Barodontalgia Among Aircrew and Divers

Idan Nakdimon; Yehuda Zadik

BACKGROUND: Barodontalgia, barometric pressure-induced dental pain, may jeopardize diving/flight safety. The aim of this systematic review was to investigate the rate of barodontalgia among military and civilian divers and aircrews based on previous reports.

METHODS: We analyzed the data of 4894 aircrew/divers reported in the literature. Barodontalgia rates (flight vs. diving, military vs. civilian, pressurized vs. non-pressurized aircrafts) were analyzed. The Chi-squared test was used to compare between groups.

RESULTS: Of the 4894 individuals, 402 (8.2%) suffered from barodontalgia. Divers (9.8%) were more vulnerable than aircrews (5.8%). Barodontalgia experience rate was 5.4% and 6.5% in military and civilian aircrews, respectively, and 7.3% and 12.8% in military and civilian scuba divers, respectively. Barodontalgia was more common among aircrews of pressurized than non-pressurized aircrafts (7.3% vs. 3.2%, respectively).

DISCUSSION: The greater amplitude of barometric pressure changes explains the higher rate of barodontalgia in divers than aircrew. The higher rate during pressurized flights is possibly because intracabin pressure in the pressurized cabin is still routinely higher than in nonpressurized aircrafts. Improved oral care and mandatory annual dental checkups may be the reason for the significantly lower rate of barodontalgia experienced among military aircrews and divers compared to their civilian counterparts. These results emphasize the essential role of atmospheric pressure change in the generation of pain during flight or diving and the importance of proper dental care.

KEYWORDS: aviation medicine, aerospace medicine, military medicine, atmospheric pressure, dental pain, pain.

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Barodontalgia (also known as aerodontalgia) is defined as a barometric pressure-induced oral pain, which may be dental or nondental.[22] This condition is mostly a symptom of pre-existing oral or maxillofacial disease. The exact mechanism of pain is still unclear.[19] Although quite rare, barodontalgia may be severe enough to suddenly incapacitate a diver or aircrew member, which could jeopardize the safety of diving or flight.[8,18]

This pain phenomenon can be divided to two classes, namely direct barodontalgia and indirect barodontalgia. The indirect type is of nondental origin (e.g., barosinusitis, barotitis-media) and is reported in up to one-fifth of cases.[23] The direct pain is of dental origin, such as recent dental therapy (up to 30% of cases), deep dental caries and leaking restorations (4–50%), and pulpitis (7–22%).[23] The pain is located mainly in the upper dentition (up to 56% of the cases)[12] and the upper and lower first molars are the most affected teeth (about 30% each).[4]

Barodontalgia was reported at altitudes of 2000 to 5000 ft (610 to 1524 m) during flights and at a water depth of 33 to 86 ft (10 to 26 m) during diving.[23] The appearance of pain on ascent is usually related to vital pulp conditions (i.e., pulpitis) and appearance on descent to necrotic pulp diseases or facial barotrauma (i.e., indirect barodontalgia referred from barosinusitis or barotitis).[19,23] Pain from peri-radicular pathology may appear during descent or ascent. Most of the cases of pain (either in flight or during diving) happen during ascent. Pain usually ceases when returning to onset level or ground atmospheric level, but may linger if originating from peri-radicular

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pathology or facial barotrauma.[4,19] The aim of this study was to examine the barodontalgia experience among (civilian and military) aircrew and divers according to the published data.

METHODS

This review study is based on the published English scientific literature regarding barodontalgia with the following criteria: study types—original prospective or retrospective studies published in English; participants—no restrictions were placed on the type of participants (i.e., children and adults, men and women were included in the analysis); measures—the prevalence of experienced barodontalgia during flight or diving was calculated; electronic searches—we searched the electronic database of Medline via Pubmed (1946 to 2017), with the keywords "Barodontalgia", "Aerodontalgia", the combinations of "Dental pain" with "Flight", "Aircraft", "Scuba", "Diving", "Altitude", and "Flying", the combination of "Toothache" with "Flight", "Aircraft", "Scuba", "Diving", "Altitude", and "Flying", and the combinations of "Tooth" with "Barotrauma" and "Flight", "Aircraft", "Scuba", "Diving", "Altitude", and "Flying". No restriction was placed on publication date when searching the electronic databases.

