HEALTH STATUS OF RECREATIONAL SCUBA DIVERS IN WESTERN AUSTRALIA

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Key Words
Ascent, equipment, fitness to dive, medical conditions and problems, low air.

Abstract

Background
Scuba diving is a physically demanding activity. Physical fitness is required to meet the routine demands of the aquatic environment, and to cope with unexpected environmental or equipment related (technical) problems. “Fitness to dive” is currently assessed by pre-training medical screening and the achievement of a minimum swimming distance. The health and physical fitness of diving trainees, however, has not been well defined. Similarly, the prevalence of diving related health and technical problems is not known.

Aims
To characterise the general health and fitness of recreational scuba divers and to identify any diving related health or technical problems.

Methods
Detailed health and diving questionnaires were mailed to 63 experienced divers and to 919 randomly selected subjects who had recently completed a PADI accredited diving course.

Results
The overall questionnaire response rate was 55%. 72% of respondents were male and 28% female, with mean age of 27 years (range 12-66). The divers’ mean body mass index (BMI) was 23.5 (range 16-40), with 24% being overweight or obese (BMI>25). Current smokers made up 11.6% with 16.9% being ex-smokers. Most divers undertook regular exercise (88% >2 hours weekly), but only 26% swam regularly. Conditions which contraindicate diving (asthma, epilepsy or diabetes) were present in 10.4%. Minor dive related symptoms such as ear and headache were experienced by 52% of subjects. Dive-related technical problems (eg swimming difficulties, low-on-air, emergency ascent) had been experienced by 37% of respondents.

Discussion
While most recently trained divers are in good health, a significant proportion are either overweight and/or do not exercise regularly. Current medical screening is not effective at excluding people considered medically unfit for diving. Despite undertaking accredited training programs, many divers had experienced avoidable technical problems when diving. Given the prevalence of these problems, the relative lack of ‘water fitness’ of most divers is of particular concern.

Introduction
Scuba diving is a physically demanding activity. Diving fitness can be defined on a number of levels; strength, endurance and psychological factors.1 Strength is very specific to the activity being undertaken and requires ongoing training to maintain. Regular swimming, preferably with scuba fins, is required to retain diving strength. Endurance is a cardiovascular phenomenon and relatively non-specific; i.e. it can be maintained by regular aerobic exercise of any form. Diving fitness also needs to consider both the physical demands of normal, comfort level diving and the sudden unanticipated demands that occasionally occur. Many divers have experienced unexpected changes in sea conditions or gear failures that suddenly necessitate a greater level of physical exertion to resolve. At the present time, scuba diving trainees undergo a simple swim test. They have to swim 200 m and they have to tread water for a couple of minutes. The energy requirement of different activities can be compared by a measure of workload, the metabolic equivalent (MET). To swim 200 m at one’s own pace, requires only 6-7 METs. Treading water is more strenuous and requires 7-9 METs. Most people have to be moderately fit to achieve that, but certainly not very fit. In contrast, a diver in full gear requires a near-maximal exertion of 13 METs to swim at one knot.1 Unless very fit, most people cannot exercise aerobically at this level. Anaerobic exercise can only be maintained for a minute or so before the diver becomes exhausted and slows down or stops.

A variety of medical conditions can also potentially affect diving fitness. In accordance with Australian Standard 4005.1,2 all prospective scuba divers are required...
to undergo medical screening and participate in an accredited dive-training program. However, the efficacy of this strategy in detecting these medical contra-indications to diving has not been determined.

The scuba training process aims to teach divers to anticipate and avoid adverse environmental conditions, to detect gear problems before diving and how to cope with unexpected failures that arise during diving activity. The efficacy of this approach and the prevalence of such problems are, similarly, unknown.

Thus, we sort to characterise the general health and physical fitness of recently trained recreational scuba divers and to identify and quantify any diving related health or technical problems.

**Methods**

A total of 982 scuba divers from two discrete populations were studied to assess the reliability of applying results to the general Western Australian scuba diving population and for the purpose of comparing recently trained divers with more experienced divers. One group was 919 divers trained by the Professional Association of Diving Instructors Australia (PADI).3 These divers were randomly selected from people who have completed a PADI accredited scuba diving course in Western Australia between January 1998 and June 1999. A further 63 divers were randomly selected from the University of Western Australia (UWA) Dive Club membership list.

