Medications taken daily and prior to diving by experienced scuba divers

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Keywords
Scuba, recreational diving, motion sickness, nasal decongestants, epidemiology, medications

Abstract

Introduction: Medication pharmacodynamics may be altered in the hyperbaric environment, yet little research has examined medications taken by divers. We aimed to determine the nature and extent of chronic and acute medication use amongst experienced scuba divers.
Method: Cross-sectional postal survey of Australian and United States (US) scuba diving club members.
Results: 709 divers responded (Australian 346, US 363). The majority were professionals (54.9%), aged 31–50 years (59.9%), and experienced divers (median years of diving: 8). A variety of prescription and over-the-counter medications were taken daily. Many were for cardiac disease or hypertension (8.9% of divers) and asthma (2.8%). Some respondents regularly took antiepileptic agents (0.3%), oral hypoglycaemics (0.4%) or insulin (0.3%). Divers frequently took medications within two hours of diving. These usually targeted sea sickness and barotrauma. Pseudoephedrine ($p < 0.001$) and nasal decongestants ($p < 0.001$) were taken significantly more frequently by US divers. Fewer divers took antihistamines, and those taken largely reflected availability.
Discussion: Many experienced divers take a variety of medications for chronic conditions. This may reflect adversely upon their fitness to dive. Research should examine the effects of commonly-used medications in the hyperbaric environment. Our findings identify those medications that should be targeted.

Introduction

The hyperbaric environment may cause a number of physiological effects on scuba divers, including bradycardia and central nervous system effects such as nitrogen narcosis.[1–5] It has been suggested that medications modulate these physiological effects, potentially increasing the risks associated with the hyperbaric environment.[1,3–7] Unfortunately, the diving literature contains a paucity of information about the interactions between medications and diving. Accordingly, most authorities recommend that no medications be taken prior to scuba diving. These recommendations and warnings are largely based on general pharmacological properties and theoretical effects under pressure, rather than on the results of clinical studies.

Despite recommendations to the contrary, there is considerable anecdotal evidence that a notable proportion of divers take a range of medications on a daily and pre-dive basis. The aim of this study was to determine the nature and extent of medication use amongst experienced recreational scuba divers. Of interest were the medications taken daily for chronic medical conditions, as well as those taken prior to diving to assist with the diving experience. The purpose of this study was to guide future research into the effects of medications on scuba diving.

Methods

This study was a cross-sectional postal survey of Australian and United States (US) scuba diving club members. Clubs and their representatives (presidents or secretaries) were identified from lists published on the Internet. These club representatives were contacted by telephone or e-mail to obtain consent for their club to participate. Twenty nine Australian and 28 US clubs participated. These clubs were spread widely across both countries and included both inland and coastal areas.

In June 2000, each club's representative was mailed a variable number of study questionnaires. Each club was provided with 5–10 additional questionnaires over and above the number of members expected to be at the meeting. These questionnaires were distributed at the next club meeting, completed immediately and returned by the representative in a stamped, addressed envelope. In order to calculate a response rate, each representative was requested to report the total number of members attending the meeting. Two months after the initial mailing, clubs that had not returned questionnaires were mailed a reminder letter. This was repeated in one further month's time, when necessary. Participation was voluntary and responses confidential.

The questionnaire was developed by two investigators and evaluated for face and context validity by the other investigators. The first section collected demographic data on the divers including diving experience. The second section consisted of a number of questions regarding diver personalities, chronic medical conditions, diving injuries, as well as medications taken. Divers were asked to self report the medications they took daily and how frequently they took certain medications within two hours of diving.

Most responses were analysed descriptively. Median values are reported with ranges. For comparisons of proportions,

Chi square analysis was performed using the STATA statistical package (Intercooled, Version 7.0, Texas, USA). The study was authorised by the Institutional Review Board (Ethics Committee) of the University of Pittsburgh, USA.