The two authors independently assessed the relevance of all reports identified by the online searches on the basis of title, keywords, and abstract (when available) and determined if the study was likely to be relevant. We obtained the full-text report of all potentially relevant articles except for six reports published in 1945, 1946, 1947, 1954, 1970, and 1982.[1,2,5,7,14,16] The review authors were not blinded with respect to report authors, journals, date of publication, sources of financial support, or results. Only original research that explored the experience of barodontalgia while flying or diving was included in the analysis; editorials/letters, case reports and series, review articles, and non-English literature were excluded. The two authors independently applied the inclusion criteria in duplicate and decide by comparing opinions and discussion.

Data was gathered from the identified articles. Weighted average and ratio were calculated for the various flight and diving outlines, and for civilian and military populations. For comparison between the groups, data was analyzed (χ^2 analysis) using SPSS software for MS Windows version 22. P-values < 0.05 were considered statistically significant.

RESULTS

Search yielded 101 matched English and 29 non-English publications (130 in total); of the 101 English articles, 39 articles were unrelated to barodontalgia (most of the articles studied dental barotrauma rather than barodontalgia), 8 were editorials/letters, 11 case reports and series, 25 reviews, and 6 articles were not found.[1,2,5,7,14,16] There were 12 relevant original research papers found. Three of them reported prevalence of barodontalgia during hypobaric chamber training (rather than in-flight or diving conditions),[3,11,13] and were therefore excluded (**Fig. 1**).

Nine studies from Australia, France, Israel, Britain, Spain, Switzerland, Jordan, and the United States[4,6,9,12,15,20–22,26] were included in the study and analyzed. All of the analyzed studies were questionnaire- or interview-based retrospective studies (**Table I**), with the primary endpoint of experience of one or more cases of barodontalgia in career-time. In total, 4894 individuals participated in these studies (**Table II**), of which 402 (8.2%) suffered from one or more episodes of barodontalgia (**Table III**).

The distribution of barodontalgia cases according to population is presented in Table III. Divers (in which 288/2925, 9.8%, individuals were affected) were more vulnerable when civilian

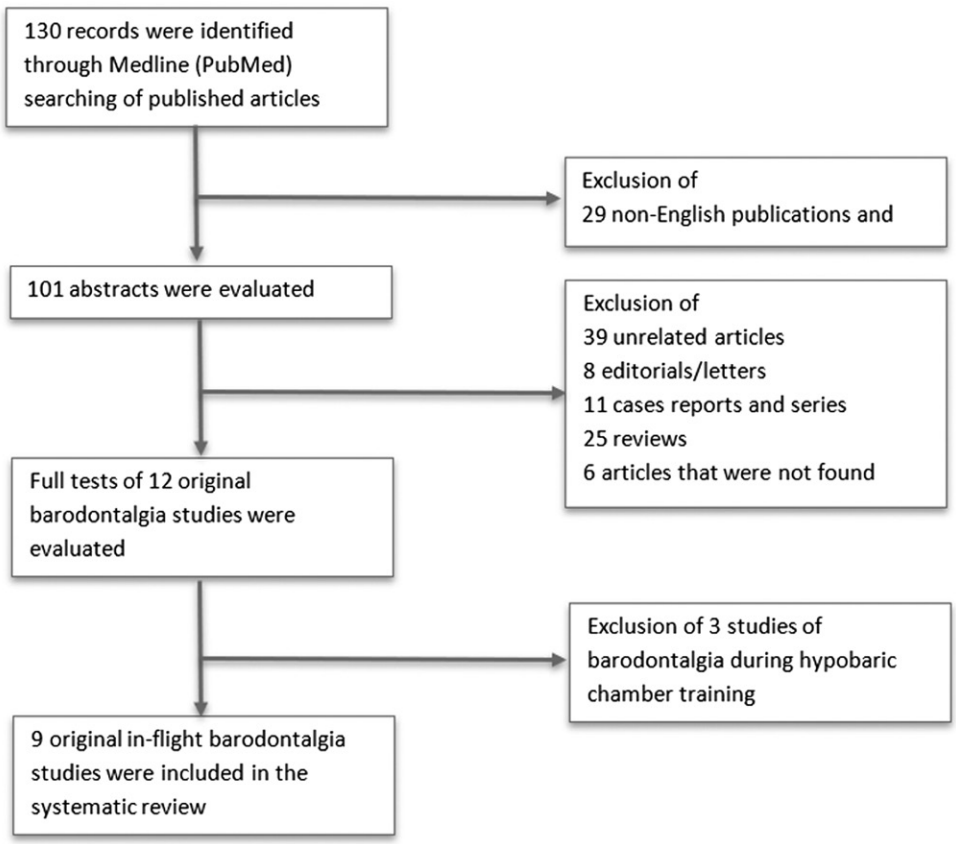

Fig. 1. The process of study selection, leading to the inclusion of nine studies in the systematic review.

