Aural health awareness and incident prevention in UK scuba divers

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Abstract
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Introduction: Otological disorders, including Eustachian tube dysfunction (ETD), are commonly observed in divers. Data were gathered to observe the prevalence of ear disorders, and awareness of ear health recommendations for recreational divers in the United Kingdom.
Methods: An anonymous online survey included: diver/diving demographics, the validated Eustachian Tube Dysfunction Questionnaire 7 (ETDQ-7) (a mean score of ≥ 2.1 indicating the presence of dysfunction), pre-existing ear health conditions, medications, decongestants and knowledge of diving and ear health guidance.
Results: A total of 790 divers (64% males) responded (age range 16–80, median 47 years). An ETDQ-7 mean score of ≥ 2.1 was calculated in 315 of 790 respondents (40%), indicating varying degrees of ETD; 56/315 (18%) recorded a pre-existing ear condition. Ear disorders, (external, middle, and inner ear issues) since learning to dive were recorded by 628/790 (79%) of respondents; 291/628 (46%) did not seek medical advice. ETDQ-7 scores of ≥ 2.1 to 6.6 were reported by 293/628 (47%). Six reported inner ear decompression sickness. Decongestants were used by 183/790 (23%). Two hundred and seventy-seven of 790 divers (35%) had aborted a dive with ear problems. Only 214/790 (27%) of respondents were aware of the United Kingdom Diving Medical Committee guidance regarding ear health and diving.
Conclusions: Ear problems and ETD since diving were widely reported in this cohort of divers, with not all divers in this study aware of ear health recommendations and advice.

Introduction

Recreational diving encompasses a broad spectrum of ages, physical abilities, and medical conditions. Otological disorders are a significant source of diving-associated adverse events, with otitis externa being the most common ear pathology followed by middle-ear barotrauma.[1–6] A plethora of other ear pathologies have been identified affecting divers including exostoses, inner-ear barotrauma, hearing loss, vertigo, and inner ear decompression sickness (inner ear DCS).[7–14]

Ear health as a component of diving medical guidelines is an important element of scuba training and good diving practice, but the training delivered to individuals new to the sport may not be optimal to develop ear-safe and symptom-free diving.[15] It is clear that symptoms frequently go unreported to medical practitioners and, for those symptoms which are reported to physicians, it is possible that unfamiliarity with the physiology and physics of scuba diving will be detrimental to the quality of the advice given.[16,17]

This observational study aimed to determine whether self-diagnosis and treatment of ear disorders, including Eustachian tube dysfunction (ETD), is commonplace amongst scuba divers, and whether United Kingdom (UK) divers are aware of and observe the United Kingdom Diving Medical Committee (UKDMC) recommendations supporting ear health.[15,17–21]

Methods

An anonymous, observational, online survey was compiled and publicised between June and November 2017 via the DDRC Healthcare website, diving exhibitions and social media. Measures included validated diver and diving demographic questions designed and used in previous field data studies.[22,23] All participants completed the validated Eustachian Tube Dysfunction Questionnaire 7 (ETDQ-7).[24]

Information on pre-existing ear conditions, ear problems since learning to dive, medical advice obtained, and diagnoses delivered was recorded. Use of decongestants and awareness of diving and ear health guidance and the year of the diver's last physical diving medical were also recorded.

Quantitative data are reported as median. Univariate analysis, including chi-square tests were used to look at relationships between pre-existing ear disorders and ETD; a nonparametric test (Mann-Whitney U) was used to look at the difference in divers with inner- or middle-ear barotrauma and number of years diving or total lifetime dives. A significant level of $P \leq 0.05$ was used throughout. GraphPad Prism 9.2.0 (332) was used for analysis. All data were scrutinised for duplicates, and completion. Approval from a research ethics committee is not required for studies of this type in the UK.

Results

A total of 790 divers (64% males) with an age range 16–80 (median 47) years responded, with significantly younger females and older males represented (*t*-test $P < 0.001$). Diving experience ranged from a few months to 58 (median 12) years. A total lifetime dives (665,482; median 400) and dives completed in the last 12 months (47,369; median 40) were recorded. One hundred and ninety-four respondents (24%) belonged to a technical diving organisation.

