations as well as plans for preparing to manage the next pandemic. The three webinars offered physicians up to 8.75 hours of CME credits. In 2022, AsMA collaborated with the Mission-Next Foundation in hosting a webinar focused on 'Air Purification Strategies and Technolgies to Defeat COVID Today and the Biothreats of Tomorrow.' This webinar offered 3.75 CME credits to physicians. Finally, AsMA collaborated once again with our IAASM colleagues in organizing "Aeromedical Aspects of Civilian Evacuation: Preparation, Reaction and Response." This was another well-attended webinar and offered physicians up to 2.75 CME credits. AsMA will continue to evaluate areas of interest that can be offered via webinar throughout the year so those who cannot attend our Annual Scientific Meeting in person can still benefit from the many Aerospace Medicine experts within our membership.

The 1st International Conference of Aerospace Medicine, scheduled for September 2020, was cancelled, and rescheduled for September 2021. The four organizing associations for this joint international conference includes the Aerospace Medical Association (AsMA), IAASM, the European Society of Aerospace Medicine (ESAM), and La Societe Francaise de Medecine Aerospatiale (SOFRAMAS). These four organizations continued to work toward a successful September 2021 event but realized that international travel would likely be a problem through 2021 and possibly into 2022, so the ICAM was postponed again to September 2022. I encourage you to mark your calendars for September 22 through 24, 2022 to attend the 1st International Conference of Aerospace Medicine in Paris, France. Registration for this conference is now open via the AsMA website as well as the ICAM 2022 website.

As of this morning, total registration for this year's joint AsMA/UHMS meeting is 1487. Of this total 1,195 (80.4%) are registered as AsMA attendees and 292 (19.6%) are registered as UHMS as UHMS attendees. This registration total is about the normal number of the registrations we would receive for an AsMA Annual Scientific Meeting during a year without COVID-19. However, the total registrations include a large number of UHMS attendees who might not normally attend an AsMA Annual Scientific Meeting. The 1,195 AsMA registrants represents about 80% of a normal AsMA Annual Scientific Meeting attendance. We are very pleased to have our UHMS colleagues joining us this year Reno.

Finally, I am required to report the Aerospace Medical Association financial status for 2021. Details are in the Treasurer's report, but the 2021 financial records received completed a full audit by Gross, Mendolosohn & Associates, P.A. on April 4, 2022. According to the Audit Report:

"In our opinion, the financial statements referred to above present fairly, in all material respects, the financial position of Aerospace Medicine Association as of December 31, 2021 and 2020 and the changes in its net assets and its cash flow for the years then ended in accordance with accounting principles generally accepted in the United States of America. The financial statement disclosures are neutral, consistent, and clear. We encountered no significant difficulties in dealing with management in performing and completing our audit."

Report of the AsMA Foundation Chair (Kim Broadwell): Dr. Broadwell thanked members for donating $2,805 during the annual meeting registration to the AsMA Foundation, with a grand total of $105,000 in the last 15 years.

AsMA members were saddened by the untimely passing of Dr. John B. Charles in February 2021. To honor Dr. Charles' leadership and scientific contributions to Space Medicine, the Space Medicine Association (SMA) established the JB Charles Research Scholarship which will be awarded at the annual SMA luncheon.

Dr. Mark Campbell has been a leader in the formation of the Space Surgery Association (SSA), an AsMA affiliate organization. The SSA is an international organization of surgeons and other physicians, procedural medicine specialists, and engineers working to develop capabilities to perform operative care in microgravity. In December 2021, Dr Campbell and his wife Betsy signed an agreement with the Foundation creating and funding the Mark and Betsy Campbell Endowed Fund to support the SSA Future Researcher Award.

The AsMA Foundation continues to serve AsMA and its members to provide CME and Genie Bopp, Foundation Secretary/Treasurer, reports that the Foundation is solid financially with assets on December 31, 2021 totaling $662,746, up from $563,540 at the close of 2020.

GOVERNANCE (Susan Northrup)

Report on ASMA Bylaws Changes (Eilis Boudreau): A large number of sections within the bylaws urgently need to be corrected. Our bylaws need to be changed to accommodate virtual meetings or hybrid meetings. Thanks to Dr. DeVoll and Dr. Baisden for their review and input. These changes have been vetted through the Executive Committee and the AsMA Council. Jim Devoll asked for a motion to approve the AsMA Bylaws changes reflecting new ethics guidance. A motion was made by the Bylaws Committee to make bylaws changes to allow for virtual and hybrid meetings. Both motions were seconded and passed.

The proposed bylaws changes will be published in the Newsletter and are in the Reno AsMA meeting app and presented on screen during the business meeting. Approved changes into the AsMA Bylaws can be found at: https://www.asma.org/asma/media/AsMA/Governance/AsMABylaws.pdf and the AsMA Policies and Procedures Manual at: https://www.asma.org/asma/media/AsMA/Governance/AsMA-P-P-Manual.pdf.

Nominating Committee Report (H. Ortega): The Slate of Officers was assembled between Sept 2021 and Dec 2021. The President Elect is Joseph Dervay; Vice Presidents - Rebecca Blue (1 yr to replace Joe Dervay), Robert Orford (2 yr) and Warren Silberman (2 yr), Treasurer - Casey Pruett; Members at Large Ilaria Cinelli, W. Brent Klein, Peter Lee. and Anthony Wagstaff.

AsMA Treasurer's Report (Nereyda Sevilla): In 2021 we ended the year $135K in the red. The 2021 budget was approved with concessions made for lower revenue and expenses as we get back to a post-COVID world. Cancelling Denver 2021 would have incurred a $500,000 penalty and loss of revenue, usually in the hundreds of thousands of dollars per conference, ultimately costing AsMA approximately $1M. Keeping the Denver conference was a break-even success yielding a net revenue of $25K. The convention revenue was $349K less than budgeted, with the expenses $118K over budget. Since the convention provides the primary source of revenue, it is expected that the overall revenue is less than budget. The webinar offerings provided another $19K in revenue new in 2021. Due to COVID, the Home Office was able to apply for and received two Payroll Protection Program funding. This are federal grants that do not have to be repaid. AsMA received a total of two PPP payments (the first $94K and the second $75K) totaling $169K of additional revenue for 2021. Efforts for an automatic payment plan for membership could help in a sustained avenue of revenue. The journal did well at $23K above budget with increases in royalties while the membership hit $143K above budget despite the lower individual and corporate membership. The increase in membership revenue is primarily due to the PPP of $169K. Journal expenses essential hit target but we were under budget for AsMA Management expenses due to IT and travel savings. Overall, we had hoped to break even this year, but ended $211K below budget. The goal remains to have $1M in the Investment Portfolio to be used for down years and unanticipated expenses. The $280K withdrawal in 2021 covered final Denver expenses, Payroll, Hosting of Council Meeting, and Scientific Review.

Recommendations: Reassess AsMA financial position after Reno and perhaps replenishing the investment portfolio to regain our $1M posture. Use the lessons learned from 2020 and 2021 and increase revenue with a potential virtual convention, meetings, and workshops. We will also continue to leverage the cost saving efforts from the membership and journal committees.

REPRESENTATION AND ADVOCACY (DeVoll/Jeff Sventek for Barry Shender)

Update on Aerospace Medical Association Resolution 2020 – 01: Resolution entitled "Vital Nature of Board-Certified Physicians in Aerospace Medicine," co-sponsored by Kris Belland, Joe 'Bugs," Ortega with Warren Silberman, and Dan Berry, approved in 2021. Approval by AsMA aligned perfectly with the American Osteopathic Association (AOA), AOCEM, FAA House of Delegates meeting. The resolution went to Commercial Space Companies and the National Transportation Board (NTSB). President of the AMA, Dr. Harmon, was extremely happy about the letter and will compose a letter to be sent out to organizations under the AMA.

Communications Committee Report: A proposal was presented and accepted by the AsMA Council during the 2021 Annual Scientific Meeting in Denver, for an enhanced communications strategy for our Association. The proposal included improving AsMA web page user experience, reinforcing AsMA's STEM outreach and science communications, creating engaging content in a regular and consistent manner for all our existing and potential audiences, and teaming up with HQ staff and journal staff to produce and publish short videos, podcasts, visual abstracts, and Q&A sessions.

Scientific Program abstract mentorship update: Letters were sent to residents and students to submit presentation and posters for feedback on their posters and presentations.

EDUCATION & RESEARCH (Warren Silberman)

Education and Research Committee: Susan Fondy has done a great job with well-organized Zoom meetings and notes. She is stepping down as chair.

Science and Technology Watch is being reinvigorated and will be placing articles for the Blue Journal headed by Ryan Mayes.

MEMBER SERVICES (Joe Dervay)

Awards Committee Report (Joe Dervay): Eric Olins has done outstanding work in crafting changes to the rules for submitting awards. The approved changes to the award rules include not nominating one individual for more than two awards per year. The committee will review the 21 current awards to determine if there are awards that should be consolidated due to addressing the same general criteria.

Membership Committee Report (Joe Dervay): Dana Windhorst is stepping down as chair. Auto Dues with ACH (automated clearing house) has been established.

