Sinus Barotraumas in Commercial Aircrew

Oskari H. Lindfors; Kimmo S. Ketola; Tuomas K. Klockars; Tuomo K. Leino; Saku T. Sinkkonen

BACKGROUND: Sinus barotraumas are a common condition in aviation medicine, sometimes compromising flight safety and even permanently grounding aircrew. Considering this and the ever-increasing amount of commercial aviation, a thorough examination is required.

METHODS: In this survey study, an anonymous, electronic questionnaire was distributed to commercial aircrew of the three major commercial airlines operating in Finland ($N = 3799$), covering 93% of the target population (i.e., all commercial aircrew operating in Finland, $N = 4083$). Primary outcomes were self-reported prevalence, clinical characteristics, and health and occupational effects of sinus barotraumas in flight. Secondary outcomes were adjusted odds ratios (OR) for frequency of sinus barotraumas with respect to possible risk factors.

RESULTS: Response rate was 47% ($N = 1789/3799$), with 61% ($N = 1088$) of the respondents having experienced sinus barotraumas in flight. Of those affected, 59% had used medications, 18% had undergone surgical procedures, and 53% had been on sick leave due to sinus barotraumas (38% during the last year) in flight. Factors associated with sinus barotraumas were female sex [OR, 2.47; 95% confidence interval (CI) 1.35–4.50] and a high number of upper respiratory tract infections (≥3 vs. <3 URTIs/yr: OR, 3.61; 95% CI 2.65–4.93).

CONCLUSION: Sinus barotraumas were reported by 61% of commercial aircrew. They caused an increased need for medications, otorhinolaryngology-related surgical procedures, and sickness absence from flight duty. The possible risk factors were female sex and a high number of URTIs/yr.

KEYWORDS: ear, nose and throat, epidemiology, health surveys, infectious diseases.

Lindfors OH, Ketola KS, Klockars TK, Leino TK, Sinkkonen ST. *Sinus barotraumas in commercial aircrew*. Aerosp Med Hum Perform. 2021; 92(11):857–863.

Sinus barotraumas in flight result from uncompensated changes in atmospheric pressure, most often affecting the frontal or maxillary sinuses. The symptoms usually manifest as either pressure sensations or pain in the corresponding facial regions, and sometimes as epistaxis. Less often, the ethmoidal or sphenoid sinuses can be affected, leading to atypical presentations.[35] In rare cases, trigeminal nerve dysfunction,[30] orbital emphysema,[27] or even maxillary bone fractures[27] can occur, seriously compromising flight safety.

Sinus barotraumas have been thoroughly discussed in recent literature, mostly under the names "sinus barotrauma", "aerosinusitis",[35,36] or "barosinusitis"[32] in aviation medicine, and under the name "airplane headache"[9,19,23] in neurological literature. Within aviation medicine, several cases[4,21,33] and case series,[6,17,22] especially in military aviation,[5,34,37] have been described, while 19.5–27.9% of Danish commercial pilots have reported at least one sinus barotrauma episode during their career.[7,28] Conversely, in neurological literature, symptoms of "airplane headache" have been reported by 5.7–8.3% of airline passengers.[10,26] Sinus barotrauma symptoms can lead to severe discomfort and pose a serious risk to flight safety, sometimes even permanently grounding aircrew.[14]

From the Department of Otorhinolaryngology–Head and Neck Surgery, Head and Neck Center, Helsinki University Hospital and University of Helsinki, Helsinki, Finland; the Finnair Aeromedical Centre, Finnair Health Services, Finnair, Vantaa, Finland; the Aava Aeromedical Centre, Aava Medical Centre, Vantaa, Finland; the Aeromedical Centre, Centre for Military Medicine, Finnish Defence Forces, Helsinki, Finland; and the Department of Leadership and Military Pedagogy, National Defence University, Helsinki, Finland.

This manuscript was received for review in January 2021. It was accepted for publication in August 2021.

Address correspondence to: Oskari Lindfors, M.D., Department of Otorhinolaryngology–Head and Neck Surgery, Head and Neck Center, Helsinki University Hospital, P.O. Box 263, FI-00029 HUH, Helsinki, Finland; oskari.lindfors@helsinki.fi.

DOI: https://doi.org/10.3357/AMHP.5849.2021

Given both the extent of the problem and the continuing increase in commercial aviation[1,2] (with the exception of the still-ongoing COVID-19 era), sinus barotraumas in flight require a thorough examination. To achieve this, the primary objectives of this study were to determine the frequency, clinical characteristics, and both health and occupational effects of sinus barotraumas in flight in commercial aircrew. The secondary objective was to elucidate possible risk factors and the tertiary to examine whether repetitive exposure to rapid changes in atmospheric pressure might gradually lead to an increase in the symptoms. The study in question was carried out simultaneously with another study on middle ear barotraumas in commercial aircrew, reported in this journal previously.[16]

METHODS

Subjects

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa (§6164/HUS/2508/2018). The need for informed consent was waived as the study was conducted anonymously.