Most divers, 576/790 (73%), were unaware of the UKDMC recommendations for ear health when diving. The majority, 501/790 (63%), had received a physical medical assessment since learning to dive, but 76/501 (15%) of that group had not undertaken a medical for more than 10 years. Moreover, 114/501 (23%) had only seen their general practitioner (GP) who is not usually trained in dive medicine. All respondents reported diving in the last 12 months and 32/790 (4%) had been refused fitness to dive at some point since learning to dive.

All divers completed the ETDQ-7 with the mean ETD scores assessed. ETD scores ranged from 1 to ≥ 6.16. Scores of ≥ 2.1, indicating moderate to severe ETD, were evident in 315/790 (40%) of respondents.

Pre-existing ear disorders were reported by 86/790 (11%). Of these, 56/86 (65%) recorded ETD scores of ≥ 2.1 which was significantly greater than respondents without a pre-existing issue but with an ETD score of ≥ 2.1 (Chi-square $P < 0.001$). Of divers with a pre-existing ear condition, 24/86 (28%) had never undergone a diving medical examination, and 12/86 (13%) had encountered further problems since learning to dive. The majority of these, 64/86 (74%), were unaware of the UKDMC recommendations for ear health when diving.

Overall, external, middle, and inner ear issues since learning to dive were experienced by 628/790 (79%) of respondents (Table 1). Just 337/628 (54%) of respondents with disorders sought medical advice or treatment, suggesting that many divers in this study self-diagnosed and treated their own ear problems; one respondent did not detail the diagnosis (Table 2).

There was no relationship between respondents with a pre-existing ear condition and those who went on to develop an ear problem since learning to dive (Fisher's exact test $P = 0.12$). There was no statistical difference between divers with inner or middle ear barotrauma and number of years of diving experience (Mann-Whitney U test $P = 0.30$), or their total life-time number of dives (Mann-Whitney U test $P = 0.50$).

Table 1

Otological problems reported by 628 divers since learning to dive, both self-diagnosed and physician-diagnosed, and indicated as external, middle, or inner ear problems; many divers reported more than one issue. The categorisation of 'small amount of bleeding' and 'pain and bleeding' should be treated with caution due to the lack of additional respondent data and ability to follow up

Divers (n = 628)	External	Middle	Inner
External ear canal red, swollen, and or itchy (307)	•		
Ear canal inflamed and partially closed (260)	•		
Outer ear painful to touch (225)	•	•	
Any other discharge from the ear (99)	•	•	
Both pain and bleeding from the ear (28)	•	•	
Small amount of bleeding from ear (27)	•	•	
Feeling of fullness in the ear (383)	•	•	
Muffled hearing (445)	•	•	•
Vertigo/dizzy (242)			•
Loud tinnitus, ringing or roaring in the ear (161)		•	•
Hearing loss (151)	•	•	•
Vomiting (55)			•

Table 2
Physician-diagnosed otological problems in 336 divers who sought a medical opinion; one respondent did not provide additional detail

Physician diagnosis	***n***
Outer ear infection / otitis externa	147
Middle ear infection / otitis media	79
Middle ear barotrauma	46
Tympanic membrane / eardrum rupture	41
Inner ear barotrauma / round or oval window rupture	12
Inner ear decompression sickness	6
External ear canal superficial vessel rupture	5
Total	336

Inner ear DCS was diagnosed by a physician in six divers (median age 54 years), but no data were recorded concerning the dive profiles and breathing gases used on the dives resulting in inner-ear DCS. One diver reported being diagnosed with a persistent foramen ovale (PFO) but the timing of diagnosis in relation to the incidence of inner ear DCS was not revealed.

Dives aborted because of ear problems were reported by 277/790 (35%) of respondents, with 254/277 (92%) aborting on descent, with 17 of these divers requiring assistance. In this group, 135/277 (49%) scored an ETD of ≥ 2.1. Overall, significantly more females (114/286) than males (163/504) aborted a dive due to ear issues (Fisher's exact $P = 0.04$). Decongestant use was reported by 183/709 (23%) with 40 of these divers routinely using a decongestant before every dive.