Participants were mailed a detailed questionnaire which included questions about the general health and fitness of participants and problems they had encountered while diving. A covering letter was sent with all questionnaires, requesting divers’ participation in the study and stating that all information provided was confidential and would not be available on an individual basis to the diving agencies. Questionnaires were returned directly to the UWA Department of Public Health. Non-respondents were sent a follow up letter and a second copy of the questionnaire one month after the initial mail out. A statistician from the University of Western Australia, Department of Public Health performed all data analysis, using the Statistical Package for the Social Sciences (SPSS). Statistical comparison between groups was by non-parametric chi-squared test, with p<0.05 being taken as significant.

**Results**

Forty questionnaires were returned without reaching the addressee. Most of these were international tourists that had listed their dive operator’s or a hotel’s address on dive training registration forms. The overall response rate in the remainder was 54.7% (515 of 942 possible respondents). The actual respondents were 477 (92.7%) PADI enrolled divers and 38 (7.3%) UWA divers. The response rate and findings were comparable between the two groups as 243 PADI divers responded (51%) as did 23 UWA divers (60.5%) (p not significant).

Overall, 343 (72%) of respondents were male and 134 (28%) were female. The mean age was 27 years, with a median age of 24 and a range from 12 to 66 years (Figure 1). There were 20 divers (4.2%) aged more than 50 years and 51 (10.7%) aged less than 16 years. Fifty five (11.6%) divers were current smokers. This is much lower than the general population prevalence of 24%.4 Eighty one divers (17%) were ex-smokers. Self-reported height and weight were used to categorise 466 divers by body mass index (BMI) (Figure 2). Obesity (BMI>30) was present in 23 (4.9%) divers and 89 (19.1)% were overweight (BMI>25); of the overweight subjects 44 (9.4%) were borderline overweight (BMI 25-27) and 45 (9.7%) clearly overweight (BMI 25-30).

![Figure 1](http://archive.rubicon-foundation.org)  Number of divers in each age group.

![Figure 2](http://archive.rubicon-foundation.org)  Body mass index of divers

Most divers (454 or 95.2%) had completed their basic dive training in Australia, and the majority (445 or 94%) had done basic diving courses since 1992, when the current Australian Standard for recreational diving training was introduced.2 The divers’ experience varied greatly, with 362 (75.9%) having done fewer than 20 dives since their training course; this included the majority of the recently trained divers. A further 87 (18.3%) had done between 20 and 100 dives and 28 (5.9%) having over 100 dives.
Divers were asked to estimate the average number of hours they spent doing various types of exercise each week. Exercise was then categorised, according to predefined criteria, as aerobic (including walking, jogging, team sports, cycling and others), isometric exercise (weight training) and water related activities (swimming and diving). The amount of exercise undertaken each week in each of the exercise categories is shown in Figure 3. Although most (420 or 88%) divers exercised regularly for more than 2 hours of aerobic exercise weekly) only 124 (26%) did two or more hours of water related activity each week.

Completion of the Recreational Scuba Training Council questionnaire (RSTC) is an obligatory requirement before undertaking any PADI dive course. Any positive response to this screening questionnaire then mandates formal medical assessment. The RSTC was the only pre-dive assessment completed by 51 (10.8%) of the respondents. Of those who had a formal health evaluation, the majority 417 (87.5%) of all divers) had full dive medicals, including lung function tests. A further 19 (4%) divers reported having additional assessment by a medical specialist prior to undertaking dive training. Only 9 divers (1.9%) reported having no formal health assessment.

Medical conditions that are considered contra-indications to diving (AS4005.1) such as current asthma, epilepsy or diabetes were present in 50 (10.5%) of subjects. Most of these had undergone full dive medicals. A number of divers with these conditions commented how easy it was to avoid detection by a combination of misrepresentation of their medical history and/or pre-medication (e.g. bronchodilators) before the dive medical. Table 1 outlines the self-reported medical co-morbidities of the divers (more than one condition may have been present in each subject).

Other conditions reported by divers included orthopaedic problems, thyroid disease, haemochromatosis, congenital complete heart block, right bundle branch block and a colostomy bag. One diver reported progressive and near complete visual loss since passing his diving medical, yet he continued to dive.

