# Aerospace Medicine Research: The Division of Environmental Physiology and the Swedish Aerospace Physiology Centre

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Our contributions to the President's Page have come to us from aerospace medical research laboratories in countries all over the world: the United States, United Kingdom, Norway, and, this month, Sweden. This month's contribution comes to us from Professor Ola Eiken, who has provided a very interesting discussion of the Division of Environmental Physiology and the Swedish Aerospace Physiology Centre, which it turns out does naval medicine and thermal and exercise physiology research, in addition to aviation and space medicine research for the European Space Agency, European Union, and industry.

## The Division of Environmental Physiology and the Swedish Aerospace Physiology Centre

The Division of Environmental Physiology (EP) and the Swedish Aerospace Physiology Centre (SAPC) at the Royal Institute of Technology, KTH (Kungliga Tekniska Högskolan), Stockholm, Sweden, are contracted to perform aviation medicine research for the Swedish Armed Forces, but also regularly conduct aerospace-oriented research funded by other agencies, such as the European Space Agency (ESA), the Swedish National Space Board, and the European Union, as well as by industrial partners, e.g., Saab Aerotech. EP and SAPC are predominantly research-based, but give undergraduate and graduate courses at the KTH, and lectures at flight- and dive-surgeon courses. In addition, EP occasionally is involved in aircraft mishap and/or crash investigations, e.g., in 2007, EP established the course of events resulting in an involuntary ejection from a fighter aircraft.

## Personnel and Research Facilities

EP and SAPC share personnel and research facilities in Stockholm. Their research staff (EP group) consists of eight senior researchers (Ph.D., Ph.D./M.D.), two research engineers, and five Ph.D. students. The group's main research laboratories in Stockholm include a human-use centrifuge (radius: 7.25 m; max G: 15 G; G onset: 5 $G \cdot s^{-1}$), a hypobaric chamber (volume: 21 $m^3$; min pressure: 3 kPa) with explosive decompression capability, and one climatic and two hyperbaric chambers. Because the EP group is contracted to conduct research for the Swedish Armed Forces, not only in aviation medicine, but also in naval medicine and thermal and exercise physiology, it also has full access to research facilities managed by the Swedish Armed Forces and Defense Material Administration, such as the dynamic flight simulator (DFS) and wave pool in Linköping, and the hyperbaric chambers, free-escape tower, and swim flumes in Karlskrona.

## History

The EP group originates from three separate units within the Swedish Defense Research Agency; the units dealt with air force-, navy- and army-related medicine, respectively. Because of funding restraints, these units were collapsed in 2000 and the new group was stationed at its present location. Since 2009, the EP group has been part of the KTH. In 2013, the EP group formed the SAPC to emphasize its engagement in aerospace physiology. This was deemed particularly important at the time, since for a few years, whilst ESA's life-science section was being reorganized, the EP group handled the project scientist duties for all medical and physiological experiments conducted at the International Space Station by ESA (liaison/coordination tasks between independent research groups and ESA).

## Some Previous and Current Aerospace Medicine Research Programs and Results

Research by the EP group has always been based on experiments performed in healthy humans. In the late 1980s and the early 1990s, the EP group developed the anti-G ensemble used in the Gripen 39 fighter, including a 3-G protection extended coverage anti-G suit and a pressure-breathing (PB) system. In the 2000s and 2010s, the EP group continued investigating high G-related problems, including interactions of G load, anti-G straining maneuvers, the anti-G suit and PB on cardiovascular responses, and pulmonary mechanics and gas distribution. Habituation effects on the pressure resistance of peripheral veins and precapillary vessels were investigated. It was shown that pressure training of arm veins increases their pressure resistance and reduces G-induced arm pain, whereas high pressure resistance of precapillary leg vessels is associated with high relaxed G tolerance. In the 2000s the EP group started a program concerning motion sickness and its effect on autonomic functions. Findings of note from this program are motion sickness produced reduction of cold-induced vasoconstriction, resulting in increased susceptibility to hypothermia and motion sickness induced reductions of arterial


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pressure and G tolerance. In the 2000s the EP group initiated a spatial disorientation (SD) research program, which has since investigated differences between non-pilots and pilots as regards their capacity to perceive the roll-tilt angle during coordinated turns performed in aircraft in complete darkness; currently, the trainability of such capacity in fighter pilots is being studied. In the 2000s the EP group, together with the Jozef Stefan Institute in Slovenia, launched a bed rest research program that is still active. Several research questions have been addressed in the bed rest program. Of note is the bed-rest-induced deconditioning of the pressure resistance in dependent arteries, arterioles, and veins, presumably contributing to the post-bed-rest orthostatic intolerance. In the 2010s, long term effects of sustained bed rest in combination with hypoxia were studied since it is anticipated that future human habitats on the Moon and Mars will be characterized by reduced gravity in combination with hypobaric hypoxia. In the 2010s the EP group also studied physiological and cognitive problems during 12-hour fighter aircraft sorties, as well as means of alleviating heat strain in helicopter cabin crew. Presently, the EP group continues to conduct research concerning cardiovascular, respiratory, and musculoskeletal effects of high G loads and simulated weightlessness, as well as concerning SD problems in aviation. In addition, in recent years, the group has been investigating decompression sickness problems in conjunction with long-duration high-altitude flying in fighter aircraft. The research group typically publishes 15–20 peer reviewed articles and reports annually on different aerospace medicine topics.