Sinus barotrauma in diving

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Abstract
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Introduction: Sinus barotrauma is a common occurrence in diving and subaquatic medicine, potentially compromising dive safety. To gain a more thorough understanding of the condition, an in-depth investigation is justified.
Methods: This was a survey study. An anonymous, electronic questionnaire was distributed to 7,060 recipients: professional divers of the Finnish Border Guard, the Finnish Rescue Services, and the Finnish Heritage agency, as well as recreational divers registered as members of the Finnish Divers' Association reachable by email (roughly two-thirds of all members and recreational divers in Finland). Primary outcomes were self-reported prevalence, clinical characteristics, and health effects of sinus barotrauma while diving. Secondary outcomes were adjusted odds ratios (OR) for frequency of sinus barotrauma with respect to possible risk factors.
Results: In total, 1,881 respondents participated in the study (response rate 27%). A total of 49% of the respondents had experienced sinus barotrauma while diving and of those affected, 32% had used medications to alleviate their symptoms. The factors associated with sinus barotrauma were pollen allergies (OR 1.59; 95% CI 1.10–2.29), regular smoking (OR 2.04; 95% CI 1.07–3.91) and a high number of upper respiratory tract infections per year (≥ 3 vs. < 3 infections per year: OR 2.76; 95% CI 1.79–4.24).
Conclusions: Sinus barotrauma is the second most common condition encountered in diving medicine, having affected 49% of the respondents. Possible risk factors include allergies to pollen, regular smoking, and a high number of URTIs per year.

Introduction

Sinus barotrauma while diving is considered to be the consequence of insufficient paranasal sinus ventilation during ambient pressure changes, when either ascending or descending on a dive, or when diving in a multilevel environment. The sinuses most often affected are considered to be the frontal and maxillary sinuses, while involvement of the sphenoid and ethmoid sinuses is thought to be less common.[1–4] Symptoms include pain and pressure sensations in the corresponding facial regions, headache in the corresponding cranial regions, and sometimes epistaxis.[1,3–8] Rare complications include vision loss,[9–12] orbital wall fractures with subcutaneous/periorbital emphysema,[13–16] and pneumocephalus.[17,18]

Prevalence estimations vary. Numbers as low as < 0.1% have been reported in hyperbaric pressure chamber tests of Taiwanese navy recruits,[19] while up to 7% of Swiss professional divers and caisson workers have reported sinus barotrauma symptoms in their respective working environments.[20] Conversely, in the case of less experienced, recreational divers, larger numbers between 17–26% have been reported.[21,22] Sinus barotrauma is widely considered the second most common condition in all diving and subaquatic medicine, second only to barotrauma of the ears.[1,23]

Considering the large amount of recreational diving, the relative commonness of sinus barotraumas and the potential hazards they pose in a subaquatic environment, an in-depth look at the issue is definitely warranted. To this end, the primary objective of this study was to determine the frequency, clinical characteristics, and the short-term health effects of sinus barotrauma while diving. The secondary goal was to elucidate possible risk factors, the tertiary goal to find out whether repeated exposure to barometric stress might lead to an increase in sinus barotrauma during one's diving career. The study in question was carried out in conjunction with a similar study on middle ear barotrauma in diving, published previously.[24]

Methods

ETHICAL CONSIDERATIONS

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).

STUDY DESIGN

Previous literature describing questionnaires on sinus barotrauma while diving was reviewed. None of the published questionnaires were directly applicable to the objectives of the study, so a new questionnaire was developed by the research group, utilising previous literature.

The questionnaire consisted of 20–52 questions (depending on answers) designed to examine the respondents' diving and medical histories and frequency of sinus barotrauma while diving. Furthermore, the respondents were asked about possible pressure-chamber testing, clinical characteristics and their need for medications and otorhinolaryngology-related (ORL-related) surgical procedures due to sinus barotrauma. The English translation of the questionnaire is presented in Appendix 1*.

The questionnaire was electronically sent via email to 7,060 recipients: professional divers of the Finnish Border Guard, the Finnish Rescue Services, and the Finnish Heritage Agency, as well as recreational divers registered as members of the Finnish Divers' Association reachable by email (roughly two-thirds of all members and all recreational divers in Finland). Data acquisition was carried out between November 2018 and September 2019, consisting of the primary email and repeated reminder emails at approximately 1–2 month intervals. Full details of data acquisition are presented in Appendix 2*.