Results

Questionnaires were returned by 709 divers: 346 from Australia and 363 from the US. The demographics of the divers are outlined in Table 1. Overall, 488 divers (68.8%) were male and most (59.9%) were aged between 31 and 50 years. The US divers were significantly older (χ^2 = 76.2, df = 5, $p < 0.001$), with 258 divers (71.1%) being aged over 40 years, compared to 144 (41.6%) in the Australian group. Most divers were professionals with a university education. Alcohol intake was greater amongst the Australians (χ^2 = 53.4, df = 4, $p < 0.001$), but overall most were moderate drinkers. Only 76 divers (10.7%) were smokers. Overall, this was an experienced group of scuba divers with the median number of years of diving for both groups being 8 years (range 0–50 for Australian and 0–45 for US divers). The median number of dives was 198 (range 0–2000) and 120 (range 0–999) for the Australian and US divers respectively.

TABLE 1
DIVER DEMOGRAPHICS (% IN PARENTHESES)

Characteristic	Australian divers n = 346		United States divers n = 363		Total n = 709	
Gender						
Male	253	(73.1)	235	(64.7)	488	(68.8)
Female	92	(26.6)	124	(34.2)	216	(30.5)
No answer	1	(0.3)	4	(1.1)	5	(0.7)
Age (years)*						
18–20	10	(2.9)	6	(1.7)	16	(2.3)
21–30	72	(20.8)	20	(5.5)	92	(13.0)
31–40	120	(34.7)	73	(20.1)	193	(27.2)
41–50	85	(24.6)	147	(40.5)	232	(32.7)
51–60	53	(15.3)	90	(24.8)	143	(20.2)
> 60	6	(1.7)	21	(5.8)	27	(3.8)
No answer	0	(0)	6	(1.7)	6	(0.8)
Highest level of education completed						
State school	8	(2.3)	4	(1.1)	12	(1.7)
High school	133	(38.4)	92	(25.3)	225	(31.7)
College/university	156	(45.1)	172	(47.4)	328	(46.3)
Post graduate university	48	(13.9)	91	(25.1)	139	(19.6)
No answer	1	(0.3)	4	(1.1)	5	(0.7)
Type of occupation						
Unemployed	24	(6.9)	16	(4.4)	40	(5.6)
Blue collar/trade	105	(30.3)	60	(16.5)	165	(23.3)
White collar/clerical	54	(15.6)	48	(13.2)	102	(14.4)
Professional	153	(44.2)	236	(65.0)	389	(54.9)
No answer	10	(2.9)	3	(0.8)	13	(1.8)
Number of alcoholic drinks/week*						
< 1	78	(22.5)	153	(42.1)	231	(32.6)
1–5	122	(35.3)	125	(34.4)	247	(34.8)
6–10	62	(17.9)	56	(15.4)	118	(16.6)
11–15	40	(11.6)	13	(3.6)	53	(7.5)
> 15	42	(12.1)	13	(3.6)	55	(7.8)
No answer	2	(0.6)	3	(0.8)	5	(0.7)
Cigarette smoker	39	(11.3)	37	(10.2)	76	(10.7)

* Significant difference between the Australian and US divers ($p < 0.001$)

MEDICATIONS TAKEN PRIOR TO DIVING

Table 2 describes decongestant use within two hours of diving. Pseudoephedrine was the most frequently used decongestant; it was taken prior to most or all dives by 71 divers (10%). There was a significant difference between the countries in terms of pseudoephedrine use prior to diving; US divers used pseudoephedrine significantly more frequently than Australian divers ($\chi^2 = 42.7$, df = 2, $p < 0.001$). Nasal decongestants were also used more frequently by US divers than Australian divers ($\chi^2 = 15.3$, df = 2, $p < 0.001$). Bronchodilators such as salbutamol (albuterol) were used before most or all dives by 21 divers (3.0%), and occasionally by 16 divers (2.3 %).

