

European Journal of Underwater and Hyperbaric Medicine



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EDITOR'S COLUMN

Dear Readers!

Diving and Hyperbaric Medicine is a steadily growing specialty. In the United States of America the UHMS has been negotiating with the US Medical Boards, which control specialist registration, and had success in establishing an examination for sub-specialty registration. This is only open to US registered specialists, however, negotiations are continuing to explore the possibility to offer a similar examination to non US registered physicians. In Australasia a search for higher qualification, a logical successor to the SPUMS Diploma of Diving and Hyperbaric Medicine, has been initiated. The Australian and New Zealand College of Anaesthetists established a Special Interest Group that works to produce a syllabus and educational standards which would allow to issue Certificates of Diving and Hyperbaric Medicine training. This will mean that Diving and Hyperbaric Medicine practitioners will have an examination marked career path.

In Europe the Joint Educational Subcommittee of the ECHM and EDTC, chaired by Jordi Desola and Jurg Wendling, has been working hard to produce EDUCATIONAL AND TRAINING STANDARDS FOR THE STAFF OF HYPERBARIC MEDICAL CENTRES. This document includes definitions of all positions to be filled to safely run a hyperbaric medical facility as well as a detailed course syllabus for the education of the physicians working in the field of diving and hyperbaric medicine. The Working Group "Safety Aspects" of COST Action B14 "Hyperbaric Oxygen Therapy" is considering this document as a basis for harmonised European Standards for Education and Training in Diving and Hyperbaric Medicine and some national bodies, like the German Society for Diving and Hyperbaric Medicine (GTÜM), have already employed this syllabus of the EDTC/ECHM document to elaborate a modernised version of their own requirements to acknowledge the training and examination of physicians in diving and hyperbaric medicine.

With these different approaches from America, Australasia and Europe, the training and education in diving and hyperbaric medicine is becoming more and more acceptable by other specialties worldwide. This will hopefully help the struggling countries, where, like in Germany, hyperbaric medicine is still recognised by many as "Unconventional Medicine".

Peter

PRESIDENT'S NOTE

Dear friends,

We are entering the run up for our annual scientific meeting which as you know will be held in Brugge, Belgium from the 4th to the 8th September 2002. The deadline for abstracts for this meeting has closed on 15th May and the Scientific Secretary of the conference Dr Costantino Balestra and his scientific committee will be going through the submitted papers.

As a recently ex-Secretary General I remember how many papers I received after the closing date, some of them of high value and from top scientists in our field. I hope Drs Germonpre and Balestra have had better luck than me and last year's secretary general who received papers up to a few weeks before the conference with strong pleas for inclusion.

This is a practice which is unfortunately common in many societies and should be strongly avoided as it seriously disrupts the valid work of the Secretary Generals and their staff in preparing the best program possible.

I have also noted that the organising committee of this 2002 conference is insisting, as I and my successor Dr Van Laak had done, that final acceptance of any paper is conditional to the early paid-up registration of the presenting author.

All too often certain colleagues send papers for inclusion into the program and then after their paper has been published and included in the program fail to show up for the meeting or even register. This is unfair to all involved, to the organising committee who ends up with a shortfall of expected funds, often ending up with a loss, as well as to the general membership who find a number of talks cancelled at the last minute.

Please understand me that I am not pointing a finger at anyone, especially those bona fide persons who fully intended to come to the conference but due to work or personal reasons could not attend at the last minute.

On a more pleasant note, I see that a fine program has been prepared for us, including the now traditional pre and post congress seminars and activities. I hope to see as many of as possible there and do not forget to book before the end of June in order to benefit from the reduced early booking rates.

I would like to remind those of you who have students presenting papers that they can benefit from the Student Travel Grant which is set at GBP 2000.00 to be shared equally between those students who are accepted.

In order to benefit the student must apply to the EUBS through the Secretary General preferably at the same time as the submission of the accepted paper or poster but not later than the 4th of September in order to be considered by the committee.

The student must also present together, with a written application, the following: Statement from the student's supervisor confirming that the student is registered as a full time university student in a field relevant to Baromedicine and is currently working towards a scientific degree; a detailed budget of the travel (economy) and accommodation (budget) expenses which will be followed, when they become available, by the original receipts.

The selected students will, if possible, be informed by the end of the conference.

Those presenting posters at the conference should not forget that they are eligible for the annual "Zetterstrom Award". Poster presentations is not only a very valid method of presenting your work but is the preferred choice of some of our most experienced and valid colleagues.

Enjoy your summer holidays and see you in September

Ramiro Cali-Corleo
President



ANNUAL MEETING 2002

Dear friends and colleagues,

"It's that time of the year again ?" – yes indeed, time to prepare for our next Annual Meeting !

As you read this, you should already have received the "Second Announcement" with all necessary information, a registration form and instructions for

abstract submission in your regular mail. You will find that we are doing everything possible to ensure that the Meeting in Brugge will be a memorable one. The pleasant weather, historic surroundings and cultural activities of Brugge in September will certainly contribute to this !