Questionnaire

The literature for questionnaires regarding sinus barotraumas in flight was reviewed. As none of the published questionnaires could be used to meet the objectives of the study, a new questionnaire was developed by the research group with the support of previous literature.

The questionnaire consisted of 16–53 questions (depending on the answers of each individual respondent) designed to best determine the respondents' aviation and medical histories as well as their frequency of sinus barotraumas in flight. Moreover, the respondents were asked about possible pressure-chamber testing, clinical characteristics, and occupational health effects of these symptoms, such as their need for medications, otorhinolaryngology-related (ORL-related) surgical procedures, and sickness absence from flight duty. The anonymous Finnish questionnaire was twice piloted with selected aircrew personnel (the English translation is presented in **Appendix A** online; https://doi.org/10.3357/AMHP.5849sd.2021).

The questionnaire was electronically sent via company e-mail to all Finnish-speaking aircrew of the three major commercial aviation companies operating in Finland. The study population was considered nationally representative as the questionnaire covered a total of 93.0% of Finnish commercial aircrew. Data acquisition was carried out between November 2018–May 2019, consisting of the primary e-mail and repeated reminder e-mails at approximately 1-mo intervals (full details of data acquisition are presented in **Appendix B** online; https://doi.org/10.3357/AMHP.5849sd.2021).

Statistical Analysis

All statistical analyses were performed using SPSS Statistics for Windows, version 25.0, released 2017 (IBM Corp, Armonk, NY, USA). A two-tailed *P*-value of < 0.05 was interpreted to indicate statistical significance.

Descriptive statistics are presented as numbers and percentages for categorical variables and as medians and interquartile ranges (IQR) for continuous variables. Categorical data were analyzed using Fisher's exact test (two-tailed) and, when there was insufficient memory to do so, using the Chi-squared test. Continuous variables were analyzed using the Mann-Whitney *U*-test or the Kruskal-Wallis test as appropriate. In order to counter the multiple comparisons, Bonferroni correction was used when appropriate.

Multivariable binary logistic regression analyses were performed to identify factors associated with sinus barotraumas in flight. Variables included in the models were sex, profession, number of flight years, age, body mass index (BMI), pollen allergies, smoking, and number of upper respiratory tract infections (URTIs) per year. The results are presented as adjusted odds ratios (OR) with 95% confidence intervals (CI), where the frequency of sinus barotraumas was dichotomized at two different cutoff points. The first cutoff point was set between "never" and at least "sporadically" suffering from sinus barotraumas during one's career, and the second between suffering from sinus barotraumas only "sporadically" and at least "occasionally". Two separate cutoff points were chosen to gain a better overall understanding of factors associated with the condition.

RESULTS

The questionnaire yielded a response rate of 47.3% (1798/3799) and, after deletion of nine technically unsuccessful responses, a final response rate of 47.1% (1789/3799). An overview of the study sample is presented in **Table I**.

In total, 38.3% of the respondents were pilots and 61.7% were cabin crew. A significant majority of pilots were men (95.2%), while women (88.6%) made up the majority of cabin crew ($P < 0.001$). Median (IQR) age was 40 (34–48) yr in pilots and 44 (33–53) yr in cabin crew ($P < 0.001$), while height, weight, and BMI more or less conformed to the sex distributions of the two profession groups ($P < 0.001$ for all variables, respectively). Further characteristics of the study sample are presented in Table I.

URTIs were less frequent in the pilot group. The proportion of respondents with 0 URTIs/yr was the same in both groups, but a larger proportion of pilots reported having only 1 URTI/yr compared to cabin crew (37.8% vs. 30.2%, $P = 0.003$). The proportion of respondents with 2 URTIs/yr was the same, but a smaller proportion of pilots reported having ≥3 URTIs/yr compared to cabin crew (23.0% vs. 31.3%, $P = 0.003$).

Sinus barotraumas in flight affected 60.8% of the respondents. In total, 48.9% of the respondents reported problems "sporadically", another 11.5% "occasionally", and a further 0.4% "almost always" when flying. The proportion of respondents having never experienced symptoms was significantly larger in pilots (44.5% vs. 35.9%, respectively), while the proportion of

Table I. Overview of the Study Sample and Sinus Barotraumas in Flight.

