Short communication

Pre- and post-dive spirometry assessment of recreational scuba divers. A pilot field study

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Key words
Scuba diving, diving research, pulmonary function

Abstract
(Wilson A, Crockett A. Pre- and post-dive spirometry assessment of recreational scuba divers. A pilot field study. *Diving and Hyperbaric Medicine*. 2006; 36: 195-7.)
Purpose: Pre- and post-dive spirometry were conducted by recreational scuba divers in order to determine whether there were acute changes in divers' forced vital capacity (FVC), forced expiratory volume in one second (FEV_1) or the FEV_1/FVC ratio following a dive. Previous studies have been conducted in artificial conditions using hypertonic saline and using professional diving equipment rather than that used by recreational divers.
Methods: Data were collected from qualified scuba divers at six different dive locations. Spirometry was undertaken prior to the dive and within 30 minutes of completing the dive using an Easyone® spirometer.
Results: There were 26 male (72.2%) and 10 (27.8%) female divers. No significant changes in lung function were detected post dive (P = 0.94). However, 8 (22%) divers had pre-dive FEV_1/FVC ratio values below normal signifying mild airways obstruction, and 23 (63.8%) were overweight.
Conclusions: Although there was no significant change in divers' FEV_1/FVC ratio following a scuba dive to indicate bronchial hyperresponsiveness due to salt-water aspiration, further studies using techniques for measuring airways resistance during tidal breathing may be more appropriate for testing this hypothesis.

Introduction

Reporting on human factors associated with scuba-diving fatalities in Australia and New Zealand, Edmonds and Walker pointed out that salt-water aspiration in the conscious diver was an unverifiable factor that relied on data from others and was obscured in the event of drowning.[1] As such, the lack of information on the prevalence of bronchial hyperresponsiveness in the sport-diving population presents difficulties in setting reasonable recommendations for medical standards. The following pilot study was conducted to ascertain whether seawater aspiration during a routine dive might increase the probability of bronchoconstriction. A search of the literature did not reveal any studies that had been conducted on recreational divers in the field.

Methods

Approval was received from the University of Adelaide Human Research Ethics Committee. NHMRC guidelines were adhered to. A convenience sample of 56 qualified divers was recruited through scuba clubs, shops and at dive sites. After giving informed consent, participants completed a short questionnaire requesting relevant health history information and personal demographic data.

Spirometric data were compared with Australian predicted normal limits.[2] Results were grouped according to spirometry variables (e.g., normal (predicted) forced vital capacity (FVC) *versus* abnormal FVC) and individual variables (e.g., age and height). Easyone® spirometers were used to ascertain divers' forced vital capacity (FVC) and forced expiratory volume in one second (FEV_1). An FEV_1/FVC ratio of less than 75% was regarded as abnormal. Assessment was undertaken prior to the dive and within 30 minutes of completing the dive. The spirometry results were assessed according to established standards for lung function testing with spirometry.[3] These criteria revealed more unacceptable results than the quality-assurance algorithm of the spirometer. Data were compared with normal limits and results grouped according to spirometry variables and demographic variables (e.g., age and height). Student's paired t-tests were applied for comparison of nominal data between groups.

Survey forms were de-identified and data entered into SPSS® V.13 for management and analysis of descriptive statistics and frequencies.

STUDY DIVE PROFILES

Dives were conducted at six different sites and included both shore and boat dives. Depths ranged from 3 to 28 metres' sea water (msw). Fourteen dives (39.2%) were conducted under 12 msw and 17 (47.6%) over 21 msw. Length of dives ranged from 25 minutes to over an hour. Efforts were made to take post-dive spirometry measures as soon as possible after the dive.

Results

DEMOGRAPHIC DATA

Of the 36 divers (see below) analysed, ages ranged from 15 to 68 years with a mean of 43 years; 15 (42%) were 46 to 55 years of age. There were 26 male (72%) and 10 (28%) female subjects. According to body mass index (BMI) scales, 18 (50%), were overweight and five (14%) were obese (BMI => 30). Four subjects (11%) were current smokers and nine (25%) were former smokers.

MEDICAL HISTORY

At the time of the dive, four (11%) divers reported they had a respiratory illness. A variety of allergies were reported: drugs – two (6%), animals – two (6%), dust, metal and pollen – three (8%), and nuts – one (3%). Two subjects (6%) reported taking decongestant nasal spray and Sudafed medication before a dive.

Five subjects (14%) indicated they had never undergone a dive medical. For those who had, the mean interval since was five years (median one year, 18 divers; range 1–30 years).

DIVING HISTORY

Diving experience ranged from under one month to 46 years, with a mean of 12.4 years. The average number of dives conducted each month per person was seven (mean) with a range of less than one to 15 per month.