But of course, the scientific part of the Meeting is the most important. Through this exchange of ideas and the lively formal and informal discussions, the Annual Meeting is a valuable opportunity to refine existing and develop new scientific insights. Abstracts are already being submitted – this can be done either via e-mail or online. We would welcome, of course, a contribution from all members ! As you will notice, we have devoted an important part of the Meeting to hyperbaric nursing and technical aspects. The participation of members of your hyperbaric staff, by presenting their work or by attending the meeting, is strongly encouraged !

You can also find all information on our Society's website, www.eubs.org – have a look !

Peter Germonpré
Secretary-General to the Meeting

OTHER MEETINGS

April 23-27 2003. International Congress "Diving in the Armed Forces Today", Cavtat (Dubrovnik), Croatia. Contact CDR Nadan M. Petri, MD, DMO, PhD, 21000 Split, IPM, p/o box 196 (HRM), Croatia. Phone 0385-21-464-543; Fax 00385-21-353-739; e-mail nadan.petri@morh.hr. Visit their website at www.military-diving.hr. Deadline for abstracts 31 December 2002.

AN INVESTIGATION OF EAR TRAUMA IN DIVERS INCLUDING EAR BAROTRAUMA AND EAR INFECTION

S.E. Mawle and C.A. Jackson

Institute of Occupational Health, University of Birmingham, Edgbaston, United Kingdom

Mawle SE & Jackson CA: An investigation of ear trauma in divers including ear barotraumas and ear infection. *European J Underwater Hyperbaric Med* 2002; 3(1): 47-50 - A sample of 142 divers including technical, recreational and instructors were examined via postal questionnaire to determine prevalence of ear barotrauma, related barotrauma symptoms and middle ear infection. Sixty-four percent of divers reported symptoms of barotrauma, which included pain (47.9%), temporary deafness with tinnitus (27.5%) and vertigo (9.9%). The prevalence of middle ear infection was present in over a third of the total sample (37.3%), and were significantly more prevalent in the left ear than the right ear ($P=0.016$). Consistently wearing a hood when diving was associated with greater barotrauma symptoms than wearing a hood only in cold conditions ($P<0.00$). A significant relationship was found between barotrauma symptoms and diver separation ($P<0.00$), and the implications are discussed with relevance to the finding that nearly 27% of divers reported incidents involving separation from buddies when diving.

Ear barotrauma, ear infection, diving

Introduction

Barotrauma, in general terms, is documented as the most common medical problem in divers (1). Like most other sports there are health risks associated with diving that can be significantly reduced by 'safe' practice (2). Barotrauma is an injury that occurs due to the result of rapid or extreme changes in pressure, and is defined as tissue damage resulting from expansion or contraction of enclosed air spaces as a result of such pressure changes, the greatest occurring near to the water surface (3). The sensation of increased pressure in the ear is commonly called 'ear squeeze' amongst divers, where the diver needs to 'equalize' by driving air from the throat through the eustachian tube to the middle ear. Failure to increase gas in the middle ear to be equal with the ambient water pressure can lead to barotrauma of descent and possible rupture of the tympanic membrane. Any condition that blocks the eustachian tube predisposes individuals to middle ear barotrauma (4). It is not clear if ear infections are related to ear barotrauma either as a causal agent or as a result of barotrauma itself (1).

Methods

This cross-sectional study used anonymous postal questionnaires containing a range of self reported outcome measures related to symptoms associated with barotrauma. A pilot study for the questionnaire was conducted at the Excel dive exhibition in London in March 2001, where comments made by divers completing the questionnaire were incorporated into the final questionnaire design. The refined questionnaire collected data concerning demographic information, diving activities, incidences of diving problems, illnesses and treatments sought for any conditions. The questionnaire defined the symptoms and conditions of: Barotitis media, Chronic media otitis, and Barotrauma. Exclusion criteria rejected divers who had completed less than one year as divers, and divers without a recognised qualification (e.g. British Sub-Aqua Society (BSAC), Professional Association of Diving Instructors (PADI), or the National Association of Underwater Instructors (NAUI)). The population was comprised of divers registered at eight dive schools in the UK, and 300

questionnaires were distributed equally amongst the schools by the postal system. Respondents were able to return their completed questionnaires using pre-paid self-addressed envelopes.

Table 1: Methods used by divers to equalise ear pressure

Action	N	%
N/A	89	62.7
Ascend	19	13.4
Valsalva	13	9.2
Decongestants	5	3.5
Don't dive	4	2.8
Persist	3	2.1
Abort	2	1.4
Slow down	1	0.7

Results

A total of 142 divers (47.3%) completed the questionnaire; the majority of which were recreational divers ($n=80$, 56.3%) followed by dive instructors ($n=44$, 31%) and technical divers ($n=18$, 12.7%). Mean age of divers was $37.8 \text{ years} \pm 10.2$, ranging from 17 to 70. Of the sample, 101 (71.1%) divers had experienced a problem equalizing their ears while diving. Because some divers had a total dive exposure of less than 100 dives, a time weighted exposure percentage was calculated in relation to divers with a problem equalizing, and the total dive exposure time with difficulty of ear clearing was calculated. The number of diving years and frequency of dives over diving years were used to calculate the percentage of time divers experienced equalizing difficulties, and was expressed thus:

Equalizing difficulties (%) =

$$= \frac{100}{\text{Dive frequency} \times \text{Equalizing problems}}$$

The results of this indicated how often divers presented with clearing difficulties whilst diving. Fifty percent ($n=71$) suffered clearing problems between 1-10% of the

time, nine percent (n=13) suffered between 11-20%, five percent (n=7) suffered between 21 - 90%, and seven percent (n=10) suffered between 91-100% of the time.