VARIABLE	ALL (*N* = 1789)	COCKPIT (*N* = 686)	CABIN (*N* = 1103)	*P*-VALUE
Sex				
Female	1010 (56.5%)	33 (4.8%)	977 (88.6%)	<0.001
Male	779 (43.5%)	653 (95.2%)	126 (11.4%)	
Age (years)	42 (34-51)	40 (34-48)	44 (33-53)	<0.001
Height (cm)	173 (168-180)	180 (176-185)	170 (166-174)	<0.001
Weight[x] (kg)	74 (64-83)	82 (75-89)	67 (60-75)	<0.001
BMI[x] (kg/m2)	24 (22-26)	25 (23-27)	23 (21-26)	<0.001
Flight years	13 (3-24)	13 (5-23)	12 (3-25)	0.360
Flight times[y]	3000 (1000-5500)[y]	3000 (1200-6000)[y1]	2000 (500-4400)[y2]	<0.001
Smoking				
Never	1521 (85.0%)	605 (88.2%)[a]	916 (83.0%)[b]	<0.001
Occasionally	198 (11.1%)	69 (10.1%)	129 (11.7%)	
Regularly	70 (3.9%)	12 (1.7%)[a]	58 (5.3%)[b]	
Allergies				
Any allergy	539 (30.1%)	202 (29.4%)	337 (30.6%)	0.634
Pollen	384 (21.5%)	155 (22.6%)	229 (20.8%)	0.375
Animal	137 (7.7%%)	59 (8.6%)	78 (7.1%)	0.236
Food	96 (5.4%)	20 (2.9%)	76 (6.9%)	<0.001
Other	93 (5.2%)	23 (3.4%)	70 (6.3%)	0.006
Surgical procedures (ORL-related)				
Any procedure	719 (40.2%)	288 (42.0%)	431 (39.1%)	0.234
Adenoidectomy	505 (28.2%)	195 (28.4%)	310 (28.1%)	0.914
Myringotomy	220 (12.3%)	99 (14.4%)	121 (11.0%)	0.032
Tympanostomy	83 (4.6%)	33 (4.8%)	50 (4.5%)	0.818
BET	7 (0.4%)	3 (0.4%)	4 (0.4%)	>0.99
Myringoplasty	11 (0.6%)	5 (0.7%)	6 (0.5%)	0.758
FESS	91 (5.1%)	30 (4.4%)	61 (5.5%)	0.320
Septoplasty	37 (2.1%)	20 (2.9%)	17 (1.5%)	0.059
RFA (inf. turbinates)	14 (0.8%)	9 (1.3%)	5 (0.5%)	0.055
Cleft palate	2 (0.1%)	0 (0.0%)	2 (0.2%)	0.527
URTI per year				
0	120 (6.7%)	46 (6.7%)	74 (6.7%)	0.003[†]
1	592 (33.1%)	259 (37.8%)[a]	333 (30.2%)[b]	
2	574 (32.1%)	223 (32.5%)	351 (31.8%)	
≥3	503 (28.1%)	158 (23.0%)[a]	345 (31.3%)[b]	
Sinus barotraumas in flight				
Never	701 (39.2%)	305 (44.5%)[a]	396 (35.9%)[b]	<0.001
Sporadically	874 (48.9%)	336 (49.0%)	538 (48.8%)	
Occasionally	206 (11.5%)	43 (6.3%)[a]	163 (14.8%)[b]	
Almost always	8 (0.4%)	2 (0.3%)	6 (0.5%)	
Always	0 (0.0%)	0 (0.0%)	0 (0.0%)	

Data missing in [x]2, [y]968, [y1]48, [y2]920 cases. Categorical data presented as numbers (%) and continuous data presented as medians (IQR). Categorical data analyzed using Fisher's exact (two-tailed) or Chi-squared tests (when insufficient memory to conduct Fisher's exact test, marked as [†]) and continuous data analyzed using Mann-Whitney *U*-test. Bonferroni correction was used when carrying out multiple comparisons. Each superscript letter denotes a subset of categories whose column proportions do not differ significantly from each other at the 0.05 level.

BET, balloon Eustachian tuboplasty; BMI, body mass index; FESS, functional endoscopic sinus surgery; ORL, otorhinolaryngology; RFA, radiofrequency ablation; URTI, upper respiratory tract infection.

those who experienced symptoms "occasionally" was significantly larger in cabin crew (6.3% vs. 14.8%, $P < 0.001$).

Factors associated with the frequency of sinus barotraumas in flight are presented as ORs and 95% CIs in **Table II**. Both respondent sex and the reported number of URTIs/yr were associated with the frequency of the symptoms, but no clear connection was detected with other factors included in the model (e.g., age, smoking, allergies to pollen). Female respondents had an adjusted OR of 1.49 (95 CI 1.04–2.12) for experiencing symptoms at least "sporadically" and an OR of 2.47 (95% CI 1.35–4.50) for experiencing them at least "occasionally" in comparison to male respondents. Regarding URTIs, respondents with ≥3 URTIs/yr had an adjusted OR of 1.57 (95% CI 1.25–1.97) for experiencing symptoms at least "sporadically" and an OR of 3.61 (95% CI 2.65–4.93) for experiencing them at least "occasionally" when compared to respondents who reported <3 URTIs/yr.

Characteristics of sinus barotraumas are presented in **Table III**. The table consists of questionnaire results from respondents affected by sinus barotraumas ($N = 1088$) and is divided into two categories ($N < 3$ and $N \geq 3$) based on the respondents' reported number of URTIs/yr (as it was shown to be associated with the condition in Table II).

The frequency of sinus barotraumas in flight clearly correlated with the number of URTIs/yr. In general, 76.3% of respondents had experienced sinus barotraumas 1–9 times, a further 12.3% 10–19 times, and the last 11.4% ≥ 20 times during their career. The number of symptomatic occasions increased as the number of URTIs/yr increased ($P < 0.001$).