INTERNATIONAL SERVICES (Robert Orford)

Despite the travel restrictions that are still in place during the pandemic we have a significant international presence here in Reno.

AsMA-ESAM-IAASM-SoFRAMAS International Conference in Aerospace Medicine ICAM (Paris - Sep 2022) (Robert Orford): The conference center will be at the City of Science and Industry, it is large venue with easy access to the Metro. AsMA will be managing all the registration for ICAM. Hotels near the venue, in the Northeast part of the city, are more reasonable than the hotels downtown.

AsMA Allied Membership (Robert Orford): The program, which we expect to be sustainable if we reach 50, currently has 21 members and will be reviewed by council at the end of the year.

Unfinished Business – none

New Business – none

Closing remarks (Jim DeVoll): Thank you for being here. It shows enormous support. Please contact me at JRDevoll@aol.com with any suggestions on how to increase membership, outreach and other new ideas.

Motion made and seconded to adjourn meeting at 1:10 pm PDT.

Respectfully Submitted,

Jeffrey Sventek, MS, CAsP, Executive Director

J. Karen Klingenberger, MD, MPH, MS, Secretary

Bylaws of the Aerospace Medical Association

(Revised May 24, 2022)

ARTICLE I. NAME

The name of this association shall be the Aerospace Medical Association.

ARTICLE II. VISION, MISSION, AND GOALS

A. Vision: The international leader in aerospace medicine and human performance.

B. Mission: Apply and advance scientific knowledge to promote and enhance health, safety, and performance of those involved in aerospace and related activities.

C. Definition: As used in this document, Aerospace Medicine is the multidisciplinary application of professional and scientific knowledge, training, and research to promote and maintain the health, well-being, safety, and performance of those involved in aerospace activities.

D. Goals:

(1) Provide opportunities for education and promote research.

(2) Provide members opportunities for professional growth and development.

(3) Represent the discipline of Aerospace Medicine to professional, commercial and governmental organizations and advocate policies and standards.

Governance of the Association is necessary to maintain a sound financial structure and ensure continuity of the Association in service to its goals.

ARTICLE III. MEMBERSHIP

SECTION 1. Categories, Qualifications, and Election for Membership.

A. Categories: There shall be the following categories of membership: (1) Member, (2) Life Member, (3) Emeritus Member, (4) Honorary Member, (5) Corporate and Sustaining Member, (6) Technician Member, (7) Student Member, and (8) Resident Member.

B. Qualifications: An applicant for membership shall have one or more of the following minimum qualifications:

(1) Be a duly licensed physician or nurse in the country of residence; or

(2) Hold a designation as an aviation medical examiner, a flight medical officer, an aviation medical director, a flight nurse, or a submarine or diving medical officer, or have held such rating in federal or national government services and normally shall be actively engaged in related capacities; or

(3) Be a graduate of a college or commissioned in the armed services with equivalent qualifications, working in or contributing to the field of aerospace medicine, aeronautics, astronautics, undersea medicine, or environmental health; or

(4) Be a scientist or engineer concerned with the life sciences in the field of, or related to, aerospace medicine, aeronautics, astronautics, undersea medicine, or environmental health; or

(5) Be engaged in teaching, research, or the applications of such research in the field of, or related to, aerospace medicine, aeronautics, astronautics, undersea medicine, or environmental health.

C. Election for Membership

(1) Application for membership shall be accompanied by the full amount of the annual membership dues. The Executive Director shall review the application. If it meets all requirements for qualification without question, the applicant shall be notified that the application has been approved in the appropriate category. If there is a question as to the qualification or category of the applicant, the application shall be referred to the Executive Committee. The Executive Committee shall review the application and shall take such action as its findings warrant. The Executive Committee may refer the application to the Council, which shall then determine whether the applicant meets requirements and in which category. Any applicant refused membership for any reason will be informed of the refusal and the reason for the refusal in writing from the Executive Director and shall be informed of their right to appeal the refusal to the appropriate level.

(2) Members shall have the rights to attend all meetings of the Association, shall be entitled to vote at the business meeting and hold office and to receive the official journal.

(3) Those on the list of active members shall continue as active members as long as they retain their membership in good standing to include payment of dues appropriate to their membership category as established by the Council.

D. Life Member: The Executive Director shall have the authority to grant Life Membership in this Association as consistent with the conditions and appropriate fee for Life Membership as established by the Council. These Life Members shall be entitled to vote and hold office and to receive the official journal.

E. Emeritus Member: The Executive Director shall have the authority to grant Emeritus Membership in this Association as consistent with the conditions and appropriate fee for Emeritus Membership as established by the Council. At age 65, those individuals who have been members for a minimum of 25 years are eligible to apply. Such Emeritus Members shall be entitled to vote and hold office and shall retain all rights and privileges of regular members in good standing. Membership entitles Emeritus Members to the electronic version of the official journal of the Association via the Aerospace Medical Association website. The print version of the official journal of the Association shall be available to Emeritus Members via a subscription at a rate to be determined by the Executive Committee.

F. Honorary Member:

(1) Honorary Members shall be elected from among those individuals who have made outstanding contributions to the advancement of aerospace medicine, aeronautics, astronautics, undersea medicine or environmental health activities. Honorary Members shall not receive the official journal of the Association except by personal subscription.

(2) The Council shall have the power to select not more than four Honorary Members in any one year. The President of the Association, with the concurrence of the Executive Committee, shall propose nominees to the Council for approval. However, any member of this Association may submit such nominations in writing to the Executive Director for transmittal via the Executive Committee to the Council.

G. Corporate and Sustaining Member:

(1) The Executive Committee shall admit as Corporate and Sustaining Members those companies, associations, foundations, groups, or individuals contributing minimum annual dues and who meet other eligibility requirements as established by the Executive Committee.

(2) Upon their approval and acceptance by the Executive Committee, Corporate and Sustaining Members shall receive such other services as the Executive Committee may deem appropriate.

(3) Corporate and Sustaining Members shall have the privilege of attending all meetings of the Association. However, they shall not be eligible to vote or hold office.

H. Technician Member:

(1) An applicant for Technician Membership must be a technician in the field of, or related to, aerospace medicine, aeronautics, astronautics, undersea medicine, or environmental health.

(2) Technician Members shall make application in the prescribed ways indicated in Section 1, C of this Article.

(3) Technician Members shall pay prescribed dues, receive the official journal of the Association, and may participate in all activities of the Association including the Annual Business Meeting, holding office and voting.

I. Student Member:

(1) An applicant for Student Membership must be enrolled full-time in an accredited college or university and have an express interest in aerospace medicine or allied sciences.

(2) Student Members shall make application in the prescribed ways as indicated in Section 1, C of this Article. Members seeking Student status beyond five years shall submit evidence of full-time student status at the time of application.

(3) Student Members shall pay prescribed dues and are entitled to the electronic version of the official journal of the Association via the Aerospace Medical Association website. Student Members are entitled to participate in all activities of the Association including the Annual Business Meeting, holding office and voting.

J. Resident Member:

(1) An applicant for Resident Membership must be enrolled full-time in an accredited residency or equivalent training program and have an express interest in aerospace medicine or allied sciences.

(2) Resident Members shall make application in the prescribed ways as indicated in Section 1, C of this Article. Members seeking resident status beyond five years shall submit evidence of full-time resident status at the time of application.

(3) Resident Members shall pay prescribed dues, receive the official journal of the Association, and may participate in all activities of the Association including the Annual Business Meeting, holding office and voting.

SECTION 2. Review of Ethical Concerns

A. The Ethics Policy of the Association, as defined in the Policies and Procedures Manual, shall apply to all categories of Association members.

B. Ethical Concerns:

(1) An ethical concern should be resolved at lowest level possible within the Association.

(2) Should the ethical concern not be resolved at lower levels, the concern may be elevated to the Executive Committee using the process delineated below.

(3) Ethical concerns addressed through this process shall be limited in scope to conduct deemed contrary to the best interests of the Association, to include the business and governance of the Association, the annual scientific meeting, and the Association's official journal. The Executive Committee shall determine if the concern is within the scope of this process.

(4) Any member may raise an ethical concern regarding another member who is believed to have violated the Ethics Policy of the Association, to include the business and governance of the Association, the annual scientific meeting, and the Association's official journal. The Executive Shall determine if the concern is within the scope of this process.

(5) The Executive Committee shall initially review the written ethical concern to determine the validity of the concern and whether a formal investigation is warranted. The Executive Committee may dismiss the concern if it is deemed not valid or outside the scope of this process.

(6) If the Executive Committee determines the ethical concern has validity and is within the scope of the process, the concern will be referred to the Ethics Body for investigation as described in the Policies and Procedures Manual.

(7) The respondent shall be advised in writing of any ethical concern regarding him or her and be provided an opportunity to respond to the Ethics Body and the Executive Committee.

(8) Once the investigation is complete, the Ethics Body shall provide a summary report of the investigation to the Executive Committee.

(9) For any ethical concern regarding a member of the Executive Committee, the Council will assume the role of the Executive Committee in this process.

C. Administrative Action:

(1) Upon receipt of the report from the Ethics Body, the Executive Committee shall determine the appropriate administrative action.