Equalizing

Divers were asked what actions they took if they had trouble equalizing their ears. The majority of divers claimed this was not applicable to them, and the various methods of equalizing are shown in table 1. The following barotrauma symptoms were measured, and divers were requested to confirm which they had experienced at any time: blood, pus, temporary deafness, tinnitus, vertigo, nausea, vomiting, disorientation and pain. Fifty-one divers (35.9%) experienced no symptoms, 47 (33.1%) experienced one symptom, 15 (10.6%) experienced 2 symptoms, 20 (14.1%) experienced 3 symptoms, 4 (2.8%) experienced 4 symptoms, 4 (2.8%) experienced 5 symptoms, and 1 person (0.7%) experienced all 6 symptoms.

Barotrauma and symptoms

Sixteen divers (11%) confirmed that they had been diagnosed with barotrauma previously, and the number of known barotrauma symptoms reported by this group were compared with the symptoms reported by divers never diagnosed with barotrauma (n=126). There was a highly significant difference ($P=0.002$) in the mean number of symptoms reported by barotrauma cases (2.2 ± 1.5) compared with non-cases (1.1 ± 1.2).

It was found that 54 (38%) of the divers had suffered with middle ear infections, and 88 (62%) had not. Twenty-nine divers (20.4%) only experienced one infection, although up to 10 separate infections were reported by one respondent. In comparing those with and without ear infections, significantly more barotrauma symptoms were reported by those with ear infections (1.9 ± 1.5) than those without (0.85 ± 1 , $P<0.00$). Even though symptoms overlap in all cases of barotrauma, the specific symptoms of different barotrauma types were categorized as indicated by dive literature (1): descent barotrauma consisted of pain; ascent barotrauma consisted of tinnitus and hearing loss; and inner ear barotrauma consisted of tinnitus and vertigo. The relationships between the symptoms reported for each type of barotrauma and ear infection status were investigated and shown in table 2. A significant difference was found ($P=0.01$) between those with and without middle ear infections and reporting of symptoms consistent with ascent barotrauma, to the detriment of those with middle ear infection.

Ear infection treatment

Of the 54 divers reporting previous ear infections, 15 (28% of ear infections) were bilateral infections, 12 (22%) concerned the right ear, and 27 (50%) concerned the left ear. Irrespective of bilateral infections, there was a greater number of infections occurring in the left ear ($P=0.01$). Divers were asked about possible treatments of their ear infections: 39 divers (72% of those with ear infections) sought professional treatment (GP, health centres, A&E services) and 15 (28%) sought other, non-professional treatments (self-medication, colleagues, or none). Reoccurrence of ear infections were measured to compare any benefit between the two treatment groups, and no significant difference was found ($P=0.29$).

Hood wearing

To identify possible risk associations with ear problems when diving, hood wearing was measured in terms of when divers wore a hood to dive (worn all the time, only in cold water, or never). Eleven (7.7%) never wore a hood, 66 (46.5%) wore a hood all the time when diving, and 65 (45.8%) only wore a hood in cold water. Divers who wore a hood in all dives had significantly more barotrauma symptoms (1.6 ± 1.5) than those divers who only wore a hood in cold conditions (0.8 ± 1 , $P<0.00$). Further, it was found that divers who wore a hood all the time were more likely to suffer symptoms of barotrauma than those who wore a hood only in cold water ($P<0.01$). Symptoms of barotrauma were divided into those which represented ascent, descent and inner ear barotrauma, and the relationship with hood-wearing behaviour was investigated, with a significant difference found between hood-wearers on symptoms of ascent barotrauma only ($P<0.00$), as shown in table 3, to the detriment of those who permanently wore hoods.

Buddy separation

Divers were asked if they had ever separated from their buddy on a dive due to an ear problem, and 38 divers (26.8%) confirmed this. Those divers who had been separated from their buddy on a dive had greater symptom scores (1.9 ± 1.5) than those who had not separated (1 ± 1.1 , $P<0.00$). There was no difference in the number of divers with/without symptoms consistent with descent barotrauma between the separated and not separated divers (20/18 and 46/58 respectively, $P=0.37$) but there was in the number of ascent barotrauma symptoms (27/11 and 93/11 respectively, $P<0.00$).