Table II. Multivariable Logistic Regression Analyses of Factors Associated With Sinus Barotraumas in Flight.

VARIABLE	OR (95% CI)	OR (95% CI)
	(*N* = 701 vs. 1088)	(*N* = 1575 vs. 214)
FREQUENCY OF SINUS BAROTRAUMAS IN FLIGHT	NEVER vs. SPORADICALLY OCCASIONALLY ALMOST ALWAYS ALWAYS	NEVER & SPORADICALLY vs. OCCASIONALLY ALMOST ALWAYS ALWAYS
Age	0.96 (0.95–0.98)	1.01 (0.97–1.04)
Flight years	1.07 (1.06–1.09)	1.04 (1.01–1.07)
BMI[x]	1.03 (0.99–1.06)	1.02 (0.98–1.07)
Sex		
Male	1.00	1.00
Female	1.49 (1.04–2.12)	2.47 (1.35–4.50)
Profession		
Cockpit	1.00	1.00
Cabin crew	1.10 (0.77–1.57)	1.13 (0.61–2.09)
Allergies (pollen)		
No	1.00	1.00
Yes	1.20 (0.94–1.53)	1.19 (0.84–1.70)
Smoking		
Never	1.00	1.00
Occasionally	1.07 (0.77–1.46)	1.15 (0.71–1.84)
Regularly	1.37 (0.80–2.36)	0.79 (0.35–1.71)
URTI per year		
<3	1.00	1.00
≥3	1.57 (1.25–1.97)	3.61 (2.65–4.93)

Data missing in [x]2 cases. An adjusted OR over 1 indicates an increase in the odds of experiencing sinus barotraumas in flight.
CI, confidence interval; OR, odds ratio; URTI, upper respiratory tract infection.

The correlation to concomitant URTIs remained relatively stable, irrespective of the reported number of URTIs/yr. In total, 79.5% of the respondents reported a concomitant URTI 100% of the times they had experienced sinus barotraumas. No difference was detected between the two groups ($P = 0.065$).

Symptoms most often appeared when descending on a flight. An overwhelming majority, 93.3% of the respondents, reported symptoms at this stage, while 26.8% reported symptoms when ascending and minorities of 8.9% and 4.0% when cruising or experiencing a sudden problem with cabin pressurization, respectively. Notably, symptoms when ascending were more prevalent (34.6%) in the group with ≥3 URTIs/yr compared to the group with <3 URTIs/yr (23.3%) ($P < 0.001$).

Symptoms of sinus barotraumas are also presented. Of the respondents, 66.4% reported pain in their maxillary and 59.7% in their frontal sinus regions, with 4.2% reporting nosebleeds as a symptom. Moreover, 8.5% reported "other" symptoms, these being almost exclusively "pressure sensations" in either the maxillary or frontal sinuses. The frequency of all symptoms increased as the number of URTIs increased, reaching statistical significance in maxillary sinus symptoms ($P = 0.004$).

Symptom duration varied. The symptoms lasted ≤2 min in 28.4% of cases, 2 min–2 h in 45.4% of cases, 2 h–2 d in 17.9% of cases, and >2 d in 8.3% of cases. The duration of symptoms slightly increased as the number of URTIs/yr increased, reaching statistical significance between the groups whose symptoms dissipated in ≤2 min ($P < 0.001$).

Symptom development differed significantly between those with <3 and those with ≥3 URTIs/yr. A majority of respondents, 65.3%, reported no development of symptoms in either direction during their career. In contrast, 21.7% of the respondents reported currently having less and 13.0% currently having more symptoms than previously during their flight career. In respondents with ≥3 URTIs/yr, 24.3% reported experiencing more sinus barotraumas than previously, as opposed to only 7.8% of those with <3 URTIs/yr ($P < 0.001$).

Treatment and occupational health effects of the symptoms are presented in **Table IV**. The table consists of questionnaire results from respondents affected by sinus barotraumas ($N = 1088$) and is divided into two categories ($N < 3$ and $N \geq 3$) based on the respondents' reported number of URTIs/yr.

Medication due to the symptoms had been resorted to by 59.2% of the respondents. In total, 71.0% of the respondents with ≥3 URTIs/yr had used medication and 53.8% of the ones with <3 URTIs/yr reported the same ($P < 0.001$). The corresponding numbers regarding prescribed medication were 58.4% and 39.4% ($P < 0.001$) and the numbers on nonprescribed medication 56.3% and 41.6%, respectively ($P < 0.001$).

Surgical procedures due to sinus barotraumas are also presented. In total, 17.6% of the symptomatic respondents had been to such procedures, the most common one being adenoidectomy (10.8%) followed by functional endoscopic sinus surgery (6.5%), septoplasty (2.1%), and radiofrequency ablation of the inferior turbinates (0.9%). Of the respondents with ≥3 URTIs/yr, 23.5% had been to at least one of these procedures, while only 14.9% of the ones with <3 URTIs/yr reported the same ($P < 0.001$).