Table 3 describes the use of agents marketed as non-sedating antihistamines. These antihistamines were used less frequently than decongestants prior to diving. Table 4 describes the most commonly used anti-emetic products. Agents for the prevention of sea-sickness include antihistamines such as dimenhydrinate and diphenhydramine as well as anticholinergic agents such as hyoscine. These anti-emetics, with the potential to alter mental alertness, were used by 81 divers (11.5%) prior to most or all dives and used occasionally by a quarter of divers overall. Hyoscine hydrobromide (Kwells™) was frequently used by Australian divers, whereas US divers more frequently used diphenhydramine (Benadryl™) and dimenhydrinate (Dramamine™). Eighty seven divers

TABLE 2
REPORTED DECONGESTANT USE WITHIN TWO HOURS OF DIVING (% IN PARENTHESES)

Medication	Australian divers n = 346		United States divers n = 363		Total n = 709	
Pseudoephedrine (Sudafed™) use prior to diving*						
Never	196	(56.6)	161	(44.4)	357	(50.4)
Occasionally	129	(37.3)	126	(34.7)	255	(36.0)
Before most or all dives	9	(2.6)	62	(17.1)	71	(10.0)
No answer	12	(3.5)	14	(3.9)	26	(3.7)
Nasal decongestant spray use prior to diving*						
Never	279	(80.6)	251	(69.1)	530	(74.8)
Occasionally	50	(14.5)	62	(17.1)	112	(15.8)
Before most or all dives	3	(0.9)	20	(5.5)	23	(3.2)
No answer	14	(4.0)	30	(8.3)	44	(6.2)

*Significant difference between Australian and US divers, $p < 0.001$

TABLE 3
COMMON NON SEDATING ANTIHISTAMINE USE PRIOR TO DIVING (% IN PARENTHESES)

Non sedating antihistamine	Australian divers n = 346		United States divers n = 363		Total n = 709	
Certirizine (Zyrtec™)						
Never	327	(94.5)	313	(86.2)	640	(90.3)
Occasionally	2	(0.6)	5	(1.4)	7	(1.0)
Before most or all dives	0	(0)	4	(1.1)	4	(0.6)
No answer	17	(4.9)	41	(11.3)	58	(8.2)
Loratidine (Claratin™, Clarityne™)						
Never	312	(90.2)	285	(78.5)	597	(84.2)
Occasionally	16	(4.6)	28	(7.7)	44	(6.2)
Before most or all dives	0	(0)	12	(3.3)	12	(1.7)
No answer	18	(5.2)	38	(10.5)	56	(7.9)
Fexofenadine (Telfast™, Allegra™)						
Never	329	(95.1)	306	(84.3)	635	(89.6)
Occasionally	0	(0)	10	(2.8)	10	(1.4)
Before most or all dives	0	(0)	8	(2.2)	8	(1.1)
No answer	17	(4.9)	39	(10.7)	56	(7.9)

TABLE 4
COMMONLY USED ANTI EMETICS AND ALCOHOL USE PRIOR TO DIVING (% IN PARENTHESES)

Medication	Australian divers n = 346		United States divers n = 363		Total (%) n = 709	
Dimenhydrinate (Dramamine™)						
Never	320	(92.5)	223	(61.4)	543	(76.6)
Occasionally	5	(1.4)	81	(22.3)	86	(12.1)
Before most or all dives	3	(0.9)	28	(7.7)	31	(4.4)
No answer	18	(5.2)	31	(8.5)	49	(6.9)
Dimenhydrinate, Hyoscine hydrobromide, Caffeine (Travacalm™)						
Never	295	(85.3)	301	(82.9)	596	(84.1)
Occasionally	18	(5.2)	13	(3.6)	31	(4.4)
Before most or all dives	16	(4.6)	5	(1.4)	21	(3.0)
No answer	17	(4.9)	44	(12.1)	61	(8.6)
Diphenhydramine, Pseudoephedrine, Guaiphenesin (Benadryl™)						
Never	323	(93.4)	280	(77.1)	603	(85.0)
Occasionally	6	(1.7)	48	(13.2)	54	(7.6)
Before most or all dives	0	(0)	1	(0.3)	1	(0.1)
No answer	17	(4.9)	34	(9.4)	51	(7.2)
Hyoscine hydrobromide (Kwells™)						
Never	257	(74.3)	320	(88.2)	577	(81.4)
Occasionally	45	(13.0)	0	(0)	45	(6.3)
Before most or all dives	28	(8.1)	0	(0)	28	(3.9)
No answer	16	(4.6)	43	(11.8)	59	(8.3)
Alcohol						
Never	281	(81.2)	282	(77.7)	563	(79.4)
Occasionally	44	(12.7)	41	(11.3)	85	(12.0)
Before most or all dives	1	(0.3)	1	(0.3)	2	(0.3)
No answer	20	(5.8)	39	(10.7)	59	(8.3)