(2) The Executive Committee shall have, but not be limited to, the following powers: dismissal of the ethical concern, censure, probation for a period not to exceed two years, suspension for a period not to exceed three years, or expulsion of a member, as the findings warrant.

(3) A two-thirds vote of the full membership of the Executive Committee is required for any ruling.

D. Appeal Process:

(1) Proposed administrative actions may be appealed to the full Council and shall be submitted in writing to the Executive Director.

(2) Should an appeal be requested, no administrative action shall proceed until the appeal process is complete.

(3) A two-thirds vote of the full membership of Council is required to modify or reverse the action of the Executive Committee. Failing to achieve modification or reversal from the Council, the action of the Executive Committee is confirmed. Action of the Council is final.

ARTICLE IV. Corporate Forum

SECTION 1. Titles, Structure, Representation, and Relationship to AsMA Committee

A. Titles: The Corporate Members shall constitute the Corporate Forum.

B. Structure: The Corporate Forum may have an internal governance structure of its choosing, with officers and procedures appropriate to its activities.

C. Representation: The Corporate Forum shall choose one of its members to represent the Forum at Council meetings. The representative shall serve as a liaison between the Council and the Forum. The Corporate Forum is aligned under the Vice President of Member Services.

D. Relationship to Corporate and Sustaining Membership Committee: The Corporate Forum will work in coordination with the Corporate and Sustaining Membership Committee as described in Article XII of these Bylaws.

SECTION 2. Membership

All members of the Corporate Forum shall be Corporate Members as determined in Article III of these Bylaws.

SECTION 3. Activities

A. Forum Events: The Corporate Forum will plan and conduct an annual Advisory event, in coordination with Council. The purpose of the Advisory will be an exchange of information and goals between the Association leadership and the Forum to facilitate good relations and advances in the field of Aerospace Medicine and Human Performance. The Forum may also sponsor a speaker or other similar event(s) for the general Association membership.

B. Forum Budget: The Association budget will consider and plan for reasonable expenses in connection with Forum events.

ARTICLE V. FELLOWSHIPS

A. There shall be the following categories of Fellows: (1) Fellow, (2) Associate Fellow, and (3) Honorary Fellow.

B. Fellow:

(1) Fellows of the Aerospace Medical Association will be selected from among the active members who have made outstanding contributions to aerospace medicine, aeronautics, astronautics, undersea medicine, or environmental health, in the practical usage of research, or by precept and example.

(2) All those now holding the grade of Fellow, or who may be hereafter elected to such, shall constitute the group of Fellows. The group shall meet and shall elect annually, its chair, who shall hold office until a successor is elected.

(3) Nominations for Fellows shall be made by the Fellows who are active members.

(4) Fellows shall be elected annually through a published process developed by the Fellows and approved by Council.

C. Honorary Fellow:

(1) Honorary Fellows shall be elected by the Fellows from among persons who have rendered outstanding service or made outstanding achievements in aerospace medicine, aeronautics, astronautics, undersea medicine or environmental health activities. Honorary Fellows shall not normally be elected from members in good standing. Honorary Fellows shall be nominated and voted upon as prescribed for the election of Fellows. However, a two-thirds majority of votes cast shall be required for election. If required for any reason, additional voting may be conducted at the time of the annual meeting of the group of Fellows.

(2) Honorary Fellows shall not be entitled to vote or hold office. They shall pay no dues and shall not receive the official journal of the Association except by personal subscription.

(3) The election of Honorary Fellows is limited to no more than two in any one year.

D. Associate Fellow:

(1) Selection as an Associate Fellow shall honor members of the Aerospace Medical Association who have contributed to the Association in a positive manner.

(2) All those holding the grade of Associate Fellow, or who may hereafter be elected to such, shall constitute the group of Associate Fellows. The group shall meet annually during which the election of officers will be announced.

(3) A candidate for Associate Fellow shall have been a member for at least five years.

(4) Applications for Associate Fellowship shall be reviewed by the Associate Fellows and submitted to the Executive Committee for approval.

ARTICLE VI. OFFICERS

SECTION 1. Elected Officers

The elected officers of this Association shall be a President, President-Elect, four Vice Presidents, Secretary, and Treasurer. The President-Elect shall be elected annually to serve one year or until a successor is elected and assumes office at the close of the Annual Business Meeting of the Association. The Vice Presidents, Secretary, and Treasurer shall serve for two years or until their successors are elected and assume office at the close of the Annual Business Meeting of the Association. The President-Elect shall automatically succeed to the office of President at the close of the Annual Scientific Meeting.

SECTION 2. President.

The President shall chair all meetings of the Council of the Association and the Executive Committee. The President shall appoint chairs of Association committees unless provided otherwise in these Bylaws. The President has the authority and obligation to provide specific tasking to committees and other functionaries doing work for the Association. The President is an *ex officio* member of all Standing Committees except the Nominating Committee. In the event an officer or elective member resigns, is incapacitated, or is otherwise unable to act, the President may appoint, with approval of the Executive Committee, an acting officer or elective member to perform those duties until the next Annual Business Meeting or for the period of the incapacity.

SECTION 3. President-Elect.

The President-Elect shall become familiar with the duties of the President and shall perform such other functions as the President may designate. In the event that the President is incapacitated or otherwise unable to act, the President-Elect shall perform the functions of and act as President for the period of such incapacity.

SECTION 4. Vice Presidents.

The four Vice Presidents shall perform such duties as designated by the President.

SECTION 5. Secretary.

The Secretary shall be responsible for reviewing the minutes of the Council and Executive Committee meetings and shall perform those duties as directed by the President. The Secretary shall have other duties usually performed by a Secretary which are not accomplished by the home office staff.

SECTION 6. Treasurer

The Treasurer shall have duties usually performed by a Treasurer and shall perform those duties as directed by the President, Council, or Executive Committee. The Treasurer shall be the chair of the Finance Committee and custodian of all monies and securities and hold same subject to the direction and disposition of the Executive Committee under the direction of the Council. The Treasurer shall perform the duties in cooperation with the Executive Director.

SECTION 7. Unbudgeted Expenditure of Funds.

No Officer may make or authorize any unbudgeted expenditure without approval

of the Executive Committee or the Executive Director. The Executive Director shall not make or authorize any unbudgeted expenditure exceeding the amount stipulated by the Policy and Procedures Manual without approval of the Executive Committee.

ARTICLE VII. EXECUTIVE DIRECTOR.

SECTION 1. Appointment

The Executive Director shall be appointed by the Council, and shall not hold an elective office.

SECTION 2. Duties.

A. The Executive Director shall be the chief operating officer of the Association and shall keep its records, and a file of its publications. The Executive Director shall notify all members of the time and place of meetings, notify Council members of the time and place of Council meetings, and shall prepare the programs of the meetings under the direction of the Council.

B. The Executive Director shall cooperate with the chairmen of various groups and committees of the Association in the execution of the policies of the Association as outlined by the Council, shall coordinate the work performed by the various committees of the Association, shall perform such duties as are assigned by the Council, and shall act under instruction of the Executive Committee.

C. The Executive Director is authorized to provide such assistance as is necessary for the proper conduct of the Association headquarters office, subject to the directives of the Executive Committee and the Council. The Executive Director shall employ and supervise the staff, authorize purchase of supplies and equipment, arrange for office and other facilities for operating purposes, within the budget and as approved by the Executive Committee, and is empowered to sign contracts and enter into agreements on behalf of the Association and within the policies established by the Council and the Executive Committee.

D. The Executive Director shall, with the Treasurer, prepare a budget covering estimated annual expenses, to be submitted to the Council for adoption.

E. The Executive Director shall serve as the general coordinator and organizer for the Annual Scientific Meeting and shall direct the chairmen of the committees appointed for the planning, preparation, and operation of the Annual Scientific Meeting of the Association subject to the supervisory authority of the Executive Committee.

F. The Executive Director may retain legal and professional services as may be required with the prior approval of the Executive Committee.

G. The Executive Director shall prepare for the Annual Business Meeting a concise and summarized report on the activities of the Association for the year, its membership, and other matters of importance to the Association.

H. The Executive Director shall report in writing the total membership of the Association as of January 1 each year to the chair of the group of Fellows prior to the annual meeting of the Fellows.

I. The Executive Director shall be insured in an amount approved by the Executive Committee.

ARTICLE VIII. COUNCIL OF THE AEROSPACE MEDICAL ASSOCIATION AND EXECUTIVE COMMITTEE

SECTION 1. The Council of the Aerospace Medical Association.

The governing body of this Association shall be the Council of the Aerospace Medical Association, hereinafter referred to as the Council. Council members shall conform their conduct and perform their duties in a manner consistent with a published Ethics Policy adopted by the Council.

SECTION 2. Membership of the Council.