Sickness absences due to the symptoms were reported by 52.6% of symptomatic respondents (47.8% of pilots and 55.2% of cabin crew). Of the ones with ≥3 URTIs/yr, this was the case in 63.0% of respondents, while the same was true for 47.8% of those with <3 URTIs/yr ($P < 0.001$). The difference between the groups was larger when looking at sickness absences from the previous 12 mo; 56.3% of respondents with ≥3 URTIs/yr had been on sick leave during the previous year while 29.7% of the ones with <3 URTIs/yr reported the same ($P < 0.001$).

DISCUSSION

In this study, both the reported number of URTIs/yr and respondent sex independently associated with the frequency of sinus barotraumas in flight. Several reports of the connection to URTIs exist in the literature,[7,24,28] but no previous studies on its role as a risk factor (Table II) or the proportion of sinus barotraumas connected to it (Table III) have been published. While no studies have investigated the connection between sinus barotraumas and sex, more nasal and sinus symptoms have been reported in females in other contexts,[11,13,15] and a correlation between blood estrogen levels and nasal mucosal congestion has also been repeatedly documented.[12,20,25] No association with smoking or allergies was detected, in contrast to the connection between allergic rhinitis and sinus barotraumas in young military aviators reported by Ulanovski et al.[31]

Table III. Characteristics of Sinus Barotraumas in Flight and the Effect of Number of URTIs/yr.

VARIABLE	ALL (*N* = 1088)	URTI / YR		*P*-VALUE
		<3 (*N* = 747)	≥3 (*N* = 341)	
Symptom				
1–9 times	830 (76.3%)	597 (79.9%)$_a$	233 (68.3%)$_b$	<0.001†
10–19 times	134 (12.3%)	85 (11.4%)	49 (14.4%)	
≥20 times	124 (11.4%)	65 (8.7%)$_a$	59 (17.3%)$_b$	
% of symptomatic times related to URTI[x]				
>100% (= erroneus)	45 (4.6%)	32 (4.9%)	13 (4.1%)	0.065
100%	771 (79.5%)	531 (81.3%)	240 (75.7%)	
51–99%	67 (6.9%)	37 (5.7%)	30 (9.5%)	
≤50%	87 (9.0%)	53 (8.1%)	34 (10.7%)	
Symptoms during flight				
When ascending	292 (26.8%)	174(23.3%)	118 (34.6%)	0.001
When cruising	97 (8.9%)	53 (7.1%)	44 (12.9%)	0.002
When descending	1015 (93.3%)	695 (93.0%)	320 (93.8%)	0.623
Cabin pressure problem	43 (4.0%)	25 (3.3%)	18 (5.3%)	0.129
Symptoms manifested as				
Pain (cheek area)	722 (66.4%)	475 (63.6%)$_a$	247 (72.4%)$_b$	0.004
Pain (forehead area)	649 (59.7%)	438 (58.6%)	211 (61.9%)	0.312
Epistaxis	46 (4.2%)	31 (4.1%)	15 (4.4%)	0.850
Other	93 (8.5%)	62 (8.3%)	31 (9.1%)	0.726
Symptoms lasted for				
≤2 min	309 (28.4%)	235 (31.5%)$_a$	74 (21.7%)$_b$	0.001
≤2 h	494 (45.4%)	337 (45.1%)	157 (46.0%)	
≤2 d	195 (17.9%)	124 (16.6%)	71 (20.8%)	
>2 d	90 (8.3%)	51 (6.8%)	39 (11.4%)	
Symptoms before flight				
Yes	361 (33.2%)	223 (29.9%)$_a$	138 (40.5%)$_b$	<0.001
No	727 (66.8%)	524 (70.1%)$_a$	203 (59.5%)$_b$	
Symptom progression over the years				
Less symptoms	236 (21.7%)	188 (25.2%)$_a$	48 (14.1%)$_b$	<0.001
Same amount of symptoms	711 (65.3%)	501 (67.1%)	210 (61.6%)	
More symptoms	141 (13.0%)	58 (7.8%)$_a$	83 (24.3%)$_b$	

Data missing in [x]118 cases. Categorical data presented as numbers (%). Categorical data analyzed using Fisher's exact (two-tailed) or Chi-squared tests (when insufficient memory to conduct Fisher's exact test, marked as †). Bonferroni correction was used when carrying out multiple comparisons. Each subscript letter denotes a subset of categories whose column proportions do not differ significantly from each other at the 0.05 level.
TM, tympanic membrane; URTI, upper respiratory tract infection.