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 analysed using Fisher's exact test (two-tailed) or where appropriate, the Chi-Square test. Continuous variables were analysed using the Mann-Whitney U test or the Kruskal-Wallis test as appropriate. The Bonferroni correction was applied to account for multiple comparisons.

Multivariable binary logistic regression analyses were performed to identify factors associated with sinus barotrauma while diving. Variables included in the models were sex, number of diving years, age, body mass index (BMI), pollen allergies, smoking and the number of upper respiratory tract infections (URTI) per year. The results are presented as adjusted odds ratios (OR) with 95% confidence intervals (CI). The frequency of sinus barotrauma was dichotomized at two different cut-off points: between "*never*" and at least "*sporadically*" suffering from sinus barotrauma during one's life; and between suffering from sinus barotrauma only "*sporadically*" and at least "*occasionally*". These two separate cut-off points were chosen to gain a better overall understanding of factors associated with the condition.

Results

OVERVIEW OF THE STUDY SAMPLE AND SINUS BAROTRAUMA WHILE DIVING

The survey achieved a final response rate of 26.6% (1,881 responses from 7,060 invitations). Details of the study sample and the frequency of sinus barotrauma while diving is presented in Table 1.

In total, males made up a majority of the study sample, comprising 79.8% of the respondents. A quarter (23.2%) of the respondents were professional divers, the other three quarters (76.8%) being recreational. Most respondents reported being scuba divers (91.9%), some reporting technical diving (18.3%) and some free diving (15.6%) as their respective diving types. Median (IQR) age was 43 (35–52) years, 44 (36–53) in males and 41 (33–50) in females. Further characteristics of the study sample are presented in Table 1.

Previous ORL-related surgical procedures had been carried out to 37.0% of the respondents, the most common being adenoidectomy (26.2%), myringotomy (10.5%), tympanostomy (4.9%) and functional endoscopic sinus surgery (4.5%). Septoplasties, which were reported by 3.2% of the respondents, were more common in males than females (3.9% vs. 0.5%, respectively). Of the respondents, 16.6% reported zero URTIs per year, another 50.9% one URTI per year, a further 22.5% two URTIs per year, the final 9.9% three or more URTIs per year.

Sinus barotrauma while diving had been experienced by 48.9% of the respondents. While 41.0% had experienced symptoms "*sporadically*", smaller proportions had experienced them "*occasionally*" (7.4%), "*almost always*" (0.4%) or "*always*" (0.1%) when diving.

Footnote: * Appendices 1–3 are available on DHM Journal's website: https://www.dhmjournal.com/index.php/journals?id=147

Table 1

Overview of the study sample. Categorical data presented as n (%) and continuous data presented as median (IQR). * Data missing in two cases. BET – balloon eustachian tuboplasty; BMI – body mass index; FESS – functional endoscopic sinus surgery; ORL – otorhinolaryngology; RFA – radiofrequency ablation; URTI – upper respiratory tract infection