Table 2: Cases of ear infection and symptoms consistent with three barotrauma types

Symptoms of barotrauma type		Past ear infection	No ear infection	X ²	P
Inner ear barotrauma	Yes	3	2	0.36*	0.55
	No	50	87		
Descent barotrauma	Yes	26	40	0.23	0.63
	No	49	27		
Ascent barotrauma	Yes	14	8	6.43*	0.01
	No	39	81		

* signifies use of Yates' correction for continuity when cell values were <10

Table 3: Hood-wearing behaviour and symptoms consistent with three barotrauma types

Symptoms of barotrauma type		Hood always	Hood in cold	X ²	P
Inner ear barotrauma	Yes	4	1	0.8*	0.37
	No	62	64		
Descent barotrauma	Yes	31	30	0.01*	0.93
	No	35	35		
Ascent barotrauma	Yes	17	4	7.95*	.004
	No	49	61		

* signifies use of Yates' correction for continuity when cell values were <10

Discussion

The incorrect use of methods to equalize ear pressure is a common cause of ear barotrauma (1). In this study, 71% of divers encountered a problem clearing their ears, and the largest single group of those (n=71) reported clearing difficulties between 1-10% of the time.

Some divers explained they had clearing difficulties due to reasons ranging from deviated septum to eustachian tube problems, previous studies have found some divers more susceptible to ear barotrauma than others (6,7). Divers in this study used various methods when they experienced clearing difficulties. Although it is suggested there are a few ways to equalize, a lack of education is highlighted amongst divers in this area as the preferred taught method is for a diver to stop and ascend (approximately 1-2 meters) until able to equalize before continuing the dive.

The incidence of ear infections among recreational divers and instructors was 35% for both groups, yet was slightly higher for technical divers at 50%, suggesting a greater risk among this group, however, no significant differences were found when investigating equalizing difficulties between the qualification groups.

The symptoms of different barotrauma types were quantified, and although some overlap among symptoms was present, it was possible to distinguish between symptoms of inner-ear, descent and ascent barotrauma. A significant association was found between symptoms of ascent barotrauma and the incidence ear infection. It is not obvious why this is so, although it is possible that after a vigorously performed valsalva, causing serious injury of the ear drum, cultures from dirty water environments could penetrate the middle ear during descent. Another reason is after inversed barotrauma of ascent. In this study ear barotrauma symptoms preceded middle ear infection.

It was also interesting that a significantly greater number of divers suffered an ear infection in their left ear than right ear. There is no reason why this is the case. Previous studies (8,9) have found that the left ear has been more prominent in hearing loss due to diving, although underwater noise was considered the main contributor to this. It is unlikely that any anatomical differences could influence laterality of ear infection as there is no clear

evidence recorded for asymmetry between left and right ears, although other authors showed problems with the right TMJ joint possibly leading to external otitis like problems more often on the right side (10). It is possible that the ergonomic design of dive equipment may be associated with the frequency of ear infections: the demand valve which feeds air into the mouth from the SCUBA usually sits to the right of the mouth and may influence methods of equalizing. Another possibility is that of laterality, with most individuals being right-handed, and possibly having greater awareness of their right side than left side, which could bias divers to differences in equalizing behaviours.

In relation to the treatment of ear infection, it was interesting to note that overall, no greater reoccurrence of ear infection was reported by divers who chose to seek alternative treatment rather than professional help. These results may tenuously suggest equal efficacy of both professional and alternative treatments with respect to reoccurrence of ear infections after treatment, although the literature promotes professional treatment (7). This result may also suggest that specialised treatment of divers' ears should be promoted, in order to detect any possible signs of barotrauma that divers may be unaware of.

Hood wearing is often seen as essential for warmth in cold water, although some divers choose to wear a hood all the time even in warmer waters to provide some protection for their heads. This study demonstrates that permanent hood wearing when diving is associated with more incidences of barotrauma symptoms than when wearing a hood only in cold waters. This suggests hood wearing has some association with the onset of ear barotrauma, possibly by preventing air escaping from the external ear. Tight fitting hoods have been acknowledged in the literature as having an association with external ear barotrauma (1). External ear barotrauma is very much related to middle ear barotrauma in relation to symptoms. On ascent, air can be prevented from escaping from the ear by a tight fitting hood, possibly leading to ascent barotrauma of the middle ear. Almost a third of the sample in this study had separated from their buddy due to an ear problem when diving, which is a significant cause for concern as diver-diver separation is acknowledged as one of the greatest risks of fatality in diving in novice

divers (2). This study has revealed a number of findings of importance to divers, including symptomology, ear infection rates and laterality, and implications of hood wearing and diver separation. This collection of findings indicate the need for further work into the area of ear trauma in divers.

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Manuscript received December 2001, accepted after revision April 2002.

BOOK REVIEW

C. Edmonds; C. Lowry; J. Pennefather & R. Walker: Diving and Subaquatic Medicine, 4th edition

Publication Date: March 2002; 670 pages

ISBN: 0 340 80630 3, Price: £85.00 or €117,37

Publisher: Edward Arnold Publishers Ltd., 338 Euston Road, London NW1 3BH, Tel: +44 (0) 20 7873 6000, fax: +44 (0) 20 7873 6325, www.arnoldpublishers.com

Since its first edition in 1976, 'Diving and Subaquatic Medicine' has applied current understanding in medicine, physiology and the behavioural sciences to the stresses which are faced both by commercial and recreational divers. Some of the world's most experienced diving physicians have been employed over the many years, and 'Diving and Subaquatic Medicine', now in its fourth edition, has always been amongst the leading texts in the field.