A majority of the respondents (60.8%) reported sinus barotraumas in flight. These numbers far surpass those reported by airline passengers (5.7–8.3%),[10,26] most likely due to the aircrew's higher level of exposure to atmospheric pressure fluctuations. Moreover, the numbers also exceed those reported by Boel et al.,[7] possibly reflecting the inclusion of cabin crew (who are predominantly women and suffer from the symptoms more often than pilots, see Table I) in our study, too. The results of the symptoms, their duration, and the flight phase in which the symptoms manifested are in agreement with previous reports, although our study failed to detect the dominance of frontal sinus symptoms described previously.[18] This might be explained by the large number of maxillary sinus complaints in our study, some of which may have in fact been symptoms of barodontalgia. Moreover, 33.2% of the respondents reported symptoms of poor pressure equalization prior to symptomatic flights, in contrast to the numbers of only 2.4–3.2% in previous works.[7] Notably, 13.0% of the respondents reported an increase in sinus barotraumas over the years, a finding we hypothesize to (at least partly) result from a repetitive exposure to atmospheric pressure fluctuations. This hypothesis is supported by a previous publication by Shagorodsky et al., reporting a connection between a large number of short flights and a higher prevalence of sinonasal symptoms in cabin crew.[29] Further research is necessary to verify and more closely investigate this finding.

Concerning treatment and occupational health effects, 59.2% of the symptomatic respondents had used some form of medication to remedy their symptoms, corresponding to the numbers reported recently by Boel et al.[7] Although the use of surgical procedures to manage sinus barotraumas has been extensively discussed,[3,8] no publications exist regarding commercial aircrew specifically. Furthermore, to the best of our knowledge, no previous reports of sickness absences due to sinus barotrauma symptoms have been published.

Regarding the external validity of our study, the study population can be considered fairly representative as it covered a total of 93.0% of the target population. Questionnaire responses were obtained from 47.1% of the study population and so a considerable nonresponse error is, in theory, a possibility. However, based on our demographic analyses, the study sample broadly conforms to the study population and can therefore be considered representative of the study and target

Table IV. Treatment and Occupational Health Effects of Sinus Barotraumas in Flight and the Effect of Number of URTIs/yr.

VARIABLE	ALL (*N* = 1088)	URTI / YR		*P*-VALUE
		<3 (*N* = 747)	≥3 (*N* = 341)	
Medication due to symptoms				
All medication				
All	644 (59.2%)	402 (53.8%)	242 (71.0%)	<0.001
All, last 12 mo	431 (39.6%)	250 (33.5%)	181 (53.1%)	<0.001
All, earlier	285 (26.2%)	196 (26.2%)	89 (26.1%)	1.000
Prescribed				
Prescribed, all	493 (45.3%)	294 (39.4%)	199 (58.4%)	<0.001
Prescribed, last 12 mo	317 (29.1%)	180 (24.1%)	137 (40.2%)	<0.001
Prescribed, earlier	201 (18.5%)	128 (17.1%)	73 (21.4%)	0.093
Nonprescribed				
Nonprescribed, all	503 (46.2%)	311 (41.6%)	192 (56.3%)	<0.001
Nonprescribed, last 12 mo	340 (31.3%)	190 (25.4%)	150 (44.0%)	<0.001
Nonprescribed, earlier	189 (17.4%)	136 (18.2%)	53 (15.5%)	0.161
Surgical procedures due to symptoms				
All procedures	191 (17.6%)	111 (14.9%)	80 (23.5%)	0.001
Adenoidectomy	118 (10.8%)	72 (9.6%)	46 (13.5%)	0.073
FESS	71 (6.5%)	45 (6.0%)	26 (7.6%)	0.354
Septoplasty	23 (2.1%)	11 (1.5%)	12 (3.5%)	0.039
RFA (inf. turbinates)	10 (0.9%)	4 (0.5%)	6 (1.8%)	0.080
Sick leave due to symptoms				
During career				
Yes	572 (52.6%)	357 (47.8%)	215 (63.0%)	<0.001
No	516 (47.4%)	390 (52.2%)	126 (37.0%)	
During last 12 mo				
0 d	674 (61.9%)	525 (70.3%)$_a$	149 (43.7%)$_b$	<0.001
1–5 d	255 (23.4%)	158 (21.2%)$_a$	97 (28.4%)$_b$	
6–10 d	104 (9.6%)	52 (7.0%)$_a$	52 (15.2%)$_b$	
≥11 d	55 (5.1%)	12 (1.6%)$_a$	43 (12.6%)$_b$	

Categorical data presented as numbers (%) and analyzed using Fisher's exact (two-tailed). Bonferroni correction was utilized when carrying out multiple comparisons. Each subscript letter denotes a subset of categories whose column proportions do not differ significantly from each other at the 0.05 level.
FESS, functional endoscopic sinus surgery; RFA, radiofrequency ablation

populations (Appendix B, online; https://doi.org/10.3357/AMHP.5849sd.2021). With caution, the results can be considered representative of all commercial aircrew operating similar aircraft, given a roughly similar demographic composition and distribution of possible risk factors.