Health problems during or immediately following diving were noted by 248 (52%) of the divers. The most prevalent were ear problems and headache, most likely due to problems with pressure equalisation and CO2 retention in novice divers, respectively. Significant symptoms such as dyspnoea, wheeze, chest pain or syncope occurred in 32 (6.8%) of divers.

One or more technical problems had been experienced by 177 (37.1%) divers (Table 2). This included a large number of divers (91 or 19%) who had become unexpectedly low on air, and 20 (4%) who had needed to ascend urgently because of perceived failure of air supply.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low on air</td>
<td>91</td>
<td>19.0%</td>
</tr>
<tr>
<td>Emergency ascent</td>
<td>20</td>
<td>3.7%</td>
</tr>
<tr>
<td>Unexpected difficulty swimming</td>
<td>113</td>
<td>23.7%</td>
</tr>
<tr>
<td>Equipment failure</td>
<td>32</td>
<td>6.8%</td>
</tr>
</tbody>
</table>

Each diver may have experienced more than one event.

There were few significant differences between the recently trained PADI divers and the more experienced UWA cohort. The UWA divers were all older than 20 years, were more likely to have completed further dive training (p<0.005) and had completed a greater average number of dives (p<0.0005). These divers also experienced a greater number of technical and health problems, however, this finding is confounded by the difference in the number of dives.

**TABLE 1**

PREVALENCE OF MEDICAL CONDITIONS IN DIVERS IN WESTERN AUSTRALIA

<table>
<thead>
<tr>
<th>Condition</th>
<th>Number</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current asthma as defined by AS 4005.1</td>
<td>46</td>
<td>9.7%</td>
</tr>
<tr>
<td>Chronic bronchitis/Emphysema</td>
<td>3</td>
<td>0.6%</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Epilepsy</td>
<td>5</td>
<td>1.0%</td>
</tr>
<tr>
<td>Ischaemic heart disease</td>
<td>1</td>
<td>0.2%</td>
</tr>
<tr>
<td>Hypertension</td>
<td>20</td>
<td>4.2%</td>
</tr>
</tbody>
</table>

**TABLE 2**

PREVALENCE OF UNEXPECTED PROBLEMS WHILE DIVING
Discussion

Safe diving requires adequate fitness levels in all participants. In this study, fitness was determined by assessing exercise, smoking, and BMI. Most divers undertook some form of aerobic exercise, but there was only a small proportion of divers who undertook regular water-related activities. This could indicate the swimming fitness of this cohort of divers was sub-optimal. The study was conducted during late summer and the autumn months. We asked divers to indicate the amount of regular exercise they partook when they were diving. Even so, we may have under-estimated swimming fitness by surveying towards the cooler months of the year.

The prevalence of current smoking in divers was 11.6%, which is significantly lower than the general population prevalence of 24% (p<0.01). A significant number (23) of divers were obese or very overweight (45), a total of 14.6% with BMI>27, conditions which maybe associated with impaired fitness.

Current medical screening is not effective at excluding people considered unfit for diving. Our data shows that divers with potentially lethal disease can escape detection under current screening guidelines. One diver had epilepsy with the most recent seizure only 6 months previously, despite taking regular anti-convulsant medication, and he has continued to dive subsequently. There is little doubt that a seizure underwater may well be fatal.

Another weakness of the current entry-level screening is that many subjects will continue to dive for years after their initial assessment and may subsequently develop significant disease. This is becoming more relevant as the mean age of both prospective and certified divers increases; already 5% of divers are older than 50 years. The importance of discussing the effects of any new medical conditions on their fitness to dive should be emphasised in training programs. Periodic health reviews, particularly of “older” divers would also potentially allow the detection of new health problems such as ischaemic heart disease.

This study highlights that, despite undertaking accredited training programs, many divers had experienced avoidable technical problems. Many of these are issues that instructor organisations would assume to have been effectively covered by dive training. The high prevalence of unexpected swimming difficulties emphasises the need for a high “survival” level of fitness. The large number of divers who had experienced unexpected low air or needed emergency ascent was greater than expected. Such scenarios could easily lead to panic situations, and this re-enforces the psychological aspect of diving fitness. This may be particularly relevant when considering the 11% of divers who were less than 16 years or age.