Table I. Features of the Analyzed Studies.

AUTHORS (YEAR OF PUBLICATION)	STUDY DESIGN	DATA COLLECTION	STUDY POPULATION	RESPONSE RATE*
Taylor et al. (2003)[20]	Retrospective	Questionnaire	Civilian divers	N/R
Gonzalez-Santiago et al. (2004)[4]	Retrospective	interview	Military aircrew	499/506, 98.6%
Zadik et al. (2007)[22]	Retrospective	Medical and dental records	Military aircrew	331/450, 73.6%
Jagger et al. (2009)[9]	Retrospective	Questionnaire	Civilian divers	125/200, 62.5%
Laval-Meunier et al. (2013)[12]	Retrospective	Questionnaire	Civilian and military aircrew	1184/1475, 80.3%
Zanotta et al. (2014)[26]	Retrospective	Questionnaires and interview	Civilian and military divers (mixed)	520/750, 69.3%
Yousef et al. (2015)[21]	Retrospective	Questionnaire	Civilian divers	154/166, 92.8%
Gunepin et al. (2016)[6]	Retrospective	Questionnaire	Military divers	1317/1389, 94.8%
Ranna et al. (2016)[15]	Retrospective	Questionnaire	Civilian divers	N/R

* One or more instances of barodontalgia recalled from previous exposures.
N/R: not reported.

(i.e., 12.8% in civilian diving vs. 6.5% in civilian flight; $\chi^2 = 17.45$, df = 1, $P < 0.001$) and military (i.e., 7.3% in military diving vs. 5.4% in military flight; $\chi^2 = 3.89$, df = 1, $P = 0.048$) populations were separated.

The overall barodontalgia experience of civilian aircrews and divers (10.4%) was significantly higher than the military aircrews and divers (6.4%; $\chi^2 = 23.28$, df = 1, $P < 0.001$). In-diving barodontalgia was experienced by 12.8% of civilian scuba divers, compared to 7.3% of military scuba divers ($\chi^2 = 20.34$, df = 1, $P < 0.001$). No significant differences were noted regarding in-flight barodontalgia rates between the military and civilian populations (5.4% vs. 6.5%, respectively; $\chi^2 = 1.02$, df = 1, $P = 0.311$).

In the military aircrew population, barodontalgia was more common in aircrews from pressurized aircrafts (i.e., fighters and transporters; 48/655, 7.3%) than nonpressurized aircrafts (i.e., helicopters; 17/526, 3.2%; $\chi^2 = 9.41$, df = 1, $P = 0.002$); specifically, the rate was higher in fighter aircrews (29/284, 10.2%) than transporter (8/155, 5.2%) and helicopter (17/526, 3.2%) aircrews ($\chi^2 = 17.07$, df = 2, $P < 0.001$).

DISCUSSION

Exposure to extreme environments such as encountered during flying and diving places individuals at risk[18] with potential incapacitation and other harmful consequences. Barodontalgia is one of these undesirable effects and is related to barometric pressure changes. This study aimed to review the literature regarding barodontalgia. There were a limited number of published studies on the topic and most reported the experience of barodontalgia (i.e., one or more episodes of pain over a lifetime) rather than incidence or prevalence.

The barometric pressure changes from 0 (outer space) to 1 (ground level) atm, while diving pressure increases by 1 atm every 10 m. Therefore, divers may be exposed to more significant pressure changes. The current analysis, according to which a higher proportion of divers (9.8%) were affected by barodontalgia in comparison to aircrew (5.8%; $P < 0.001$), supports this notion and contradicts the theory of similarity in experience of barodontalgia between scuba divers and aircrews.[25] The difference between diving and flight environments remains when examining civilian (12.8% in diving vs. 6.5% in flight; $P < 0.001$) and military (7.3% in diving vs. 5.4% in flight; $P = 0.048$) populations. This finding supports the primary role of pressure changes in in-flight/in-diving oral pain. It should be noted that one study reported a mixed population of civilian and military divers;[26] we only included its data in the analysis of overall in-diving barodontalgia.