Discussion

The majority of responding divers encountered otological problems during their sport diving activities, with many respondents reporting more than one episode. Some divers joined the sport with unassessed pre-existing ear problems which remained undeclared. The reason for failure to seek medical review in divers with pre-existing ear problems remains unclear. There are several potential reasons for this such as a lack of awareness of relevant medical guidelines, a poor understanding that diving with a pre-existing ear condition may lead to sequelae or a willingness to ignore the potential damage that may be sustained whilst diving (possibly to ensure they are not excluded from the sport). It is also possible, as otological symptoms are common in the general population, that a diver may consider them too trivial to seek medical advice. A small number of divers with pre-existing otological issues did consult with their GP, but not all GPs are familiar with diving medicine, relevant guidelines and associated health issues.[22,23]

Although most respondents scored an ETDQ-7 score of ≤ 2, the 40% with an ETD of ≥ 2.1 included divers with pre-existing ear health problems. The routine use of ETD testing for divers to prevent further ear injury has been suggested.[17–21] Our data failed to demonstrate a relationship between ETDQ-7 measures and an increased number of aborted dives or greater development of ear problems, potentially due to adaptation of diving habits and diving more conservatively.

Many respondents sought medical advice or treatment for perceived problems or injury, but a large number of respondents also chose to self-diagnose and self-treat. Free text suggested that a fear of being prevented from diving was one of the main considerations in failing to seek a medical opinion combined with the ease of hiding the issue through the self-declaration process.[22,23,25]

In Table 1 there were insufficient additional details from respondents to definitively distinguish between 'small amount of bleeding' and 'pain and bleeding'. More severe issues such as inner ear DCS are not always reported or accurately diagnosed.[3,7,25] The present data (Table 1) suggested that divers may experience symptoms of inner ear DCS but choose not to seek advice. Inner ear DCS was physician-diagnosed in six respondents, but dive profiles including gas mix and depth, pre-existing persistent (patent) foramen ovale, treatments and outcomes were not revealed. The increasing prevalence of inner ear DCS has been observed in recreational dive populations and discussed.[14] This may be due to technical advances in dive equipment, as well as mixed gas diving enabling more divers in general to access greater diving depths than in the past. Although three technical divers reported inner ear DCS these data should be treated with caution as this finding is likely due to small numbers and/or reporting bias.[1,12–14]

Decongestants were successfully used in a quarter of all respondents with some using decongestants prophylactically for every dive. There was no statistical difference between decongestant use and the rate of inner and/or middle ear barotrauma, suggesting that decongestants were being self-administered without negative outcomes.

Divers generally showed a poor awareness and understanding of the ear health recommendations published by the UKDMC.[15] It is unknown whether better informed divers would have been at lower risk of inner ear DCS in this cohort. It is likely that the rate of aborted dives and the high level of unreported and self-treated ear problems could be significantly reduced through better education and timely review (if there has been a change in ear health) by an appropriately trained physician; this coupled with a more discerning view on whether to dive given their ear-health status at any time.

The diver and diving demographics in this cohort were consistent with UK diving club culture, which accounts for more dives per annum per head than might be expected in sport divers from other geographical areas.[22,23]

LIMITATIONS

This was an anonymous, self-reporting survey with no controls or the ability to follow up divers who reported issues. Although the ETDQ-7 is a useful and reliable tool it is only a window of information regarding the respondents' ear status covering the one-month period immediately prior to completion of the questionnaire. No further auditory testing was performed on our respondents. It is widely accepted that surveys of this type may suffer from bias with divers experiencing problems more likely to respond, but conversely the anonymity of the study allows gathering data that may be lost otherwise to the researcher.

Conclusions

Some divers joined the sport with unassessed, pre-existing otological problems. Of 790 respondents to this survey, 628 (79%) reported ear problems during their diving career, almost half of whom were undertaking preventative measures pre-dive and self-diagnosing and self-treating symptoms rather than seeking medical advice. Education of divers and diving instructors on medical guidelines, equalisation techniques and encouragement to seek medical advice where appropriate should be encouraged.

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