It is possible that our survey respondents are not representative of recently trained scuba divers. Only 55% of people responded to the questionnaire, however, there is little reason to suspect any systematic bias in these respondents. With regard to the sample size, accurate figures for the total number of divers trained in the time period surveyed are not available, however commercial estimates are in the order of 10,000 individuals in Western Australia. The survey population approached represents 9% of this number and is statistically robust. Similarly, the study population is likely to be representative of the broader Australian recreational scuba diving community. Although a number of different dive agencies operate in Australia, PADI is the largest and is thought to train 80% of all divers. Overall, there were only small differences between the recent (PADI) trainees and the more experienced (UWA) divers. The increased number of problems is consistent with the greater number of dives; proportionally, there were fewer problems per dive in the UWA group, in keeping with their greater diving experience. The similarity of results in these samples supports the contention that these findings can be generalised to the broader Australian recreational diving population.

Conclusions

While most recently trained divers are in good health, a significant proportion are either overweight and/or do not exercise regularly. Current medical screening is not effective at excluding people considered medically unfit for diving. There is a definite need to re-evaluate the current screening methods, and to promote continued health surveillance in divers. Despite undertaking accredited training programs, many divers had experienced avoidable technical problems while diving. Given the prevalence of these problems, the relative lack of “swimming fitness” of most divers is of particular concern.

Acknowledgments

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References

4 Grove C, Lalor E, Cresp R, Valinsky L and Langton P.
Prevalence of asthma in a cohort of Western Australian scuba divers. Presented at the Annual Scientific Meeting of SPUMS, Fiji, May 2000


The study was conceived by Dr Paul Langton who presented the paper in Fiji. The questionnaire design and data collection were by Rebecca Cresp, Carolyn Grove and Emma Lalor in conjunction with Liora Valinsky. The project was performed as a component of the Public Health unit in fifth year medicine at UWA, and was co-supervised by Paul Langton and Liora Valinsky.

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Drs Rebecca Cresp, Carolyn Grove and Emma Lalor are now Resident Medical Officers in Perth.

AUDIENCE PARTICIPATION

David Taylor (Melbourne)

I am interested in what you have done as we did a similar study. I have concerns with some of the design of your project, particularly the selection of your candidates. You sent out questionnaires to I think 982 people, most of whom had recently been qualified. Now that and the fact that most of them had done fewer than 50 dives, suggests to me that this paper is a glimpse of the profile of young divers. We know that possibly up to 60% of this group might have stopped diving within a year of finishing their training. Were your responders representative of people like us who have dived for many years, the maintained diving population if you like.

Secondly 55% response rate is probably about as good as you are going to get. It is very difficult to do better, but there is quite a potential for significant selection bias. I wonder whether you could comment whether the response rate is partly due to the fact that a lot of the divers who did not respond had actually given up diving since their course, or whether they were in fact ashamed to answer such a questionnaire.

Paul Langton

Firstly we wanted to get a broad picture of who was taking up diving. We had also tried to look at those subjects who continue to dive. We approached a number of local dive clubs but few if any maintained mailing lists; those that did were not happy to give us confidential access those mailing lists. Thus, unfortunately we had no good way of accessing a large group of active divers. We were fortunate in gaining the cooperation of the University dive club to look at their small number of divers.

Secondly, with respect to the question of responder bias, we looked carefully at all the variables and compared the experienced UW A to the recently trained divers. Although the UW A respondents was a relatively small group, the only variable they were consistently different on, was the number of dives, as you would expect. They were a little older, but they had experienced similar percentage of technical problems. They had similar health problems. It is true, that it is not a great snapshot of the current divers but within the limitations of what we could do, it is not bad. With regard to the response rate, 55% was much better than we expected. We tried to address the problem of potential responder bias by a non-responder survey. We picked, at random, a small number of people who had not responded and spent a some effort trying to contact them by phone and get them to complete a (limited) survey. The non-responder sample, when they did finally respond, had quite similar characteristics, certainly from our main outcome measures, which were actually asthma related. Our 55% sample of the original population is approximately 9% of the recently trained divers in Western Australia. That is actually quite a statistically robust proportion of the population. There are a number of other surveys that have been done world wide, mostly through the Diver Alert Network (DAN) organisation, which have been sampling only 1 to 2% of their populations.