Membership of the Council shall consist of the President, President-Elect, the immediate Past President, the four Vice Presidents, the Secretary, the Treasurer, 12 elective members, one member selected by each of the Constituent Organizations, one member selected by the Fellows group, one member selected by the Associate Fellows Group, the Aerospace Medical Association Delegate to the American Medical Association, the Aerospace Medical Association Delegate to the American Osteopathic Association, a student or resident representative selected by the Aerospace Medicine Student Resident Organization, the Editor-in-Chief of the Association's official journal (*ex officio* member without vote; appointed by the President and approved by Council), a representative from the Corporate Forum (*ex officio* member without vote), and the Parliamentarian (*ex officio* member without vote; appointed by the President and approved by Council). The Executive Director shall be an *ex officio* member without vote. Of the 12 elective members, 4 shall be elected to the Council each year for three-year terms. No such elected member shall be eligible for more than two successive terms as an elective member. In the event an elected member of the Council resigns or is otherwise unable to complete a term on the Council, the Nominating Committee shall propose a nominee or nominees for election to fill the remaining year or years in that term. In the event a non-elected member resigns, is incapacitated, or is otherwise unable to attend a Council meeting, the appointing entity may designate an alternate by notifying the Executive Director or Secretary. All voting members of the Council must be members of the Association.

SECTION 3. Powers of the Council.

A. The Council establishes policy for the Association. The Council shall be vested with the management of the funds, properties, and the affairs of the Association and shall act in the capacity of a board of directors. The Council shall adopt such regulations as may be appropriate for governing the Association including an Ethics Policy for its members. It shall have the power to approve proposed budgets, authorize expenditures, seek and accept contributions, authorize contracts in the name of the Association, define and promote the activities of the Association, approve applications for constituency or affiliation with the Association, determine special classifications of membership and the eligibility of applicants for membership, authorize employment of auditors, and provide for issuance and distribution of the official educational scientific publications of the Association, including the official journal of the Association. The Council shall have the power to approve the appointment of an Executive Director and the Editor-in-Chief of the official journal of the Association, or any educational or scientific journal or other publication, on recommendation of the Executive Committee.

B. The Council shall provide for the business and conduct of the annual special meetings, and through its Executive Committee shall be responsible for the program of the annual scientific sessions and shall approve and grant any award given by the Association.

C. The Council shall establish such rules and regulations for the election of Associate Fellows as it deems advisable and which are not in conflict with the provisions of the Bylaws

D. The Council may delegate powers and duties to officers and employees of the Association.

E. The Council may assign responsibility to the Executive Committee for the management of the Association's finances and the investment of the Association's funds.

F. The Council may establish standards and procedures for certification of the professional competence of individuals within the special disciplines of the Association. Certification shall be made by action of the Council.

G. The Council may, at any time, on its own initiative, propose resolutions.

H. The Council shall perform such other duties as provided by the Bylaws.

SECTION 4. Meetings of the Council.

A. Regular Meetings: The Council shall have at least three regular meetings a year at the time and place called by the President as follows:

(1) Not more than 30 days before the Annual Business Meeting of the Association.

(2) Not more than two days after the Annual Business Meeting of the Association. If such a meeting is called before the close of the Annual Scientific Meeting, the President for the succeeding year shall be installed as Chair of the Council by the then President. The new Chair, the succeeding President, shall preside during the reorganization of the Council and consider any new business or items directed to the Council by the membership at the Annual Business Meeting.

(3) Not more than eight months nor less than four months after the Annual Business Meeting.

B. Special Meetings: Special meetings of the Council shall be held at the time and place called by the President, or the Executive Director may call a meeting upon written request of any 12 members of the Council.

C. Attendance and Quorum:

(1) Attendance at any regular or special meeting of the Council may be in person or in any manner consistent with procedures published in the Policies and Procedures Manual.

(2) Forty percent of the Council shall constitute a quorum at any duly called meeting of the Council.

SECTION 5. Executive Committee.

A. The Executive Committee shall consist of the President, the President-Elect, the four Vice Presidents, Secretary, Treasurer, Executive Director (*ex officio* without vote), and three members of the Council nominated by the President for the succeeding year, who shall be elected by a majority vote of the Council at its first meeting following the annual election of officers and councilors.

B. Except as otherwise provided in these Bylaws, the Executive Committee shall have the power to exercise all the functions of the Council between Association meetings and when the Council is not in session. The Council may delegate to such Executive Committee any or all of the powers granted to the Council by law or by these Bylaws, and not specifically delegated to any other committee or reserved to the Council by law.

C. The Executive Committee shall act as a Committee on Credentials.

D. The Executive Committee shall be responsible to the Council for the program of scientific meetings. The Executive Committee shall follow the guidelines in the Policy and Procedures Manual for review and acceptance of proposed exhibits for the Annual Scientific Meeting.

E. The Executive Committee shall be in charge of the finances of the Association and the investment of funds of the Association under the direction of the Council. It shall regulate and approve the budgets of all other committees.

F. The Executive Committee shall have the power to appoint the Editor of the official journal of the association, or any educational scientific journal or other publication, with the approval of the Council, and may recommend the members of the Editorial Board to the Council after consulting with the Editor.

G. The Executive Committee shall have the power to appoint a Managing Editor and such Assistant Editors as it deems necessary.

H. The Executive Committee shall approve changes to the Aerospace Medical Association Policies and Procedures Manual as necessary to be consistent with the Bylaws and Council direction.

I. The Executive Committee shall select the time, place, and format of the Annual Scientific Meeting.

J. Meetings: Attendance at any meeting may be in person or in any other manner consistent with procedures published in the Policies and Procedures Manual. A majority of the Executive Committee shall constitute a quorum at any duly called meeting of the Committee. The President shall call such meetings of the Executive Committee as the business of the Association may require, or a meeting shall be called by the Executive Director upon written request of a majority of the Executive Committee.

ARTICLE IX. ORGANIZATIONS.

SECTION 1. Constituent and Affiliated Organizations.

A. Qualifications:

(1) All Constituent and Affiliated Organizations shall have a similar mission and goals to those of the Aerospace Medical Association as outlined in Article II; have the objective of furthering the goals of this Association through local meetings, acquaintanceship, and discussion by the members, embraced within the group, of matters relating to aviation, space, or undersea medicine, or their allied sciences; increasing the value of this Association to its members, and helping maintain and increase its membership. The mission, goals, limitations, and activities of such group shall not be inconsistent with those of the Aerospace Medical Association. The Bylaws or other instruments of organization of such group shall be in conformance with the general provisions of the Bylaws of this Association and shall be approved by the Council of the Aerospace Medical Association.

(2) Constituent and Affiliated Organizations shall make formal written application through its responsible officers to the Association through the Council of the Aerospace Medical Association. Such application shall indicate the name of the group and the proposed area of its jurisdiction.

(3) A copy of the Constitution, Bylaws or other instruments of organization and amendments thereto of such group shall accompany its application. The application shall be presented to the Council of the Aerospace Medical Association. When the Council has approved the application by a two-thirds vote, a formal notification recognizing the Constituent or Affiliated Organization shall be issued to the group by the Council and such notification shall include a statement of the mission and goals of the Aerospace Medical Association as set forth in Article II.

B. Discontinuance of Constituency or Affiliation: Discontinuance of an existing organization shall be referred to the Executive Committee for study, whereupon the Executive Committee shall make a recommendation to the Council for appropriate action.

C. Constituent Organizations:

(1) Constituent Organizations must have a minimum membership equivalent to 2% of the active membership of the Aerospace Medical Association as determined and communicated in accordance with the Policies and Procedures Manual. With its application for constituency, each Constituent Organization shall furnish the Executive Director a current roster of its members in good standing, giving name, residence, and connection with aerospace medicine or its allied sciences. All members of the Constituent Organization shall be members of the Aerospace Medical Association. A Constituent Organization may have sustaining partners, however, that are not active members of the Aerospace Medical Association. These sustaining partners are not members and do not count toward the 2% criterion for Constituency status. By January 1 of each calendar year, each Constituent shall furnish the Executive Director a current roster of its members.

(2) Each Constituent Organization shall be represented on the Council by an individual who is a member of the Association designated by the Constituent Organization. Each such organization shall present the name of its designated primary representative to the Executive Director during the Annual Scientific Meeting. In the event the primary representative cannot attend a Council Meeting, the name of an alternative representative shall be presented to the Executive Director or Secretary.

D. Affiliated Organizations:

(1) Each Affiliated Organization shall furnish the Executive Director with a current demographic description of its membership with its application for Affiliated status.

(2) Each Affiliated Organization shall communicate with the Association at least once per year to indicate its desire to remain an Affiliated Organization of the Association.

SECTION 2. Regional Subdivisions and Chapters.

It is the policy of the Association to encourage and recognize the establishment of local chapters and subdivisions of its members. The Council shall have the authority to control the establishment, guidance, and termination of regional chapters and subdivisions and may establish regulations for this purpose upon such terms and conditions as it may deem appropriate in order to further the mission and goals of the Association. The provisions of the certificate of incorporation and of these Bylaws shall be equally binding upon the Association and all its regional sections, subdivisions, or chapters.

ARTICLE X. CERTIFICATION BOARDS.

SECTION 1. Certification Boards.

A. Titles: The Association may sponsor Certification Boards.

B. Qualifications: All Certification Boards shall have a similar mission and goals to those of the Aerospace Medical Association as outlined in Article II; have the objective of furthering the goals of this Association through evaluation and examination of individuals seeking certification by the Association on matters relating to aviation, space, undersea medicine, or their allied sciences; increasing the value of this Association to its members, and helping maintain and increase its membership.