The barodontalgia experience of civilian aircrews and divers was significantly higher than their military counterparts (9.6% vs. 6.4%, respectively; $P < 0.001$), probably due to better oral care[24] and mandatory annual dental checkups of military aircrews and divers.[22] However, while civilian divers experienced significantly higher rates of barodontalgia (12.8%) than military divers (7.3%; $P < 0.001$), the experience of military aircrew (5.4%) is similar to their civilian counterparts (6.5%; $P = 0.311$). Military aircrew tend to have good oral care and most have a mandatory annual dental checkup.[24] Flying is characterized by frequent significant changes in the atmospheric pressure and, in the mid-1940s, Ritchey and Orban suggested that rapid ascent is related to higher rates of barodontalgia;[17] the more rapid the ascent the less physiological ability to compensate for the barometric changes. In addition, more recently, Laval-Meunier et al. suggested that other factors such as speed, acceleration,

Table II. Study Population Distribution.

POPULATION	AIRCREW, *N* (%)	DIVERS, *N* (%)	TOTAL, *N* (%)
Civilian	674 (13.8%)	1088 (22.2%)	1762 (36.0%)
Military	1295 (26.5%)	1317 (26.9%)	2612 (53.4%)
Total	1969 (40.2%)	2925 (59.8%)*	4894 (100%)

Based on Refs. 4, 6, 9, 12, 15, 20–22, and 26.
* The population studied by Zanotta et al.[26] was of civilian and military divers together; therefore, this data was included in the total diver population but not in the civilian or military analyses.

Table III. Distribution of 402 Barodontalgia Cases According to Population.

POPULATION	FLIGHT, *N* (%)	DIVING, *N* (%)	TOTAL, *N* (%)
Civilian	44 (6.5%)	139 (12.8%)	183 (10.4%)
Military	70 (5.4%)	96 (7.3%)	166 (6.4%)
Total	114 (5.8%)	288 (9.8%)*	402 (8.2%)

Based on Refs. 4, 6, 9, 12, 15, 20–22, and 26.
* The population studied by Zanotta et al.[26] was of civilian and military divers together, therefore this data was included in the total diver population but not in the civilian or military analyses.

temperature, and vibrations may also contribute to the induction of oral pain during flight.[12]

According to the results, aircrew of pressurized aircrafts suffer more from barodontalgia than those of nonpressurized aircrafts (7.3% vs. 3.2%; $P = 0.002$). This finding agrees with the assumption that cabin pressurization reduces the rate of barometric-related conditions, including barodontalgia, because even after pressurization, standard intracabin pressure is compatible to an altitude of 8000 to 18,000 ft (2438 to 5486 m), which is much higher than the pressure found in routine nonpressurized aircrafts (i.e., helicopter, 3000–5000 ft or 914–1524 m). Indeed, analysis of the three flight platforms revealed a significant difference ($P < 0.001$) in experienced barodontalgia rates between fighter (10.2%), transport (5.2%), and helicopter (3.2%) aircrews; these rates correlate with the barometric pressure changes of the platforms.

Overall, 5.4% of military aircrew reported at least one episode of in-flight barodontalgia; a lower rate than reported during WWII, which was 9.5%.[10] This finding questions the theory that the experience of barodontalgia in the first half of the 20th century and current rates (between 2003 and 2016) are similar.[25] The current low rate can be attributed to cabin pressurization, fluoridation of drinking water and oral hygiene products, which lead to reduced dental morbidity, and better dental care.[24]

Regarding the in-flight barodontalgia, a distinction has to be made between actual flights and hypobaric simulators. It seems that data from hypobaric chamber simulators cannot be compared to in-flight data due to inconsistency in exposure (i.e., once every few years vs. weekly or daily exposure, respectively). Therefore, in contrast to previous publications,[4,12] the current analysis did not include hypobaric chamber experiences.

In conclusion, the systematic review supports the following concepts: 1) the experience of barodontalgia is higher among scuba divers than aircrew; 2) despite frequent and rapid changes in the atmospheric pressure during military flights, military aircrew are less vulnerable to barodontalgia than civilian aircrew, probably due to better oral health; 3) the rate of barodontalgia in various flight platforms correlates with chamber altitude (the inner chamber pressure after pressurization); and 4) experience of barodontalgia among military aircrew is lower than reported during WWII. These concepts demonstrate the essential roles of atmospheric pressure changes in the generation of oral pain during flights and dives, and the importance of proper dental care and oral hygiene maintenance in populations susceptible to barodontalgia.

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