With regard to internal validity, the results of the frequency, clinical characteristics, and health and occupational effects of sinus barotraumas are otherwise reliable, but vulnerable to a reporting bias among the respondents (i.e., recall bias). In turn, the results of the possible risk factors are subject to confounding and, to adjust for this possibility, multivariable logistic regression analyses were carried out: these demonstrated an independent association of both respondent sex and the number of URTIs/yr to sinus barotraumas in flight. By applying the Bradford Hill guidelines to our results, further support for these hypotheses can be offered (**Appendix C**, online; https://doi.org/10.3357/AMHP.5849sd.2021). Other limitations mainly include the use of patient-reported and, therefore, completely subjective estimations of all collected data. While this is certainly a limitation, many of the outcomes the study was intended to examine were in themselves subjective, so such a limitation could not be entirely avoided.

The strengths of the study include its exceptionally large sample size and the level of detail regarding questions submitted to the respondents. No studies to date have investigated the characteristics, progression, or health and occupational effects of sinus barotraumas on such a detailed level. Furthermore, the anonymity of the questionnaire increases its reliability; eliminating the possibility of respondent identification also eliminates the reason for dishonesty when submitting one's response.

Given the extent of the condition in commercial aircrew and the fact that no means to control the pressure equalization of one's paranasal sinuses exist, the most effective preventive measure is to refrain from flight duty when suffering from a URTI. In addition to verifying the possible risk factors, more research on the best possible treatment protocol is needed. We suggest this to be the center of future research on sinus barotraumas in flight.

In conclusion, sinus barotraumas in flight are relatively frequent in commercial aircrew, having been reported by 60.8% of the population. The symptoms lead to an increased need for medications, ORL-related surgical procedures, and sickness absences from flight duty, particularly in female workers and in those suffering from a high number of URTIs/yr. Although refraining from flight duty is warranted when suffering from a URTI, future research should further examine these risk factors and try to develop the best possible treatment protocol to remedy the symptoms.

ACKNOWLEDGMENTS

The views expressed in this manuscript are solely those of the authors and do not reflect the official policy or position of either Aava co., Finnair co., or the Finnish Defense Forces.

Financial Disclosure Statement: The authors have no competing interests to declare. This study was funded by Research Grants from the Department of Otorhinolaryngology – Head and Neck Surgery, Head and Neck Center, Helsinki University Hospital, grant code Y1014KN014. The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Authors and Affiliations: Oskari H. Lindfors, BM, Tuomas K. Klockars, M.D., Ph.D., and Saku T. Sinkkonen, M.D., Ph.D., Department of Otorhinolaryngology - Head and Neck Surgery, Head and Neck Center, Helsinki University Hospital and University of Helsinki, Helsinki, Finland; Kimmo S. Ketola, M.D., Finnair Aeromedical Centre, Finnair Health Services, Finnair, Vantaa, Finland; Tuomas K. Klockars, Aava Aeromedical Centre, Aava Medical Centre, Vantaa, Finland; and Tuomo K. Leino, M.D., Ph.D., Aeromedical Centre, Centre for Military Medicine, Finnish Defence Forces, and Department of Leadership and Military Pedagogy, National Defence University, Helsinki, Finland.