Variable	All (*n* = 1,881)	Female (*n* = 380)	Male (*n* = 1,501)
Age (years)	43 (35–52)	41 (33–50)	44 (36–53)
Height (cm)	178 (172–183)	167 (163–171)	180 (175–184)
Weight (kg)	83 (74–91)	68 (62–75)	85 (78–94)
BMI ($kg \cdot m^{-2}$)	26 (24–28)	24 (22–27)	26 (25–28)
Diving (years)	10 (4–17)	6 (3–11)	10 (4–20)
Number of dives*	200 (80–550)	150 (50–400)	200 (100–600)
Diving type			
Professional	436 (23.2%)	30 (7.9%)	406 (27.0%)
Recreational	1,445 (76.8%)	350 (92.1%)	1,095 (73.0%)
Diving mode			
Free diving	293 (15.6%)	53 (13.9%)	240 (16.0%)
Scuba diving	1,728 (91.9%)	359 (94.5%)	1,369 (91.2%)
Technical diving	344 (18.3%)	46 (12.1%)	298 (19.9%)
Smoking			
Never	1,542 (82.0%)	318 (83.7%)	1,224 (81.5%)
Occasionally	242 (12.9%)	37 (9.7%)	205 (13.7%)
Regularly	97 (5.2%)	25 (6.6%)	72 (4.8%)
Allergies			
Any allergy	629 (33.4%)	157 (41.3%)	472 (31.4%)
Pollen	451 (24.0%)	96 (25.3%)	355 (23.7%)
Animal	226 (12.0%)	64 (16.8%)	162 (10.8%)
Food	151 (8.0%)	54 (14.2%)	97 (6.5%)
Other	99 (5.3%)	42 (11.1%)	57 (3.8%)
Surgical procedures (ORL-related)			
Any procedure	696 (37.0%)	127 (33.4%)	569 (37.9%)
Adenoidectomy	492 (26.2%)	93 (24.5%)	399 (26.6%)
Myringotomy	198 (10.5%)	43 (11.3%)	155 (10.3%)
Tympanostomy	93 (4.9%)	19 (5.0%)	74 (4.9%)
BET	14 (0.7%)	4 (1.1%)	10 (0.7%)
Myringoplasty	22 (1.2%)	2 (0.5%)	20 (1.3%)
FESS	84 (4.5%)	12 (3.2%)	72 (4.8%)
Septoplasty	60 (3.2%)	2 (0.5%)	58 (3.9%)
RFA (inf. turbinates)	16 (0.9%)	4 (1.1%)	12 (0.8%)
Cleft palate	2 (0.1%)	0 (0.0%)	2 (0.1%)
URTI per year			
0	313 (16.6%)	52 (13.7%)	261 (17.4%)
1	958 (50.9%)	193 (50.8%)	765 (51.0%)
2	424 (22.5%)	96 (25.3%)	328 (21.9%)
≥ 3	186 (9.9%)	39 (10.3%)	147 (9.8%)
Sinus barotrauma in diving			
Never	961 (51.1%)	205 (53.9%)	756 (50.4%)
Sporadically	772 (41.0%)	152 (40.0%)	620 (41.3%)
Occasionally	139 (7.4%)	22 (5.8%)	117 (7.8%)
Almost always	7 (0.4%)	1 (0.3%)	6 (0.4%)
Always	2 (0.1%)	0 (0.0%)	2 (0.1%)

Table 2
Multivariable logistic regression analyses of factors associated with sinus barotrauma while diving. An adjusted OR over 1 indicates an increase in the odds of experiencing sinus barotraumas while diving. BMI – body mass index; CI – confidence interval; OR – odds ratio; URTI – upper respiratory tract infection

Variable	Frequency of sinus barotrauma in diving	
	Never (n = 961) versus Sporadically, Occasionally Almost always, Always (n = 920)	Never, Sporadically (n = 1,733) versus Occasionally, Almost always, Always (n = 148)
	OR (95% CI)	**OR (95% CI)**
Age	0.97 (0.96–0.98)	0.98 (0.96–1.00)
Diving years	1.05 (1.04–1.07)	1.02 (1.00–1.05)
BMI	1.03 (1.00–1.05)	0.99 (0.95–1.04)
Sex		
Male	1.00	1.00
Female	1.02 (0.80–1.30)	0.68 (0.42–1.10)
Allergies (pollen)		
No	1.00	1.00
Yes	1.49 (1.19–1.86)	1.59 (1.10–2.29)
Smoking		
Never	1.00	1.00
Occasionally	1.07 (0.80–1.41)	1.04 (0.61–1.76)
Regularly	0.86 (0.56–1.32)	2.04 (1.07–3.91)
URTI per year		
< 3	1.00	1.00
≥ 3	1.70 (1.24–2.34)	2.76 (1.79–4.24)

FACTORS ASSOCIATED WITH THE FREQUENCY OF SINUS BAROTRAUMA

Factors associated with the frequency of sinus barotrauma while diving are presented in Table 2. The frequency of the symptoms was best explained by pollen allergies and the number of URTIs per year, smoking having a more moderate association to the symptoms. No correlation to age, number of diving years, body mass index (BMI) or sex was detected in the analysis.

Those with pollen allergies had an adjusted OR of 1.49 (95% CI 1.19–1.86) for experiencing sinus barotraumas at least "*sporadically*" and an OR of 1.59 (95% CI 1.10–2.29) for experiencing them at least "*occasionally*", compared with those without such allergies. Moreover, those with ≥ 3 URTIs per year had an adjusted OR of 1.70 (95% CI 1.24–2.34) for experiencing symptoms at least "*sporadically*" and an OR of 2.76 (95% CI 1.79–4.24) for experiencing them at least "*occasionally*", compared with those who reported having < 3 URTIs per year.

While no association between smoking habits and symptoms at least "*sporadically*" was detected, regular smokers did have an OR of 2.04 (95% CI 1.07–3.91) for experiencing symptoms at least "*occasionally*", compared with non-smokers.