SPIROMETRY

Of the 56 divers recruited, data from 20 divers was either incomplete or rejected on technical grounds.[3] Both pre- and post-dive spirometry data met the standards for acceptability and repeatability for 36 divers (64%) and were analysed.

Critical incidents that affected data collection included one case of ear barotrauma and several of seasickness. Complications due to rough seas and seasickness affected subjects' ability to perform post-dive spirometry.

Compared with before the dive, no statistically significant differences in spirometry measurements were detected post dive (Table 1). Nevertheless, eight (22%) divers had pre-dive FEV_1/FVC ratio values below normal, signifying mild airways obstruction.

Discussion

This pilot study sought to provide information on the prevalence of any acute lung function changes associated with recreational diving. The experience, average age and mean body mass index of the population were found to be consistent with divers of other studies.[4] Of interest were the findings relating to obesity, fitness and medications used.

This study has contributed to new knowledge by being undertaken in the field, as opposed to in the laboratory environment. Some previous studies have investigated expired airflow limitations in professional scuba divers or changes to lung function as a result of exposure to hyperoxia at depth and to decompression stress resulting in venous gas micro-embolism during ascent. Several studies examining bronchospasm and respiratory function in scuba divers with known respiratory dysfunction and allergic respiratory conditions have been identified.

However, only two of these studies considered the relatively shallow dives of sport scuba divers and the pattern of resultant lung function changes that may occur. In addition, these studies were conducted in artificial environments utilising chemical substitutes for seawater.[5,6]

Cirillo et al studied the effects of scuba dives on airway responsiveness in non-asthmatic, atopic subjects and concluded that there is a relationship between the development of early airway hyperresponsiveness and atopic subjects.[6] However, this relationship has also been demonstrated in non-diving atopic subjects. Tetzlaff et al studied 18 male sport divers in a hyperbaric chamber wearing full-face masks rather than using oral demand valves.[5] The study concluded that atopic divers were more susceptible to the effects of diving on lung function than divers without an atopic history and suggested that the mechanical and physiological loads of scuba diving are associated with a

Table 1
Differences between pre- and post-dive spirometry data in 36 scuba divers; mean differences with 95% confidence intervals and paired t-test probabilities are shown
(FVC – forced vital capacity; FEV_1 – forced expiratory volume in 1 second)

Parameter	Mean difference	95% confidence intervals of the difference	P values
FVCpre – FVCpost	-0.066	-0.051 to +0.183	0.261
FEV_1pre – FEV_1post	+0.013	-0.111 to +0.137	0.835
FEV_1/FVCpre – FEV_1/FVCpost	+0.973	-3.075 to +1.129	0.354

reduction in airways conductance. Effects on respiratory function were consistent with small airways dysfunction, which may lead to long-term effects on respiratory function in scuba divers.[5]

In addition, given that half of the divers in the present study were aged 46 years and over, it is reasonable to anticipate that, as the diving population ages, divers will have health needs that require appropriate management to keep them healthy and active. It is imperative that information on risks related to diving be disseminated to the diving public.[7] In 2004, the South Australian coroner reported that of five diving deaths all were not medically fit to dive, due to specific medical conditions, cardiovascular unfitness or being overweight.[8] The coroner's recommendations included regular medical assessments for recreational divers. The use of spirometry during routine medical assessment by general practitioners may detect unforeseen problems.

Conclusions

There was no significant change in divers' pre- and post-dive FEV_1/FVC ratio indicating bronchial hyperresponsiveness due to salt-water aspiration. Due to difficulties faced in the field such as fatigue and seasickness, studies using techniques for measuring airways resistance during tidal breathing may be more appropriate for testing this hypothesis. The incidental findings of unfitness and obesity warrant investigation by further studies.

Acknowledgements

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Diving Medicine Special Interest Group

A diving medicine special interest group has been formed recently within the RACP. Its mission is to promote diving medicine and the specialty of occupational medicine.

Objectives:
- To develop, implement and manage a Certificate of Competency (COP) in diving medicine
- To develop, implement and manage a website of interest and use to practitioners who have an interest in diving medicine
- To conduct a session or lecture relevant to diving medicine as part of each year's AFOM ASM

Proposed regulations for the COP in diving medicine:
- Medical practitioner
- Medical scientist or educationalist at doctoral level who has a primary interest in diving medicine
- Acceptable postgraduate qualification in diving medicine (e.g., SPUMS Diploma, University of Auckland PG Diploma or Masters degree)
- Ongoing commitment to diving medicine

For further information or to join the diving medicine SIG please contact:
<afom@racp.edu.au>