This edition has been completely revised and covers the latest research in diving medicine, the current diving patterns and the necessary diving equipment, as well as free and indigenous diving. It is also updating the previous edition's coverage of established diving disorders, discussed from an historical, aetiological, clinical, pathological, preventative and therapeutic perspective in the accessible but informative style that has made the previous editions so popular.

Compared to other textbooks 'Diving and Subaquatic Medicine' has always put much emphasis on clinical diving medicine, without lacking the scientific evidence background. The book encompasses the complete range of diving disorders and therefore remains the most valuable text for doctors and paramedics who are called upon to minister to the medical needs of those divers who venture on or under the sea, especially in remote locations.

There is little to find missing in this book. Even the Appendices have been updated and the diving medical reading list contains some newly acquired texts. It is one of the minor pitfalls in this book that journals and professional societies are listed incompletely, and some of those listed are given with an expired contact address.

Those who know the book will waste no time in acquiring this update, those new to the text will find it a must for the personal bookshelf.

**Dr Peter HJ Mueller,
EJUH Editor**

WORLD CONGRESS OF DROWNING, 2002

Task Force on: Breath-hold, scuba and hose diving

David H. Elliott

Recreational scuba diving is recognised as a safe sporting activity. There are relatively few accidents compared with other sports although, when an accident does occur in the water, it happens in a very unforgiving environment. What might be an insignificant incident at the surface can start a sequence of events that quickly escalates to become life threatening. The environment in which this happens is also the probable reason why up to some 60 per cent of in-water diving fatalities meet their deaths by drowning. Drowning is the *mode* of their deaths, but not the cause. In examining the *causes* of drowning in divers, one must look at the way in which people dive. To reduce the risk of drowning in divers one must address not only their in-water procedures but also basic issues such as fitness, training and equipment.

For this reason the diving community has been invited to participate in the **World Congress of Drowning** to be held in Amsterdam on 26, 27 and 28 June 2002. This Congress has been arranged by *The Society to Rescue Persons from Drowning*, a Society that was founded in the Netherlands in 1767. Partners in this venture include the International Federation of Red Cross and Red Crescent, ILS (International Life Saving) and DAN.

The aims of the Congress are

- to make recommendations on the prevention, rescue and treatment of drowning victims;
- to stimulate and facilitate initiatives to further promote the prevention of drowning;
- to reduce the number of drowning victims;
- to improve the survival rate and outcome of drowning victims.

The "Breath-hold, scuba and hose diving" Task Force comprises David Elliott (UK), Chairman, with Fred Bove (USA), Glen Egstrom (USA), Des Gorman (New Zealand), Rob van Hulst, (Netherlands), Maida Taylor (USA) and Juerg Wendling (Switzerland).

Among those who have already agreed to take part in the mini-workshops are Chris Acott (Australia), Peter Bennett (DAN), Mark Caney (PADI International), Jim Caruso (USA), Joel Dovenbarger (DAN), Alessandro Marroni (DAN-Europe), Richard Moon (USA).

Diving is just one of 9 task forces convened to review particular aspects of this vast topic. Other task forces and their Chairpersons include

- Epidemiology: Christine Branche, CDC, Atlanta
- Rescue: Chris Brewster, International Life Saving Federation, USA
- Resuscitation: Paul Pepe, Emergency Medicine, University of Texas

- Hospital treatment: Jean Louis Vincent, Erasmus Hospital, Brussels
- Immersion hypothermia: Beat Walpoth, University Hospital, Bern, Switzerland
- Brain: David Warner, Duke University Medical Center, USA

and each task force has its own international group of experts.

The diving task force covers the hazards associated with all types of diving. This includes recreational diving of every variety. It also covers subsistence fishermen-divers in the third world divers, most of whom have inadequate equipment and no proper training and who have an unknown rate of in-water incidents. The other large group is military and working divers who follow procedures that for them should make the risk of drowning negligible.

A number of drowning fatalities in divers occurs among divers who may have made an avoidable error or who may have been subjected to one. After reviewing such accidents the task force has prepared draft recommendations and reviewed those submitted by others. The following topics are among the questions that they consider deserve discussion at the World Congress.

Should diver certification last a lifetime, or is there a need for re-certification after a few years? What changes can be recommended in the training of divers and diving instructors that might enhance diving safety? Should a once-only medical declaration that was made before training have the potential to last for a lifetime? At what age can a child be competent as one of a buddy-pair? Should there be a greater emphasis at all levels of recreational diver training, but particularly for instructors, on the likely causation of known in-water fatalities?

Visit the web site for more details about the Congress, its task forces and the arrangements. Some 60 task force members from 20 nations have prepared formal presentations and reviewed the many recommendations for the Congress. Each task force has a summary of its proposed agenda, each will have a plenary session for all and then a number of sessions on selected diving topics. So look through the recommendations as a drop-down menu in the diving section. Because they come from a wide range of sources, some appear worthwhile, a few provocative and others may not be universally acceptable. These will be discussed and, where appropriate, their implementation will be reviewed at the Congress in Amsterdam.