CHARACTERISTICS OF SINUS BAROTRAUMA

Characteristics of sinus barotrauma and its circumstances are presented in Table 3. The table consists of questionnaire results from respondents affected by sinus barotrauma (n = 920) and is divided into two categories (n < 3 and n ≥ 3) based on the respondents' reported number of URTIs per year (as it was shown to be highly associated with the condition in Table 2).

Most respondents, 77.8%, had experienced sinus barotrauma symptoms 1–9 times, a further 13.6% 10–19 times and the final 8.6% 20 or more times while diving. The number of sinus barotrauma episodes increased as the number of URTIs per year increased (P = 0.042) and notably, a total of 72.0% of the respondents reported an URTI 100% of the times they had experienced sinus barotrauma while diving.

Sinus barotrauma symptoms were reported mainly when descending by 83.2% and mainly when ascending by 29.6% of the respondents. Symptoms predominantly manifested in relatively shallow depths, where relative volume changes in response to increasing pressure are the largest: in 41.0% of cases, the symptoms appeared at 0–4 metres of seawater (msw) and in another 40.1% at 5–9 msw. The final 18.9% reported symptoms at a depth of ≥ 10 msw.

Table 3

Characteristics of sinus barotrauma while diving and the effect of number of URTIs per year. * Data missing in 256 cases. Categorical data presented as n (%) and analysed using Fisher's exact (two-tailed). Subscripts $_a$ and $_b$ denote a subset of categories whose column proportions do not differ significantly from each other at the .05 level. msw – metres of sea water; URTI – upper respiratory tract infection

Variable	All (*n* = 920)	URTIs per year		*P*-value
		< 3 (*n* = 807)	≥ 3 (*n* = 113)	
Symptoms				
1–9 times	716 (77.8%)	633 (78.4%)	83 (73.5%)	0.042
10–19 times	125 (13.6%)	112 (13.9%)	13 (11.5%)	
≥ 20 times	79 (8.6%)	62 (7.7%)$_a$	17 (15.0%)$_b$	
% of symptomatic times related to URTI*				
100%	478 (72.0%)	409 (71.6%)	69 (74.2%)	0.657
51–99%	64 (9.6%)	54 (9.5%)	10 (10.8%)	
≤ 50%	122 (18.4%)	108 (18.9%)	14 (15.1%)	
Symptoms during dive				
Mainly ascending	272 (29.6%)	233 (28.9%)	39 (34.5%)	0.227
Mainly descending	765 (83.2%)	669 (82.9%)	96 (85.0%)	0.687
Symptoms manifested at:				
0–4 msw	377 (41.0%)	330 (40.9%)	47 (41.6%)	0.991
5–9 msw	369 (40.1%)	324 (40.1%)	45 (39.8%)	
≥ 10 msw	174 (18.9%)	153 (19.0%)	21 (18.6%)	
Symptoms manifested as:				
Pain (cheek area)	488 (53.0%)	428 (53.0%)	60 (53.1%)	1.000
Pain (forehead area)	667 (72.5%)	585 (72.5%)	82 (72.6%)	1.000
Epistaxis	177 (19.2%)	155 (19.2%)	22 (19.5%)	1.000
Other	36 (3.9%)	28 (3.5%)	8 (7.1%)	0.071
Symptoms lasted for:				
≤ 2 min	515 (56.0%)	457 (56.6%)	58 (51.3%)	0.415
≤ 2 hours	313 (34.0%)	273 (33.8%)	40 (35.4%)	
≤ 2 days	72 (7.8%)	59 (7.3%)	13 (11.5%)	
> 2 days	20 (2.2%)	18 (2.2%)	2 (1.8%)	
Symptoms before dive				
Yes	313 (34.0%)	259 (32.1%)	54 (47.8%)	0.001
No	607 (66.0%)	548 (67.9%)	59 (52.2%)	
Changing vulnerability over the years				
Less	359 (39.0%)	320 (39.7%)	39 (34.5%)	0.495
Same	523 (56.8%)	455 (56.4%)	68 (60.2%)	
More	38 (4.1%)	32 (4.0%)	6 (5.3%)	

Symptoms of sinus barotrauma were mainly pain in the frontal (72.5%) and maxillary (53.0%) sinus regions, epistaxis being less prevalent but still reported by 19.2% of the respondents, and more often reported by those with symptoms on ascent (31.0% vs. 15.3%, $P < 0.001$). Other symptoms (3.9%) mainly included pressure sensations of the frontal and maxillary regions, nasal discharge from the nasal cavity, and pain and sensory disturbances of the teeth.