(12.3%) reported consuming alcohol prior to diving. It was not determined whether alcohol was consumed in combination with an anti-emetic whose sedative activity could be potentiated by alcohol.

MEDICATIONS TAKEN DAILY

Table 5 describes the numbers of medications taken on a daily basis by the divers. Approximately one quarter of respondents took one or more medications daily. The US divers took significantly more medications every day than the Australian divers ($\chi^2 = 32.6$, df = 6, $p < 0.001$). Table 6 describes the medications taken.

Divers took a range of cardiovascular medications including angiotensin converting enzyme inhibitors, angiotensin II receptor antagonists, beta blockers, calcium channel blockers and diuretics. One respondent took a combination of clopidogrel, simvastatin and atenolol. The diver taking digoxin also took aspirin and a thiazide diuretic. Therefore

TABLE 5
NUMBER OF MEDICATIONS TAKEN DAILY FOR ANY MEDICAL CONDITION (% IN PARENTHESES)

Number	Australian divers n = 346		US divers n = 363		Total n = 709	
None	292	(84.4)	244	(67.2)	536	(75.6)
1	34	(9.8)	60	(16.5)	94	(13.3)
2	15	(4.3)	35	(9.6)	50	(7.1)
3	4	(1.2)	12	(3.3)	16	(2.3)
4	1	(0.3)	7	(1.9)	8	(1.1)
5	0	(0)	3	(0.8)	3	(0.4)
6	0	(0)	2	(0.6)	2	(0.3)

TABLE 6
MEDICATIONS TAKEN EVERY DAY FOR ANY MEDICAL CONDITION (% IN PARENTHESES)