SECTION 2. Membership.

All members of a Certification Board must be members of the Association and be approved by Council. The Council shall select one of its members to represent each Certification Board at Council meetings. The representative should be certified in an appropriate field and will serve as a liaison between the Certification Board and the Council.

SECTION 3. Discontinuance of a Certification Board.

Discontinuance of an existing Certification Board shall be referred to the Executive Committee for study, whereupon the Executive Committee shall make a recommendation to the Council for appropriate action.

ARTICLE XI. ELECTIONS.

Elections shall be held at the Annual Business Meeting of the Association. Only active members in good standing shall be entitled to vote in the election of officers and members of the Council. These shall be elected by a majority vote of those voting members present at the Annual Business Meeting. If there is more than one nominee for an office, the nominees shall be excused and the vote shall be by show of hands.

ARTICLE XII. COMMITTEES

SECTION1. Standing Committees.

A. There shall be the following standing committees:

(1) Aerospace Human Performance, (2) Aerospace Safety, (3) Air Transport Medicine, (4) Arrangements, (5) Awards, (6) Bylaws, (7) Communications, (8) Corporate and Sustaining Membership, (9) Education and Training, (10) Finance, (11) Global Liaison and Outreach, (12) History and Archives, (13) Membership, (14) Nominating, (15) Registration, (16) Resolutions, (17) Science and Technology, and (18) Scientific Program.

B. Other committees of the Association may be established as provided in the Bylaws or determined by the Council.

SECTION 2. Appointment and Duties.

A. The President, in consultation with the President-Elect and with the concurrence of the Executive Committee, shall appoint all chairs of standing committees except as otherwise provided in the Bylaws.

B. The chair of each committee may be directed by the President of the Association to accomplish specific tasks and reports relative to the area of expertise of that committee. Committee Chairs shall identify at least one Deputy Chair. Committees may have such subcommittees as the President and the committee may deem necessary to carry out their purposes. The Policies and Procedures Manual describes the committees' reporting responsibilities and details of their activities and function.

SECTION 3. Standing Committees Functions.

A. Aerospace Human Performance Committee: This committee shall be responsible for establishing an integrating function and forum sponsoring panels and seminars, preparing reports, resolutions, and recommendations concerned with personnel selection, human performance, and human factors input in the concept, design, development, test and evaluation, and operational deployment of aerospace programs and systems. The committee will seek to promote research and application of human performance knowledge in every phase of systems development and deployment. Human performance and systems integration require a multidisciplinary approach involving decision-making, behavioral, biomedical, psychosocial, physiological, and engineering factors. The goal of the committee is to produce recommendations for improving aerospace systems performance.

B. Aerospace Safety Committee: The goal of this committee shall be to improve the safety of aviation and space activities. The committee shall direct its efforts to identifying specific, important aviation and space safety issues, national or international in scope that represents a significant threat to the health and safety of

people involved in aviation and space activities, either as crew members or passengers. The objective of the committee shall be the resolution of aviation and space safety issues through either educational or regulatory processes. The committee may, with approval of the Council or Executive Committee, recommend research projects, prepare reports and scientific papers, sponsor panels and seminars, or formulate recommendations and resolutions to accomplish this objective.

C. Air Transport Medicine Committee: This committee shall be responsible for performing studies and preparing reports, resolutions, and recommendations on biomedical aspects of air transport operations. This committee shall concentrate its efforts on the promotion of international health, safety, and care through the mechanism of collecting information, analyzing data, and recommending solutions leading to improving health and safety in air transport operations.

D. Arrangements Committee: The Arrangements Committee works with the Association Headquarters Staff to make logistical arrangements for the Annual Scientific Meeting.

E. Awards Committee: The Awards Committee shall obtain and review all nominations for the various awards and honorary citations presented by the Association and make recommendations to the Council in such manner as the Council may prescribe.

F. Bylaws Committee: This committee shall be a fact-finding committee on matters pertaining to the Bylaws. The committee shall study proposed amendments to the Bylaws referred by the Council, and make its recommendations to the Association through the Council. If deemed necessary, this committee shall revise or develop new Bylaws for submission or approval in turn by the Council and the Association subject to proper publication, notification, and approval by a two-thirds vote of members attending the Annual Business Meeting as set forth in Article XVI.

G. Communications Committee: This committee shall oversee the communications program of the Association including brochures, books, and electronic media. The Communications Committee, at the request of the President or Council, prepares, reviews, and publishes publications sponsored by the Association other than the journal. The Committee may propose other projects related to communications that must be approved by Council.

H. Corporate and Sustaining Membership Committee: This committee shall be responsible for initiating programs and activities whose purposes and objectives are to increase and represent the interests of the corporate and sustaining members. This committee shall assist the Executive Director and the Executive Committee in reviewing the applications for corporate and sustaining membership referred to it, secure all available information concerning such applicants, and submit its recommendations to the Executive Committee through the Executive Director.

I. Education and Training Committee: This committee shall promote international aerospace medicine and allied disciplines through excellence in education and training conducted or cosponsored by the Association and consistent with the Association's objectives. It shall establish procedures to ensure the dissemination of educational and training related information and materials to the membership; coordinate the Association's education and training needs with the Scientific Program Committee; and coordinate the Association's Continuing Medical Education (CME) role.

J. Finance Committee: this committee shall update and review the Association's financial balance sheets on an ongoing basis, provide an overview of the Association's financial position to the Council at its regular meetings, and bring forward or review potential new courses of financial action. The committee is comprised of a Chair and four regular members. The Chair will appoint the regular members of the committee. The President-Elect of the Association is an *ex officio* member of the Finance Committee.

K. Global Liaison and Outreach Committee: This committee shall be responsible for initiation, coordination, and promotion of the Association's global perspectives, namely: 1) to promote coordination, cooperation, and harmonization of efforts associated with global aerospace medicine and human performance challenges, 2) to promote the importance of and opportunities in aerospace medicine and human performance in each country or region, 3) to identify and promote global best practices in aerospace medicine and human performance research and applications, and 4) to strengthen the connection between AsMA and its global membership, its global constituents and affiliated organizations.

L. History and Archives Committee: This committee shall be responsible for acquiring, preserving, and maintaining those items of historical significance that represent and depict the achievements of the Association and its members. This responsibility shall be exercised through historical research, commemorative presentations, and fostering the preservation of library, archival, and museum collections.

M. Membership Committee: This committee shall be responsible for initiating programs and activities whose purposes and objectives are to increase membership in the Association and to promote public relations. This committee shall act in an advisory capacity to the Executive Committee and the Council in matters relating to the establishment of eligibility requirements for all classes of membership.

N. Nominating Committee: Elected officers and the elective members of the Council shall be nominated by a Nominating Committee made up of the five most recent living Past Presidents of the Association and a representative selected from each Constituent Organization of the Aerospace Medical Association. The immediate Past President shall serve as a member of the Nominating Committee for a one-year term, and shall become Chairperson of that committee in the subsequent year. A Chairperson or any Past President who is unable or unwilling to discharge their associated responsibilities shall be replaced by the President with another Past President. The Nominating Committee shall conduct its activities by electronic communication. Each individual nominated shall have been approved by at least a simple majority vote of the Nominating Committee members. The report of the Nominating Committee shall be made as stipulated in the Policies and Procedures Manual and orally at the opening ceremony of the Annual Scientific Meeting. Any member may offer additional nominations, including name of nominee and office for which nominated, from the floor at the Annual Business Meeting; however, the Executive Director must be provided written notice of the nomination no less than twenty-four hours before the Annual Business Meeting. Such nominations must be accompanied by a petition of at least 2% of the active members of the Association and must be accepted by a two-thirds majority vote of members attending the Annual Business Meeting, before the nominee can be a candidate in a vote for a named position.

O. Registration Committee: The Registration Committee assists with registration activities associated with the Annual Scientific Meeting. This includes distribution of registration materials and coordination of tickets for events.

P. Resolutions Committee: Resolutions may be proposed to the Resolutions Committee by individual members, standing and special committees, Constituent Organizations, the Executive Committee, and the Council. Proposed resolutions that have been reviewed and coordinated by the Resolutions Committee shall be submitted to Council. If disapproved by Council, the resolution will be returned to the Resolutions Committee for further review and coordination. If approved by Council, the resolution will be presented to the Association membership. Proposed resolutions will be published on the Association's website for a period of at least 60 days to offer members the opportunity for review and comment. Members of the Association will be notified by electronic means when resolutions are posted on the website for review and when posted for a vote. Members may submit comments to the Resolutions Committee within the 60-day comment period. Comments received from members may be incorporated into the proposed resolution by the Resolutions Committee, after which the revised resolution shall be resubmitted to Council. After final review and approval by Council, the draft resolution will be posted on the Association's website for a vote by the membership. Association membership shall have final approval of resolutions. Voting on resolutions by the Association members can be performed remotely by electronic means or in person during Annual Business Meetings of the Association. Electronic voting on proposed resolutions will be open for a period of at least 30 days. A quorum of 100 Association members is necessary for a vote, and a majority of those voting members is required for final approval of a proposed resolution. Voting will not be terminated prematurely when a quorum is achieved but will remain available for the entire 30-day period. If a quorum is not met at the end of the 30-day period, the voting period may be extended up to an additional 30 days.