For details, visit <<http://www.drowning.nl>>

THE MEDICAL ASSESSMENT OF FITNESS TO DIVE

David H. Elliott

Biomedical Seminars, London, United Kingdom

Steady progress has been made over recent years towards the harmonisation of fitness requirements for different categories of diving and in ensuring that the medical examiners of divers have the opportunity to receive appropriate training to make knowledgeable decisions. Basic or introductory courses in diving medicine of around one week duration are available from naval and other sources around Europe and, though not formally audited and with one small exception, are each likely to exceed the training objectives agreed by the ECM and EDTC¹. That one exception is easily rectified and is a need to include also the topic of fitness for compressed air workers (caisson workers; "sandhogs") and tunnelers using mixed gases.

For more than 20 years, a series of refresher courses have been run by Biomedical Seminars, a non-profit partnership managed by Karen Reeves, to provide an opportunity for Approved HSE Medical Examiners to meet the HSE requirement for periodical revision training. They have been held once or twice a year under the direction of myself together with Nick McIver. Diving doctors have attended them from all over Europe and from every corner of the globe, indeed from every country that has a significant diving industry. While the focus has been on the needs of working divers, from scientific to offshore saturation diving, the recreational divers have not been ignored. They have the same if not greater medical problems and the same medical examiners are likely to see them when they need to be assessed. This has meant that when, for example, the question of fitness to dive as a diabetic is being discussed, the whole range of professional and amateur diving categories is covered.

A large number of distinguished consultants and diving doctors have freely given up one of their weekends to speak at these sessions, usually to focus on some specific fitness problem as a theme for the weekend. The HSE sends one of its medical representatives to speak and to review some difficult decisions. The benefit to those attending the course, a benefit that also applies to the speakers themselves, is the rare opportunity to hear the experience of others in a subject rarely discussed in detail elsewhere. In 1989 similar one-day courses were established at the annual scientific meetings of the UHMS though these have tended to focus more on the recreational than the working diver.

Occasionally in the UK a larger meeting has been held, in particular at Edinburgh in 1994, in order to facilitate a review of the formal HSE guidance on fitness standards². Another was the meeting in 2000 held at The Royal Society of Medicine in association with the Medical Subcommittee of the European Diving Technology

Committee, Chairman Juerg Wendling, to review the proposed harmonisation of standards for working divers in Europe. It was planned that this was to be the last such meeting by Biomedical Seminars because David Elliott was retiring from his positions with the EDTC and IMCA and Nick McIver was retiring from the North Sea Medical Centre. At that time we promised to assist anybody who wanted to take on the organisation of these events, but there have been few volunteers. The offer remains open.

A number of persons attending the RSM meeting made a request that Biomedical Seminars should run a course in mainland Europe so, in December 2002, a 2-day meeting was held in a hotel at Schiphol Airport. The programme followed the format of previous years with several special topics in the spotlight. Among the speakers were Prof Louw Feenstra, Professor of Otolaryngology at Rotterdam, Dr Nerys Williams of the HSE, Dr Juerg Wendling of EDTC, Prof Wouter Sterk of Leiden University and Dr Peter Mueller, the editor of this journal.

Dr Nerys Williams reviewed the HSE's procedures relating to the Approved Medical Examiners of divers (AMEDs) and explained how, as a matter of quality control, it was now necessary to introduce a stricter process of audit. For legal reasons, it is not possible for a UK government agency to audit doctors who reside outside the UK and some other system had to be created. Doctors resident outside Europe had already been informed that their Approval had been withdrawn. Doctors outside the UK but within a European nation would be granted a temporary extension of their Approval. During this period it is hoped that agreement would be reached between each pair of governments concerned on the mutual recognition of each other's national system for assessing working divers' fitness. This would mean that, when implemented, a diver would be able to work in another EU country with a medical certificate from his own country. However a diver from outside Europe would no longer be able to get a medical certificate from an Approved doctor at home but would need to get it in the European country where he or she is to work.

The HSE fitness standards are also in use outside Europe and HSE fitness certificates are often specified as a requirement for divers in diving contracts around the world. There is no reason why the standards should not be used as a norm, but the revised process no longer allows HSE certificates to be issued other than by the AMEDs in the UK and temporarily a few AMEDs in Europe. The current solution is simply to recognise that IMCA, a world-wide association of marine contractors that includes the major offshore diving contractors, should

assume responsibility for monitoring the quality of all aspects of diving medical support for its members worldwide.

Louw Feenstra then gave a comprehensive and lucid review of the E.N.T. aspects of diving fitness and diving illnesses. The full account will hopefully be in the proceedings. Among the topics raised was that of the value of the Sharpened Romberg as an early diagnostic indicator of neurological decompression sickness. Though apparently used routinely by some, it is not well known to all. As discussed also at the RSM meeting in 2000, this is a test that could be considered for harmonisation within Europe. For that reason we are privileged that SPUMS has permitted a key paper from the South Pacific Underwater Medicine Journal³ to be reprinted in this issue of our journal (see next page!). From comments made in and after the Schiphol meeting the Sharpened Romberg would seem worthy of wider evaluation.