Aubrey Seknow (Melbourne)

As a diving medical examiner I am always aware of the obesity of some of the candidates that come in. Would you set a limit as to what BMI you would say to the person, well you are not fit to dive?

Paul Langton

There are theoretical risks and perhaps a little bit of data to suggest that obese divers are more prone to decompression related illness. I do not see that as the major issue though. I think it is more related to fitness because of
the obviously inverse relationship between obesity and fitness. A lot of our divers are unfit and I think obese divers are more likely to have problems if trying to swim at high level if they encounter problems underwater. I think if a fat diver came to me and wanted to become a fit individual to take up diving, I would encourage them to get swimming fit. Now it is very likely that they would lose some weight as well, but I would argue that they need to be swimming fit and maintain that level of fitness as they continue to dive.

Aubrey Seknow (Melbourne)
Can you put a number on it? If the BMI is 35, would you then say no to them until they come back to you with a BMI that is more acceptable?

Paul Langton
I would not actually set a cut off. I think looking around some of the boats today, you would see a few people with BMI substantially above 30 who can dive without any problems. 35 is really morbid obesity and I would try and dissuade them from diving but I am not in a routine dive medical practice so perhaps others can better answer your question.

Vanessa Haller (Victoria)
I was surprised that asthma was not among the perceived medical problems. If someone does not say they have diabetes and I do not detect anything to suggest they may have diabetes, I do not explain to them the risk of diabetes and diving. I think this is likely to be the norm, so those having medicals would probably not have an idea of the risks of certain medical conditions.

Paul Langton
I agree fully. The asthma results I have taken out intentionally, as they will be presented in more detail subsequently. In fact we did even more on asthma than on the other medical and technical problems potentially affecting divers.

Diabetes should be picked up by prospective divers being honest and sometimes they are not. It should also be picked up by people admitting what medications they are on, but the dishonest ones are clever enough to fib about their medications as well. It is worth reminding ourselves that up to 50% of late-onset diabetes is undiagnosed, so some simple screening tests in the older dive candidate would be reasonable.

I seem to recall, at least when I did a diving course, that the instructors did mention the potential diving problems of diabetics. I am not sure whether this information is in the current course contents. Respondents were very, very clever in giving us comments on how they managed to avoid being detected with their various conditions.

Fiona Sharp (Perth)
A lot of the divers in your survey said they had swimming difficulties. I know a lot of simple drowning deaths have been due to people panicking. How does panic relate to the reported swimming difficulties?

Paul Langton
I think panic was a very big factor in some of the swimming difficulties reported by the divers. As they were a relatively inexperienced diving group, swimming difficulties may have reflected as much panic as anything. But if one is not fit, and one gets into an unusual situation you are more likely to panic. It is difficult to dissect out the factors, but I agree, panic is a very big factor.

Jürg Wendling (Switzerland)
I think we would probably all agree that a person with the very high body mass index or other risk is not fully fit for unrestricted diving. In Switzerland we have restricted fitness which is not as fit as being declared fit for unrestricted diving. We have problems in managing with these restrictions.

First of all we have to explain to the candidate where his problems are and where he has some restriction. In the Swiss guidelines, for instance, we have recommendations to give them advice not to go diving in rough conditions or for other things. I think there is no reason for a depth limit, but there is a reason to recommend no decompression dives. For instance for the asthmatic, if he has any symptom he must go up immediately. This is not unrestricted fitness for all categories because we do not know what they will do next. The problem is, what shall we write on the certificate? Is it just an informed consent? Should we have this countersigned by the candidate in our protocol or should we write this on the certification. I do not know the answer.

Paul Langton
I think that system is reasonable in some circumstances. However, although we can say do not dive if the water conditions are rough, over 20% of the divers had encountered unexpected swimming problems. Also, almost 20% had encountered unexpected problems with gear failure or running low on air. The prevalence of problems is so high that I think it is difficult just to recommend that an individual only dives in nice easy conditions and makes sure their tank is full and that they surface before the tank is empty.

The reality is that is not going to happen. All the recently trained divers, having done a PADI course, will have been educated about how they should dive. And many of them are, in fact, still diving with relatively well supervised dive clubs with dive masters etc, and there were still a lot of unexpected problems.