Medication	Australian divers n = 346		United States divers n = 363		Total n = 709	
Cardiovascular medications						
b-blockers	3	(0.9)	10	(2.8)	13	(1.8)
Calcium channel blockers	3	(0.9)	4	(1.1)	7	(1.0)
ACE inhibitors/ATII antagonists	5	(1.4)	18	(5.0)	23	(3.2)
Other antihypertensives	0	(0)	3	(0.8)	3	(0.4)
Digoxin	1	(0.3)	0	(0)	1	(0.1)
Diuretics	3	(0.9)	4	(1.1)	7	(1.0)
Lipid lowering agents	7	(2.0)	14	(3.9)	21	(3.0)
Aspirin	5	(1.4)	12	(3.3)	17	(2.4)
Clopidogrel	1	(0.3)	0	(0)	1	(0.1)
Anti asthmatic/allergy medications						
Inhaled corticosteroids	3	(0.9)	6	(1.7)	9	(1.3)
Intranasal corticosteroids	2	(0.6)	4	(1.1)	6	(0.8)
Oral corticosteroids	0	(0)	1	(0.3)	1	(0.1)
Inhaled bronchodilators	3	(0.9)	5*	(1.4)	8	(1.1)
Cromoglycate	0	(0)	2	(0.6)	2	(0.3)
Monteleukast	0	(0)	1	(0.3)	1	(0.1)
Antihistamines	2	(0.6)	26	(7.2)	28	(3.9)
Decongestants	0	(0)	4	(1.1)	4	(0.6)
Hormonal/endocrine medications						
Contraception (oral or depot)	11	(3.2)	6	(1.7)	17	(2.4)
Hormone replacement therapy	4	(1.2)	14	(3.9)	18	(2.5)
Thyroid supplementation	2	(0.6)	16	(4.4)	18	(2.5)
Oral hypoglycaemic agents	1	(0.3)	2**	(0.6)	3	(0.4)
Insulin	0	(0)	2	(0.6)	2	(0.3)
Osteoporosis agents	2	(0.6)	2	(0.6)	4	(0.6)
Analgesics/Rheumatology medications						
NSAIDs	4	(1.2)	3	(0.8)	7	(1.0)
COX-2 inhibitors	0	(0)	4	(1.1)	4	(0.6)
Methotrexate	2	(0.6)	1	(0.3)	3	(0.4)
Allopurinol	0	(0)	3	(0.8)	3	(0.4)
Others	2	(0.6)	2	(0.6)	4	(0.6)
Neuropsychiatric medications						
Anti-epileptic agents	1	(0.3)	1***	(0.3)	2	(0.3)
Anti-depressant agents	3	(0.9)	10	(2.8)	13	(1.8)
Anti-psychotic/mood alterants	2	(0.6)	3	(0.8)	5	(0.7)
Anxioloytic agents	0	(0)	5	(1.4)	5	(0.7)
Interferon b-1A	0	(0)	1	(0.3)	1	(0.1)
Anti-ulcer medications	6	(1.7)	12	(3.3)	18	(2.5)
Miscellaneous agents	2	(0.6)	10	(2.8)	12	(1.7)
Unidentifiable responses	0	(0)	7	(1.9)	7	(1.0)

* One diver took salbutamol, budesonide, salmeterol, cromoglycate and oral hydrocortisone daily
** One diver took glyburide and metformin
*** This diver took topiramate and carbamazepine

the digoxin was possibly for atrial fibrillation rather than congestive heart failure.

A range of reliever and preventer anti-asthmatic medications were taken on a daily basis. One respondent took a combination of salbutamol, salmeterol, budesonide, cromoglycate and oral hydrocortisone.

Thirty five divers (16% of female divers) took either the oral contraceptive pill or hormone replacement therapy. Unexpectedly, 16 US divers (4.4 %) reported taking thyroid supplementation. Five divers took medication for diabetes; insulin alone (two divers), metformin alone (two divers) and a combination of metformin and a sulfonylurea (one diver). Two divers took anti-epileptic medications; one took a combination of carbamazepine and topiramate, suggesting a history of epilepsy not readily controlled by first line agents. One diver took interferon b-1A used for relapsing-remitting multiple sclerosis. Anti-psychotic and mood altering medications included clozapine and various amphetamine derivatives.

Discussion

This study demonstrates that experienced divers take a range of medications within two hours of diving. The most commonly-used agents are decongestants, anti-emetics and bronchodilators. These medications are probably used to prevent aural barotrauma, sea-sickness and exercise-induced bronchoconstriction respectively.

Only a few studies have evaluated the effects of decongestants and anti-emetics in the hyperbaric environment.[3,4,8–11] A randomised placebo-controlled, double blind crossover trial evaluated the psychometric effects of pseudoephedrine and dimenhydrinate at 101 kPa and 303 kPa in a dry hyperbaric chamber.[3,4] Dimenhydrinate reduced mental flexibility (trail making test, $p < 0.05$) and depth reduced verbal memory ($p = 0.001$). Therefore the combination of dimenhydrinate and depth may contribute to the dangers of diving. In the pseudoephedrine arm, no significant alterations in psychometric performance were demonstrated. However, there was a trend towards increased anxiety scores and a significant increase in heart rate.