Q. Science and Technology Committee: This committee is responsible for informing and educating the Association regarding interdisciplinary problems in the areas of systems analysis and technology utilization, as well as aeromedical, biomedical, and human factor requirements.

R. Scientific Program Committee: The Scientific Program Committee is responsible for the development and execution of the scientific program for each year's Annual Scientific Meeting. The Chair, with the help of committee members, arranges for abstract submission and review, scheduling of scientific sessions, and presentation of the scientific program.

SECTION 4. Special Committees.

The Council or the President may create special committees as may be deemed necessary with such membership and for such a period of time as may be considered appropriate. The Council or the President shall establish and define the functions of such committees.

ARTICLE XIII. MEETINGS

SECTION 1. Required Meetings.

Required meetings may be conducted in one of the following formats (1) in-person only, (2) combined in-person and virtually, or (3) virtual only.

A. The Association shall conduct at least one Annual Business Meeting which shall be open to the general membership and devoted to the reception of annual reports, the nomination and election of officers, consideration of amendments to the Bylaws, consideration of resolutions, and any other such business as decided by the Council.

B. The Association shall conduct at least one scientific meeting each year.

SECTION 2. Time and Place of Meetings.

The Annual Scientific Meeting shall be conducted at a time and place, and in a format selected by the Executive Committee. Meetings shall be held as provided

for in these Bylaws. In cases of emergency, the Council shall have the authority to cancel, postpone, or change the site or format of an annual meeting, or a special Association meeting may be authorized or called by the Council.

SECTION 3. Quorum.

The Annual Business Meeting shall require a minimum of one hundred (100) active members to constitute a quorum.

SECTION 4. Parliamentary Authority.

The current edition of Robert's Rules of Order Newly Revised shall cover the procedure at all meetings unless otherwise provided by these Bylaws. Unless provided otherwise by Robert's Rules of Order Newly Revised or by these Bylaws, all elections and questions shall be decided by a majority of votes cast.

SECTION 5. Parliamentarian.

The duties of the Parliamentarian will be as specified in the Parliamentary Authority, with the intent to help ensure the orderly progress of meetings and the fair and equitable treatment of all participants.

ARTICLE XIV. DUES AND SUBSCRIPTIONS

SECTION 1. Annual Dues.

A. Annual dues for all classes of membership shall be set by the Council with the proposed change becoming effective no sooner than 60 days following advance notice published in the journal of the Association, during which time members may register their comments with the Executive Director of the Association and such comments shall be given due consideration by the Council.

B. Membership dues are payable on the last day of the month in which the applicant is selected for membership and annually thereafter.

C. Annual dues shall include subscriptions to the official scientific journal of the Association and to such other records, reports, proceedings, and publications as authorized by the Council except where otherwise provided.

D. The Executive Committee may authorize suspension of dues or subscriptions on the part of any member.

SECTION 2. Exemption from Dues.

A. Honorary Member: Honorary Members shall be exempt from the payment of dues.

B. Life Member: Following payment of the appropriate fee, the Life Member shall thereafter be exempted from the payment of annual dues.

SECTION 3. Active Member.

An active member (a member in good standing) is one who is qualified for membership and is current in the payment of dues. Active members are entitled to all the rights and privileges of membership including voting and holding office.

SECTION 4. Delinquency.

A member is delinquent if Association dues are not paid within 60 days of the due date. If dues are not paid within 30 days after notification of delinquency, the member shall be removed from the active membership role of the Association for nonpayment of dues.

SECTION 5. Reinstatement.

Any member dropped for nonpayment of dues may be reinstated to member-in-good-standing status on payment of dues for the current year in advance.

ARTICLE XV. FUNDING AND FINANCES

SECTION 1. Funding.

Funds may be raised (a) by dues; (b) by assessments on active members on recommendation of the Council and after approval by the membership; (c) from the publications of the Association at a rate established by the Council; and (d) in any other manner approved by the Council. Funds may be appropriated by the Council to defray the expenses of the Association.

SECTION 2. Finances.

A. Fiscal Year: The fiscal year shall begin on January 1 and end on December 31 each year.

B. Insurance: The Executive Director shall procure Directors' and Officers' Liability Insurance in an amount determined by the Council, the cost to be paid by the Association. The Executive Director, Treasurer, and other persons approved by Council may sign checks.

C. Budget: The Council, at its fall meeting, shall adopt an income and expense budget covering all activities for the next fiscal year. No officer may make or authorize any unbudgeted expenditure without approval of the Executive Committee or the Executive Director. The Executive Director shall not make or authorize any unbudgeted expenditure exceeding the amount stipulated by the Policy and Procedures Manual without approval of the Executive Committee.

D. Audit: An audit shall be made by a certified public accountant at a frequency and time described in the Policy and Procedures Manual. The audit shall be submitted to the Executive Committee at its meeting prior to the Annual Scientific Meeting of the Association. The report of the audit shall be made available to the membership at the Annual Business Meeting of the Association.

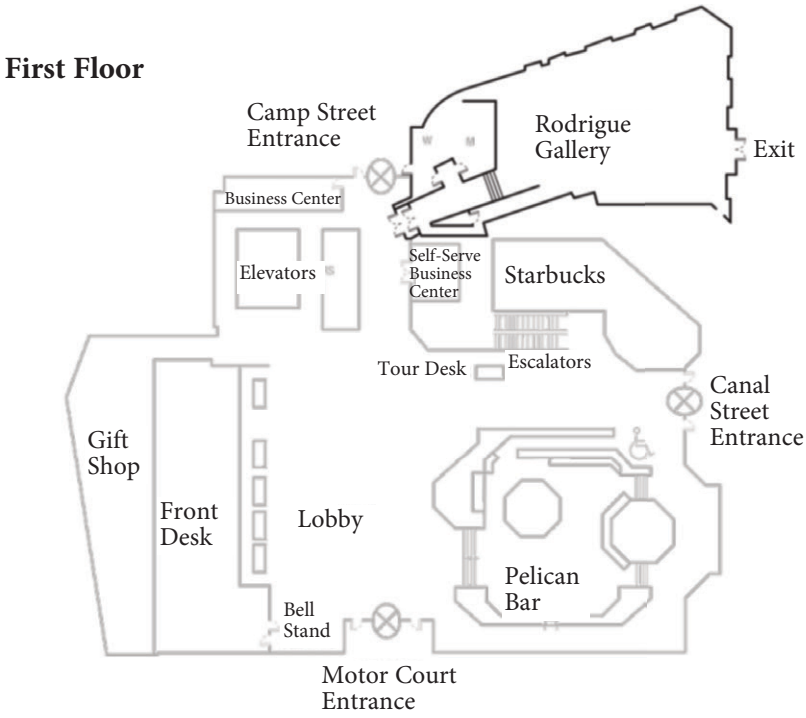
ARTICLE XVI. AMENDMENTS.

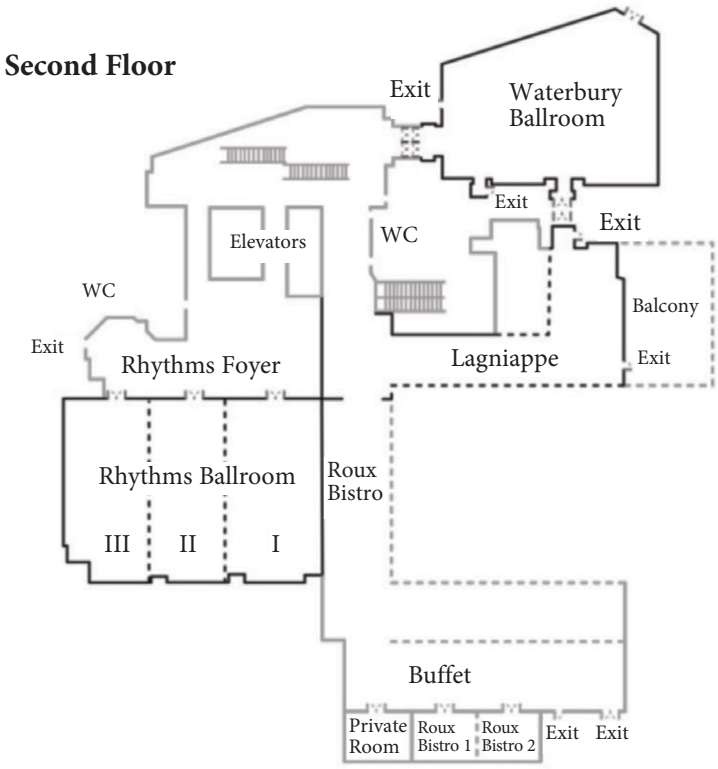
The Bylaws of the Association may be amended at any Annual Business Meeting of the Association by two-thirds vote of active members present at such meeting. Association Bylaws amendment proposals may be submitted by any member of Council or a petition of at least 2% of the active membership of the Association. Proposed amendments must be communicated to the Association Headquarters by the end of December and approved by two-thirds vote of the Council members for consideration at the Annual Business Meeting. The membership must be notified of the proposed amendments no less than 60 days prior to the Annual Business Meeting. The Policy and Procedures Manual will describe the process for review, modification, and presentation of amendment proposals for the membership vote on each amendment at the annual meeting.