Nick McIver and I separately later reviewed the revised Recreational Safety Training Council (RSTC) medical guidance on sport diver fitness that was issued in June 2001. As a contributor to the document I feel that this is a significant improvement on the previous edition though, because it still contains a few details of assessment with which I do not agree, I have withdrawn my name from the list of endorsers. That is a legal detail and I have no doubt that when used as described it will continue to be a useful screening tool particularly in communities where doctors knowledgeable in diving medicine are not available.

Wouter Sterk reviewed the recent advances in deep tunnelling techniques, in particular the development of trimix saturation procedures in the Netherlands⁴. David Elliott reviewed the factors that need to be considered when reviewing a diver for fitness to resume diving after neurological decompression illness and Nick McIver presented some case histories that were relevant to making the decision fit / not fit. Peter Mueller presented an outline of the meeting on diver fitness held in the German language earlier in the year. This was an apt introduction to the main focus of this 2-day meeting, the proposed harmonised medical standards for working divers in Europe.

Juerg Wendling, as Chairman of the Medical Committee of the EDTC, led the discussion on harmonisation of fitness standards with Rob van Hulst and other members of the EDTC as Panellists and many helpful comments from. The meeting reviewed most of the difficult issues where differences exist between national views. One example was the importance of retaining the initial chest x-ray in relation to its radiation dose. Another issue was the indication for a spiral CT scan of the chest. A similar concern was related to the need for health surveillance in selected divers for dysbaric osteonecrosis because MRI is too expensive and not widely enough available for routine screening whereas radiological screening provides a significant dose of x-rays. Other issues included the role

of the annual ECG, the definition of a disqualifying hypertension, the need for annual audiometry and, as always, the role of fitness testing. A concern for established divers was raised, that of the hazard of OPSI (overwhelming post-splenectomy infection) if diving remotely from medical support, as in saturation diving. These and other issues debated were noted for consideration in the draft EDTC document and, I am sure, also noted by the HSE.

Details of all these topics should be in the proceedings that currently are being produced by Wouter and Eelco Sterk. Two video cameras were used to make a continuous recording of these two days and, together with the original visual aids, they will form the basis for the proceedings on CD. These should be available at cost, about 30 EURO, around July 2002 from HKTS, Linieweg 5, 7921VK Zuidwolde, The Netherlands, Fax: (+31) 528 37 29 68 or E-mail: strong@inn.nl.

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SHARPENING THE SHARPENED ROMBERG TEST

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Lee C-T: Sharpening the sharpened Romberg test. *European J Underwater Hyperbaric Med* 2002; 3(1): x-xx - The Sharpened Romberg Test (SRT) is a test of balance commonly used in Diving Medicine. Interpretation of an abnormal test can be confounded by several factors. This study was conducted to further evaluate the usefulness of the SRT. In the first part of the study, naval and civilian volunteers in a Naval Base were recruited as subjects. The SRT scores were recorded in two separate trials; once in the morning (4 attempts) and once in the evening (4 attempts) to evaluate the effect of practice on the SRT. In the second part of the study immediate pre- and post-dive scores in a group of divers were measured to evaluate: (1) the effect of decompression; (2) the effect of the normal post-dive fatigue; and (3) the vestibular effect of swaying after a boat ride. Comparisons were also made between the distributions of the SRTs of the normal subjects and those of a retrospective group of DCI patients treated at the Slark Hyperbaric Unit, Royal New Zealand Navy Hospital (RNZNH), Auckland. The SRT was found to have an early learning effect. Second attempts were significantly better than the first ($p < 0.001$) within the same trial. However this learning effect plateaued by the third and fourth attempts. No difference was found between trials (morning and evening). There was a post-dive decline in the scores of the first attempts only ($p < 0.05$). Subsequent second to fourth attempts were not affected by diving. The practice effect is only evident between the first and second attempts within the same trial but not between trials. The pre- and post-dive data showed that the SRT was not affected by decompression, post-dive fatigue or the vestibular sensation of swaying that is commonly experienced after a boat ride. Comparison of the distributions between controls and DCI patients showed a bimodal pattern. Fifty-four percent (54%) of the DCI patients had 'normal' scores (60 seconds), while 14% had scores between 16-35 seconds and 32% scored less than 15 seconds. In contrast, 95% of the control groups had 'normal' scores while 5% scored between 16-35 seconds. Therefore, accepting a score of less than 40 seconds as being "abnormal" will give the SRT a sensitivity of 46%, specificity of 95% and predictive value of 82%.