The symptoms dissipated in ≤ 2 min in 56.0% of cases, in 2–120 min in 34.0% of cases and in 2 h–2 d in 7.8% of cases. The final 2.2% reported the symptoms lasting for > 2 d. Notably, symptoms lasting for > 2 h were more often reported by those with symptoms on ascent. A third (34.0%) reported symptoms of poor pressure equalisation preceding the incident dive.

Symptom development over the years was also examined. While more than half (56.8%) reported no change in the frequency of the symptoms in any direction, roughly a third (39.0%) reported currently experiencing less symptoms than previously during their diving careers. A marginal proportion, 4.1%, reported currently experiencing symptoms more often than previously.

Table 4

Health effects of sinus barotraumas while diving and the effect of number of URTIs per year. Categorical data presented as n (%) and analysed using Fisher's exact (two-tailed). FESS – functional endoscopic sinus surgery; RFA – radiofrequency ablation

Variable	All (n = 920)	URTI per year		P-value
		< 3 (n = 807)	≥ 3 (n = 113)	
All medication				
All	298 (32.4%)	255 (31.6%)	43 (38.1%)	0.197
All, last 12 months	157 (17.1%)	125 (15.5%)	32 (28.3%)	0.001
All, earlier	171 (18.6%)	156 (19.3%)	15 (13.3%)	0.155
Prescribed				
All	228 (24.8%)	190 (23.5%)	38 (33.6%)	0.027
Last 12 months	118 (12.8%)	91 (11.3%)	27 (23.9%)	< 0.001
Earlier	125 (13.6%)	112 (13.9%)	13 (11.5%)	0.560
Non-prescribed				
All	176 (19.1%)	152 (18.8%)	24 (21.2%)	0.525
Last 12 months	90 (9.8%)	71 (8.8%)	19 (16.8%)	0.011
Earlier	93 (10.1%)	86 (10.7%)	7 (6.2%)	0.181
Surgical procedures due to symptoms				
All	107 (11.6%)	85 (10.5%)	22 (19.5%)	0.011
Adenoidectomy	53 (5.8%)	43 (5.3%)	10 (8.8%)	0.133
FESS	47 (5.1%)	34 (4.2%)	13 (11.5%)	0.004
Septoplasty	20 (2.2%)	15 (1.9%)	5 (4.4%)	0.087
RFA (inferior turbinates)	10 (1.1%)	7 (0.9%)	3 (2.7%)	0.114

HEALTH EFFECTS OF SINUS BAROTRAUMAS

Health effects of sinus barotraumas are presented in Table 4. The table consists of questionnaire results from respondents affected by sinus barotrauma (n = 920) and is divided into two categories (n < 3 and n ≥ 3) based on the respondents' reported number of URTIs per year.

Medication due to sinus barotrauma had been used by 32.4% of the affected divers, 24.8% reporting the use of prescribed medications and 19.1% the use of non-prescribed ones. The use of medications was more frequent among those who reported having ≥ 3 URTIs per year, this applying to both non-prescribed (P = 0.011) and prescribed (P = 0.001) medications, as well as all medications together (P = 0.001). The medications used were mainly decongestants.

Surgical procedures due to sinus barotrauma had been undertaken by 11.6% of affected divers. Adenoidectomies had been performed on 5.8%, while 5.1% had undergone functional endoscopic sinus surgery (FESS), 2.2% had septoplasties, and 1.1% had radiofrequency ablation of inferior turbinates. Notably, those with ≥ 3 URTIs per year had undergone FESS significantly more often than those with < 3 URTIs per year (11.5% vs. 4.2%, P = 0.004).

Discussion

COMPARISON WITH PREVIOUS RESEARCH

In this study, the number of URTIs and pollen allergies were both associated with sinus barotrauma while diving. Although several case reports of recent URTIs leading to sinus barotrauma exist,[13,15] no publications with large sample sizes have documented the connection (as subjects with active URTIs are naturally excluded from studies). Despite this, URTIs are still widely considered to be a risk factor for sinus barotrauma while diving,[2–5,7,23] and the analogous connection between chronic rhinosinusitis and sinus barotrauma has been documented.[12,25] The connection to pollen allergies is not entirely new either. In one study, a history of sinusitis and/or allergic rhinitis was shown to be associated with sinus barotraumas while diving.[22] As patients with any active rhinologic pathology were (naturally) excluded from the study, no connection to active disease states could be detected.