ARTICLE XVII. DISTRIBUTION OF ASSETS UPON DISSOLUTION.

In the event that the Association shall be dissolved, its assets at the time of dissolution shall be distributed to one or more organizations exempt from Federal Income Tax in accordance with Section 501(c)(3) of the Internal Revenue Code of 1954 or subsequent provisions to be used for purposes identical or similar to those of the Association.

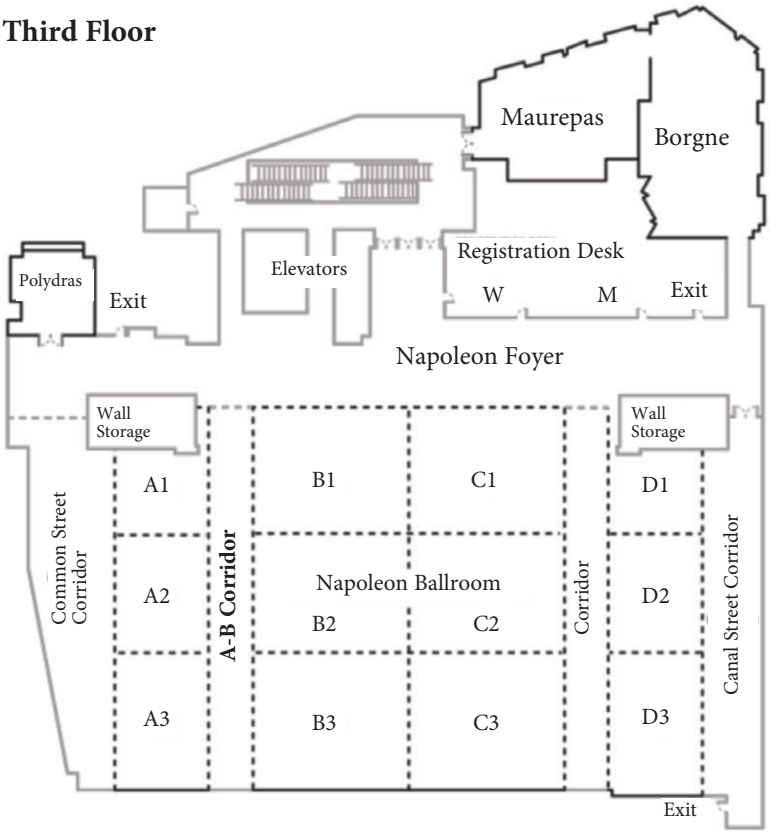
Sheraton New Orleans Hotel
First & Second Floors