Sipinen and colleagues evaluated the neuropsychological and cardiovascular effects of clemastine fumarate, a sedating antihistamine, in a double blind, placebo-controlled, cross over study.[10] Once again this study was conducted in a hyperbaric chamber to a simulated depth of 51 metres. Clemastine did not increase the sedative effects of nitrogen narcosis nor increase the risk of cardiac arrhythmias.

Hence it is clear that while many divers are taking drugs prior to diving, the effects of these drugs in the hyperbaric environment have been poorly investigated. Further research is indicated to determine if divers are, in fact, at increased risk as a result of altered drug pharmacodynamics while diving. Those drugs that may affect diver safety should be identified and the nature and extent of the effect should be quantified. This information would allow divers to weigh the risks and the benefits of pre-dive medication use. Of particular interest are the effects of the potentially sedating anti-emetics used commonly in Australia, such as the Travacalm® combination product and diphenhydramine.

The finding that medications are taken daily by one quarter of divers provides insight into the medical conditions with which these divers dive. While the hyperbaric environment may modulate the effects of these medications, of greater importance is the impact of the underlying medical conditions on a diver's fitness to dive. Some divers appear to be diving despite absolute or relative contraindications to scuba diving eg. ischaemic heart disease, diabetes, asthma and epilepsy. This study is supported by an analysis of chronic medical conditions suffered by the Australian cohort. These data have been reported elsewhere.[5]

Differences were noted between the Australian and US divers. The US divers took more chronic medications, but this group was significantly older. Therefore, the differences in the number of medications used may reflect differences in the ages of the two groups. The differences in the specific agents used prior to diving may reflect differences in product availability in the two countries, as well as marketing practices. The frequency of use of decongestants prior to diving varied between the two groups. This may be due to differences in access to the medications. In Australia, pseudoephedrine can be sold only in pharmacies, whereas in places such as Florida, these agents may be sold in a variety of shops, including dive shops. This means that there is the potential to purchase decongestants (and anti-emetics) within metres of the dive boat.

This survey has some limitations. First, selection bias is likely, as we have surveyed only experienced dive club members. These results may not be reflective of all experienced divers and are likely not representative of the novice diver, who tends to be younger. Also, only a very small proportion of active Australian and US divers were surveyed. This is further likely to introduce selection bias. Few dive club representatives reported the number of divers at the meeting at which the survey was administered. Therefore it was not possible to determine a response rate.

Furthermore, there may be some potential recall and misclassification bias of medication names. If divers were concerned about their dive club officials learning that they had certain diseases or took certain medications, there is the potential for prevarication bias.

Studies are required to evaluate the effects of chronically-used medications on the risks associated with the hyperbaric environment. It would likely be more valuable, however, to evaluate the impact of the various medical conditions on diving of which the chronic medications are a marker, eg. asthma, ischaemic heart disease and epilepsy.

Conclusions

Many experienced scuba divers take a variety of medications for chronic conditions. These medications are likely to be markers of the chronic medical conditions with which the divers dive. These conditions may impact adversely on divers' fitness to dive. In addition, many experienced divers take medications to assist with diving. Further research is required to evaluate the impact of these medications on divers' fitness to dive.

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Ventilatory support in a hyperbaric environment

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Key Words
Hyperbaric oxygen, medical conditions and problems, treatment, ventilators

Abstract
As ventilatory support becomes more complex and varied, a good understanding of the changes that can occur in the hyperbaric environment to both the patient and the devices used is vital. Only with this knowledge may patients be managed safely. Unfortunately, few studies have been done so far on the physiological effects of IPPV and other respiratory support in the hyperbaric environment. What is known of these changes is summarised in this paper.

Introduction

A number of patients accepted for treatment with hyperbaric oxygen therapy (HBOT) may require some form of respiratory support. Patients with severe neurological decompression illness, arterial gas emboli, carbon monoxide poisoning and necrotising infections may all require mechanical ventilation. To manage these patients appropriately requires a good understanding of the physiological changes that occur to the respiratory system, and the effects of intermittent positive pressure ventilation (IPPV), positive end expiratory pressure (PEEP), and