Sinus barotrauma while diving had affected 48.9% of the respondents. While incidences of < 0.1% have been reported in Taiwanese navy recruits in pressure chamber measurements,[19] up to 7% of Swiss professional scuba divers reported having experienced such symptoms.[20] In

less experienced, recreational divers, 26% of diving course participants experienced one or more sinus barotrauma episodes during their training.[22] Considering that the present study examined the lifetime (to date) prevalence of sinus barotrauma, the numbers naturally surpass those reported above.

Symptoms most often appeared when descending rather than ascending (83.2% vs. 29.6%, respectively), in agreement with previous reports.[20,22] The symptoms that appeared when ascending tended to be more severe and sustained compared to those that appeared when descending; this might be partly explained by the fact that a dive can be discontinued if symptoms appear on descent, but not if they appear on ascent.

Moreover, symptoms appeared in relatively shallow waters (81.1% reported symptoms at < 10 msw) where the relative volume change in response to increasing pressure is the largest. To the best of our knowledge, no previous studies have reported on the depth at which the symptoms occurred, although general mentions of this do appear in the previous literature.

The symptoms most often manifested in the frontal regions as described previously,[1] with maxillary pain and epistaxis being less frequently reported. Although we failed to include simply "*headache*" as a symptom and could therefore risk overlooking the prevalence of sphenoid sinus barotraumas, only 3.9% reported having had "*other*" symptoms, and none of these were further specified as being headache-related. To the best of our knowledge, the duration of sinus barotrauma symptoms has not been previously reported in any large cohorts.

Finally, a total of 11.6% of symptomatic respondents reported undergoing ORL-related surgical procedures due to sinus barotrauma while diving. Whereas the other procedures could plausibly have been undertaken in response to sinus barotrauma, the reports of adenoidectomies most likely represent a misunderstanding by the respondents (as adenoidectomy is a paediatric procedure completely unrelated to sinus ventilation), and therefore, should be interpreted with caution.

STRENGTHS AND LIMITATIONS

The external validity of the results is certainly the study's largest limitation. As our study population did not consist of the entire target population (i.e., all recreational and professional divers in Finland) and our study sample was comprised of only 26.6% of the potential population, the results cannot be considered representative of all Finnish divers. However, as our study is (by far) the largest survey on sinus barotrauma to date, the results are, nevertheless, a valuable contribution to research on sinus disorders in diving.

Regarding internal validity, the data describing the frequency, characteristics and health effects of sinus barotrauma can be considered reliable. However, the results identifying possible risk factors are vulnerable to several biases, and multivariable logistic regression analyses were utilised to best minimise this effect. In our analysis, both a large number of URTIs and pollen allergies were associated with sinus barotraumas while diving; both of these hypotheses being further supported by applying the Bradford-Hill guidelines for observational data (see Appendix 3*).

The main strength of the study is its large size. In addition, another strength is the level of detail elicited by the questions: no previous studies have examined sinus barotrauma while diving in such an elaborate manner. Also, the anonymity of the questionnaire further strengthens the findings; with no possibility of identification, any motivation for dishonesty disappears when submitting one's response.

Other limitations include the use of patient-reported and hence completely subjective estimations of all collected data. This limitation could not be avoided as many of the outcomes investigated were in themselves subjective. Nevertheless, there is a possibility that some of the symptoms attributed to sinus barotrauma here were the result of other pathologies, such as barodontalgia, for example. Finally, given the 27% response rate, the possibility of a reporting bias among respondents cannot be excluded.

As sinus barotrauma while diving seems to be relatively common with no means to control the pressure equalisation to one's paranasal sinuses, the best preventive measure seems to be to abstain from diving when suffering from an URTI, or symptoms of active allergies. Future research should focus on further examining these possible risk factors, recognising others, and on developing the best possible treatment modalities to combat the issue.

Conclusion

Sinus barotrauma seems common in both recreational and professional divers, having affected, at some time or another, 48.9% of the 1,881 divers who responded. Symptoms most often involved the frontal and maxillary regions and appeared at relatively shallow depths. Sinus barotrauma was strongly associated with a high annual number of URTIs, allergies to pollen and possibly smoking. Future research should focus on verifying these findings and on recognising other factors potentially involved. Abstaining from diving seems essential when suffering from an URTI.

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Appendix 1. English translation of the questionnaire
Appendix 2. Details of data acquisition
Appendix 3. Application of the Bradford-Hill guidelines for observational data: sinus barotraumas while diving and the condition's possible risk factors

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