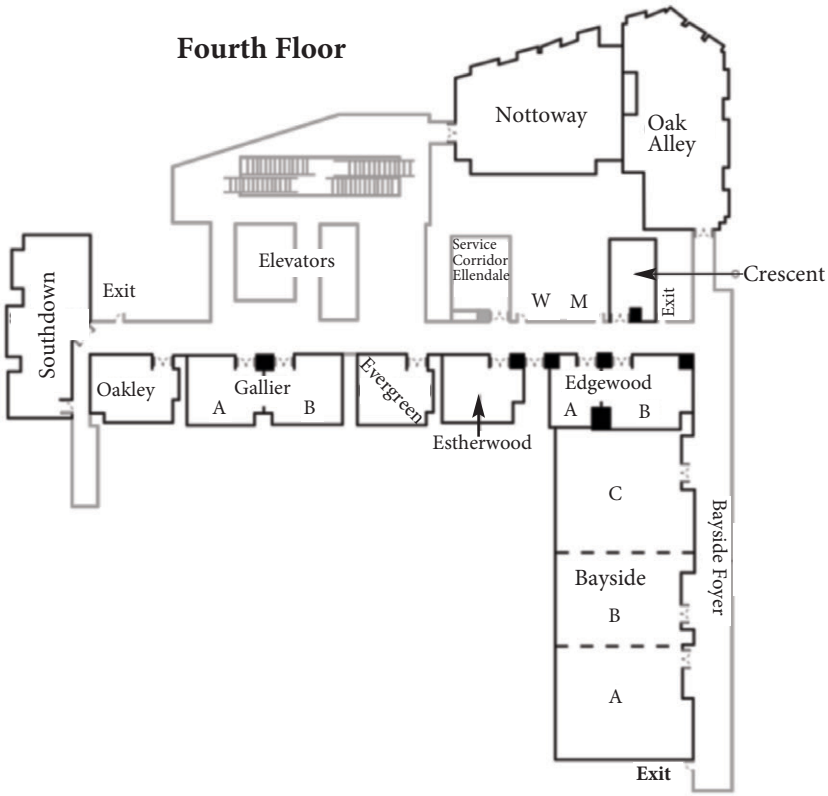


Sheraton New Orleans Hotel
Third & Fourth Floors

Third Floor

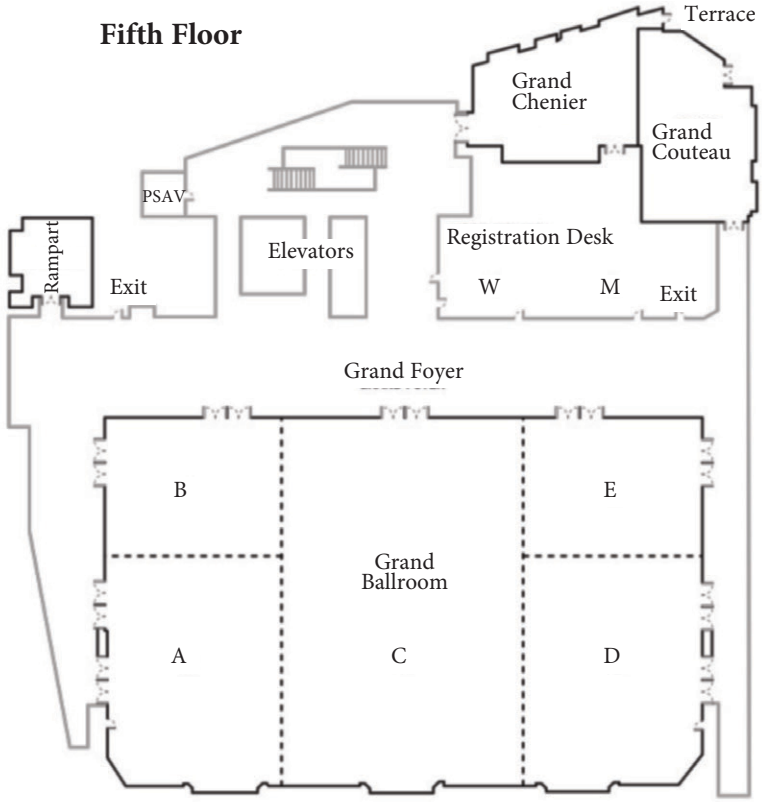


Fourth Floor

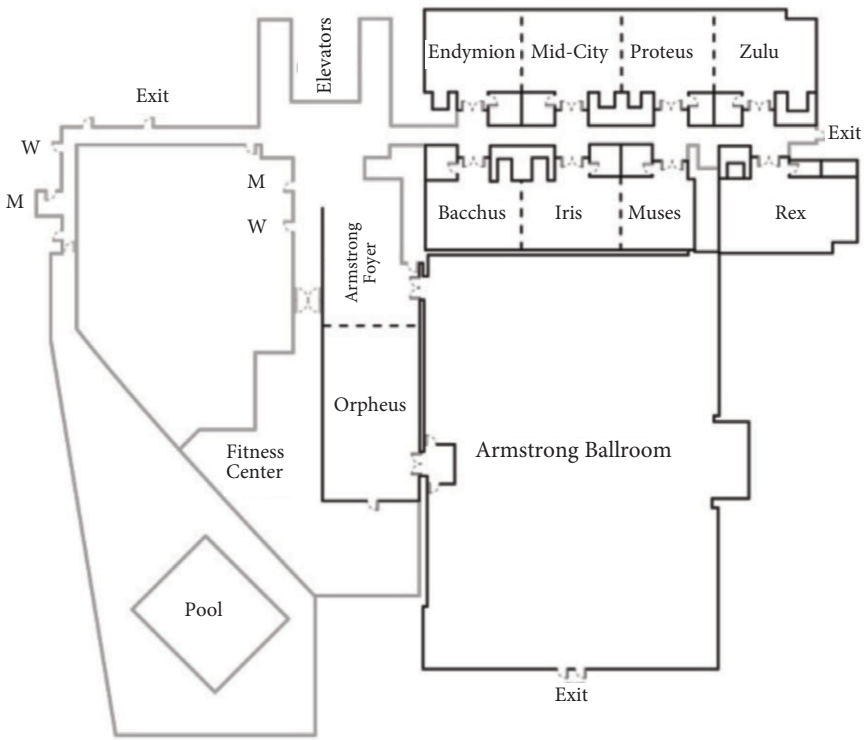


Sheraton New Orleans Hotel
Fifth & Eighth Floors

Fifth Floor



Eighth Floor



AEROSPACE MEDICAL ASSOCIATION 93RD ANNUAL SCIENTIFIC MEETING SCHEDULE
SHERATON HOTEL, NEW ORLEANS, LA; May 21-25

MONDAY, 22 May							
	GRAND BALLROOM A-B-C	GRAND BALLROOM D-E	GRAND CHENIER	NAPOLEON C1-D1	NAPOLEON C2-D2	NAPOLEON C3-D3	NOTTOWAY
8:00-9:30 a.m.	GRAND BALLROOM A-E—OPENING CEREMONIES AND 68TH LOUIS H. BAUER LECTURE						
10:30 a.m.-12:00 Noon	SPACE PANEL: Collaborative Approach to Human Spaceflight Medical Support	CLINICAL PANEL: Current Trends in Vision Screening and Surgery for Pilot Selection	CLINICAL SLIDES: Clinical Aerospace Neurology	HP SLIDES: Do You Really Want to go that High? Barotrauma & DCS	HP PANEL: Changes in Medical Standards & System Capabilities & New Technologies	HP SLIDES: Human Performance Under Aerospace Stress	CLINICAL SLIDES: Mental Health & Certification
Noon-2:00 p.m.	SPECIAL LUNCHEONS--CAMA, Navy, Air Force, Army, Aerospace Human Factors, Corporate Forum						
2:00-3:30 p.m.	SPACE SLIDES: There's an App for That... Medical Devices in Space	CLINICAL SLIDES: COVID-19 & History...Potpourri	SAFETY SLIDES: Safety & Survivability: What Went Wrong	HP SLIDES: Just Like the Aircraft!	HP PANEL: Operational Vision I: Color and Vision Standards	SPACE PANEL: Layperson Performance in Centrifuge-Simulated Spaceflight	CLINICAL SLIDES: Clinical Considerations in Aerospace Medicine
4:00 - 5:30 p.m.	SPACE PANEL: The SpaceX Inspiration4 Mission: Results of Multiscale Omics Profiling Short-Duration Spaceflight	CLINICAL PANEL: Risk Management In Aviation Medicine	CLINICAL SLIDES: Misc: Cancer Risk, HIV, Waivers, DCS, & Urticaria	HP SLIDES: New Angles in Human Systems Integration	HP PANEL: Operational Vision II: Visual Performance	SPACE PANEL: Clinical Considerations for Commercial Spaceflight & Analog Environments	CLINICAL PANEL: Selected Cases and Novel Solutions from Junior Flight Surgeons
TUESDAY MAY 23							
8:30 -10:00 a.m.	GRAND BALLROOM A-B-C—9th MEMORIAL REINARTZ LECTURE						
10:30 a.m.-12:00 Noon	SPACE PANEL: Clinical and Research Insights into Spaceflight Associated Neuro-ocular Syndrome (SANS)	CLINICAL PANEL: Evolving Science Surrounding Pilot Healthcare Seeking Behavior, Disclosure and Avoidance	SAFETY PANEL: Safety Considerations of Reduced Crew Operations on Long-Haul Flights	HP PANEL: Physiologic Events In High-Performance Aviation: A NATO Working Group	CLINICAL SLIDES: COVID and Healthcare Integration	HP PANEL: Does Science Support Using UV-C Lighting To Reduce Disease Transmission on Aircraft?	OTHER PANEL: Germany's Hot Topics in Aerospace
Noon-2:00 p.m.	AEROSPACE MEDICAL ASSOCIATION LUNCH AND BUSINESS MEETING						
2:00 – 3:30 p.m.	SPACE PANEL: NASA Exploration Atmosphere - the Path to the Moon and Mars	CLINICAL PANEL: Aerospace Toxicology	SAFETY SLIDES: Safety & Survivability: What Caused That	HP SLIDES: How to Train for Flight	CLINICAL PANEL: Neuroticism In Aviators: Should We Be Worried?	HP PANEL: Spatial Disorientation Research, Modeling, And Mitigation	
4:00 – 5:30 p.m.	SPACE PANEL: Impacting Exploration Spaceflight Risk Prediction And Medical System Design	CLINICAL PANEL: Alpha-1 Antitrypsin Deficiency: A Horse Among Zebras	SAFETY PANEL: Safety Culture in Aviation and Medicine: Assessment and Interventions	HP SLIDES: Fatigue Countermeasures - Performance	CLINICAL PANEL: TBI--International Aerospace Neuroscience Consortium	HP SLIDES: Hypoxia Potpourri	

WEDNESDAY, MAY 24								
	GRAND BALLROOM A-B-C	GRAND BALLROOM D-E	GRAND CHENIER	NAPOLEON C1-D1	NAPOLEON C2-D2	NAPOLEON C3-D3	NAPOLEON A1-B3	NOTTAWAY & OAK ALLEY—POSTERS
8:30 -10:00 a.m.	SPACE PANEL: NASA Approach for Developing Medical Capabilities and Technologies for Deep Space Exploration	CLINICAL PANEL: Planning Comprehensive Medical Readiness Program for Flight Surgeons	HISTORY PANEL: Women In Operational Missions In Aerospace Medicine: Lessons On Leadership	CLINICAL PANEL: Resident in Aerospace Medicine (RAM) Grand Rounds I	HP SLIDES: Operational Issues in Fatigue Management	SPACE PANEL: Herniated Disc On ISS: Diagnosis, Treatment and Operational Mission Impacts	HP PANEL: Technician Perspective On Physiological Advancements	
10:30 a.m.-12:00 p.m.	SPACE SLIDES: To Infinity and Beyond	CLINICAL PANEL: Fortifying Comprehensive Medical Readiness Program For Flight Surgeons	CLINICAL PANEL: IANC Aerospace Neurology Panel	CLINICAL PANEL: Resident in Aerospace Medicine (RAM) Grand Rounds II	CLINICAL SLIDES: Clinical Practice Guidelines-Aeromedical Risk Analysis	HP PANEL: In-Flight Environmental & Physiological Data from a Joint Perspective	HP PANEL: Improving the Future Today: Aeromedical Research and Pilot-Physicians	Space Medicine Posters 1
Noon-2:00 p.m.	Special Luncheons: Aerospace Physiology Society, Aerospace Human Factors Association, Space Medicine Society, Wing of AsMA, Aerospace Nursing and Allied Health Professionals Society.							
2:00 – 3:30 p.m.		CLINICAL PANEL: A Moment of Focus on Attention-Deficit/Hyperactivity Disorder (ADHD)	SAFETY PANEL: Safety Centers Year-in-Review	CLINICAL PANEL: Resident in Aerospace Medicine (RAM) Grand Rounds III	CLINICAL PANEL: Advances In Aerospace Medicine In Iberoamerica	SPACE SLIDES: Space Medicine to Scale	HP PANEL: Taming Virtual Reality for the Next Generation	Human Performance Posters 1
4:00-5:30 p.m.	GRAND BALLROOM —13th Annual RAM Bowl							

THURSDAY, MAY 25								
8:15 -9:15 a.m.	GRAND BALLROOM—57th HARRY G. ARMSTRONG LECTURE							
10:00 -11:30 a.m.	SPACE PANEL: Commercial Spaceflight Applications For Space Medicine: A Multi-Carrier & Mission Agnostic Standardized Approach	HP SLIDES: Taking Sensorimotor Studies for a Spin	OTHER PANEL: Aeromedical Ethics Panel	HF SLIDE: Collision, Stress, and Vision	CLINICAL PANEL: USAFA Graduates: Leaders Who Inspired Cadets In "The Next Generation"	SPACE PANEL: Education in Space Medicine	CLINICAL PANEL: Resident in Aerospace Medicine (RAM) Grand Rounds IV	Clinical Medicine & Safety Posters
11:30 a.m. - 1:30 p.m.	SPECIAL LUNCHEONS—Space Medicine Association							
1:30-3:00 p.m.	SPACE SLIDES: Nascent Space Medicine Challenges	HP SLIDES: Body of Knowledge: Physiology Updates	OTHER PANEL: ABPM ASAMS Board Review Preparation	ATM PANEL: Updates on Health Promotion in Aeromedical Regulation	CLINICAL PANEL: Self-Reported Impacts of COVID-19 on Psychological Health of USAF Personnel	SPACE SLIDES: Spaceflight Is Risky Business	HP PANEL: Extended Reality Applied To Aerospace Medicine And Human Performance	Space Medicine Posters 2
3:30-5:00 p.m.	SPACE SLIDES: Gravity, It's the Law	HP PANEL: Cardiac Technology - Using New Techniques to Support Aviation		ATM PANEL: Cardiac Arrest In The Air Transport Environment: What's New?	CLINICAL PANEL: USAF AMWD Outcomes Evidence: USAFSAM Pilot Project	CLINICAL PANEL: Adapt or Perish Redux: Challenges and Opportunities for Aerospace Medical Professionals	HP PANEL: NAWCAD Human System Engineering	Human Performance 2 and Other Posters

COLOR CODES	CLINICAL	TRAVEL/AIR TRANSPORT	HUMAN PERFORMANCE	SPACE	OTHER	SAFETY

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