REFERENCES

1. Air transport, passengers carried. [Accessed April 28, 2020]. Available from https://data.worldbank.org/indicator/IS.AIR.PSGR?view=chart.
2. Air transport, registered carrier departures worldwide. [Accessed April 28, 2020]. Available from https://data.worldbank.org/indicator/IS.AIR.DPRT?view=chart.
3. Andrews JN, Weitzel EK, Eller R, McMains CK. Unsuccessful frontal balloon sinuplasty for recurrent sinus barotrauma. Aviat Space Environ Med. 2010; 81(5):514–516.
4. Atkinson V, Lee L. An unusual case of an airplane headache. Headache. 2004; 44(5):438–439.
5. Baughman SM, Brennan J. Barotrauma secondary to inflammatory maxillary sinus polyp: a case report. Aviat Space Environ Med. 2002; 73(11):1127–1131.
6. Berilgen MS, Müngen B. Headache associated with airplane travel: report of six cases. Cephalalgia. 2006; 26(6):707–711.
7. Boel NM, Klokker M. Upper respiratory infections and barotrauma among commercial pilots. Aerosp Med Hum Perform. 2017; 88(1):17–22.
8. Boston AG, McMains KC, Chen PG, Weitzel EK. Algorithm for management of the refractive aerosinusitis patient. Mil Med. 2018; 183(7–8):e246–e250.
9. Bui SBD, Gazerani P. Headache attributed to airplane travel: diagnosis, pathophysiology, and treatment – a systematic review. J Headache Pain. 2017; 18(1):84.
10. Bui SBD, Petersen T, Poulsen JN, Gazerani P. Headaches attributed to airplane travel: a Danish survey. J Headache Pain. 2016; 17:33. Erratum in: J Headache Pain. 2016; 17:50.
11. Chen Y, Dales R, Lin M. The epidemiology of chronic rhinosinusitis in Canadians. Laryngoscope. 2003; 113(7):1199–1205.
12. Haeggström A, Östberg B, Stjerna P, Graf P, Hallén H. Nasal mucosal swelling and reactivity during a menstrual cycle. ORL J Otorhinolaryngol Relat Spec. 2000; 62(1):39–42.
13. Hirsch AG, Stewart WF, Sundaresan AS, Young AJ, Kennedy TL, et al. Nasal and sinus symptoms and chronic rhinosinusitis in a population-based sample. Allergy. 2017; 72(2):274–281.
14. Høva JK, Thorheim L, Wagstaff AS. Medical reasons for loss of license in Norwegian professional pilots. Aerosp Med Hum Perform. 2017; 88(2):146–149.
15. Kuiper JR, Hirsch AG, Bandeen-Roche K, Sundaresan AS, Tan BK, et al. Prevalence, severity, and risk factors for acute exacerbations of nasal and sinus symptoms by chronic rhinosinusitis status. Allergy. 2018; 73(6):1244–1253.
16. Lindfors OH, Ketola KS, Klockars TK, Leino TK, Sinkkonen ST. Middle ear barotraumas in commercial aircrew. Aerosp Med Hum Perform. 2021; 92(3):182–189.
17. Mainardi F, Lisotto C, Maggioni F, Zanchin G. Headache attributed to airplane travel ('airplane headache'): clinical profile based on a large case series. Cephalalgia. 2012; 32(8):592–599.
18. Mainardi F, Maggioni F, Lisotto C, Zanchin G. Diagnosis and management of headache attributed to airplane travel. Curr Neurol Neurosci Rep. 2013; 13(3):335.
19. Mainardi F, Maggioni F, Zanchin G. Headache attributed to aeroplane travel: an historical outline. Headache. 2019; 59(2):164–172.
20. Millas I, Liquidato BM, De Sousa Buck H, Barros MD, Paes RAP, Dolci JEL. Evaluation of estrogenic receptors in the nasal mucosa of women taking oral contraceptives. Contraception. 2011; 83(6):571–577.
21. Misirovs R, Mohamad S. Reverse squeeze maxillary sinus barotrauma. Ear Nose Throat J. 2020; 99(1):NP9–NP10.
22. Nagatani K. Two reports of flight-related headache. Aviat Space Environ Med. 2013; 84(7):730–733.
23. Nierenburg H, Jackfert K. Headache attributed to airplane travel: a review of literature. Curr Pain Headache Rep. 2018; 22(7):48.
24. Pfund Z, Trauninger A, Szanyi I, Illes Z. Long-lasting airplane headache in a patient with chronic rhinosinusitis. Cephalalgia. 2010; 30(4):493–495.
25. Philpott CM, El-Alami M, Murty GE. The effect of the steroid sex hormones on the nasal airway during the normal menstrual cycle. Clin Otolaryngol Allied Sci. 2004; 29(2):138–142.
26. Potasman I, Rofe O, Weller B. Flight-associated headaches-prevalence and characteristics. Cephalalgia. 2008; 28(8):863–867.
27. Powell MR, Hurley LD, Richardson TC. An unusual complication of barotrauma at altitude. Aerosp Med Hum Perform. 2015; 86(11):994–998.
28. Rosenkvist L, Klokker M, Katholm M. Upper respiratory infections and barotraumas in commercial pilots: a retrospective survey. Aviat Space Environ Med. 2008; 79(10):960–963.
29. Shargorodsky J, Zheng L, Stillman F, Soong A, Navas-Acien A, Reh D. The association between airline flight and sinonasal symptoms. Int Forum Allergy Rhinol. 2016; 6(4):437–444.
30. Sharma N, De M, Pracy P. Recurrent facial paraesthesia secondary to maxillary antral cyst and dehiscent infraorbital canal: case report. J Laryngol Otol. 2007; 121(6):e6.
31. Ulanovski D, Barenboim E, Raveh E, Grossman A, Azaria B, Shpitzer T. Sinusitis in pilots of different aircraft types: is allergic rhinitis a predisposing factor? Am J Rhinol. 2008; 22(2):122–124.
32. Vaezeafshar R, Psaltis AJ, Rao VK, Zarabanda D, Patel ZM, Nayak JV. Barosinusitis: comprehensive review and proposed new classification system. Allergy Rhinol (Providence). 2017; 8(3):109–117.
33. Vandenbulcke R, van Holsbeeck B, Crevits I, Marrannes J. Frontal sinus barotrauma. J Belg Soc Radiol. 2016; 100(1):60.
34. Weitzel EK, Flottmann JT, McMains KC. Endoscopic frontal sinus drillout for recurrent barotrauma: a procedure to save a pilot's career. Aviat Space Environ Med. 2009; 80(7):660–662.
35. Weitzel EK, McMains KC, Rajapaksa S, Wormald PJ. Aerosinusitis: pathophysiology, prophylaxis, and management in passengers and aircrew. Aviat Space Environ Med. 2008; 79(1):50–53.
36. Weitzel EK, McMains KC, Wormald PJ. Comprehensive surgical management of the aerosinusitis patient. Curr Opin Otolaryngol Head Neck Surg. 2009; 17(1):11–17.
37. Yoshida Y. Aerosiniusitis: an experience of treatment of two cases. JJOMT. 2003; 51(1):71–84.