Decompression illness, investigations, treatment

Introduction

Decompression Illness (DCI) is a multi-system pathological entity with a myriad of presentations.^{1,2} Initially DCI was first described in caisson workers and then in divers, aviators and astronauts. Limb pain was the predominant symptom in these groups of patients.³⁻⁷ Over the past three decades published reports of DCI have mainly been from the recreational diving population.⁸⁻¹³ This is due to the increasing popularity of the sport worldwide. Neurological involvement, especially those referring to the spinal cord and vestibular system, appears to be more common in this group of divers.^{2,14-16} Animal studies have shown that, in the spinal cord, bubbles and haemorrhage were seen predominantly in white matter and tended to be most conspicuous in the lateral and dorsal columns.^{17,18}

Manifestations of neurological DCI range from mild, subjective symptoms to the dramatic presentations of unconsciousness, paraplegia or quadriplegia. In practice, divers commonly present with subjective complaints, often with little or no objective evidence of neurological abnormalities.⁹ It appears that the clinical neurological examination lacks the accuracy to detect the diffuse and multilevel pathology seen in decompression illness. Therefore, the diagnosis of DCI requires a high index of suspicion, and a history of recent diving or exposure to raised environmental pressure.¹⁹

The usefulness of the Sharpened Romberg Test (SRT) as a clinical marker of DCI was recently highlighted, especially in cases where the disease process was in question.^{20,21} Almost 49% of the 35 cases with DCI in that series were found to have grossly abnormal

SRT scores with seventy percent (70%) of these achieving a 'normal' score after completion of hyperbaric treatments. Therefore, in this series at least, the SRT score was useful as a quantifiable sign in 50% of the cases.

The Sharpened Romberg Test

The classical Romberg Test as described by Moritz Romberg (1795-1873) is routinely used in neurology to assess proprioceptive loss. It is, however, not sensitive to vestibular or cerebellar impairment.^{22,23} Barbey described the first modification of this test in 1944²⁴ and Fregly, in the late 1960s, employed this "sharpened" Romberg Test (SRT) together with his ataxia test battery as measurements of vestibular impairment at the US Naval Aerospace Medical Institute.^{25,26} Also known as "Tandem Romberg"²⁷ or "Modified Romberg",²⁸ the SRT has also been employed in several ataxia test batteries in gerontology and toxicology.²⁹⁻³² Dr Carl Edmonds introduced its use to Australian diving medicine in 1974 as an alternative to the classical Romberg Test, as it is more sensitive to proprioceptive and vestibular impairment. Since then the SRT has found wide acceptance in the routine assessment of diving patients.³³⁻³⁵

Variations in the SRT

The Sharpened Romberg Test, as originally described by Fregly, involved the subject "standing on the floor with eyes closed and with arms folded against chest, feet aligned in strict tandem heel-to-toe position, and body

very nearly, if not completely, erect for a period of 60 seconds. A maximum of four trials were administered.^{23,36}

Several variants of the SRT have since been described. Some involved the subject having to stand in the usual tandem heel-to-toe fashion but with arms strictly by the side.^{28,29,37} Others allowed the subject in this position to freely move his arms in order to regain posture.^{30,31} The SRT has also been performed with subjects standing on narrow wooden rails in order to lower the 'ceiling effect'.³⁸ One investigator proposed that the SRT should be performed with the head tilted.³³

Factors affecting the SRT

Although the SRT is a sensitive test of proprioception, its specificity in DCI is not clearly defined. Being a test of static postural equilibrium, the SRT is affected by several factors other than dorsal column or vestibular diseases.

AGE AND GENDER

Studies have confirmed that the SRT performance worsens with advancing age.^{24-26,29,31} Decline in performance generally begins between the age of 30-40 years in males and as early as 30 years in females.^{25,39} The reasons for these gender differences are unknown.²³ The number of females tested was generally small²⁵ and in selected groups²⁹ and therefore the finding should be interpreted with caution, especially as one study failed to demonstrate a difference.²⁸

LEARNING EFFECTS

Like many tests of performance, SRT scores can improve with subsequent attempts due to a learning or practice effect. Thomley et al. had 18 subjects practise on the SRT twice a day for five consecutive days.⁴⁰ Both learning and ceiling effects were reported but the tests were stable over trials. Other studies have shown similar results.^{28,25} Briggs et al. found that the majority of their subjects obtained the maximum balance times (60 seconds) in the first trial.²⁹ A minimum of three trials appeared to provide a good indicator of balance capabilities. The most consistent and sensitive means of measuring the SRT is to record the best score out of 4 attempts.^{20,30,31}

FOOTWEAR

No difference was found between wearing shoes or being barefooted.²⁹ However, shoes with soft soles (such as tennis/basketball shoes) are generally not to be worn because soft surface conditions (which would include foam mats on the floor or thick carpets) distort proprioceptive input and hence would not be suitable.^{23,26,37}

DOMINANCE

Some investigators required the subjects to perform the SRT with the dominant leg behind. However,

in one study no effect of dominance was found.²⁹

ACTIVITY LEVEL

In a study that employed self-reported questionnaires, a significant effect was found between activity level and balance performance (including the SRT).³¹

The SRT in diving medicine

Maintenance of postural equilibrium is a dynamic process in which visual, vestibular and somatosensory (proprioceptive, cutaneous and joint) information are integrated with muscular and skeletal responses to maintain the body's position over the base support. The Romberg test assesses the vestibular and somatosensory contribution to balance by eliminating the visual input. The Sharpened Romberg Test (SRT), by having the subject stand heel-to-toe, makes further demands on the vestibular and somatosensory systems by narrowing the base support. It is generally more difficult to perform and is therefore more sensitive to processes that interfere with these systems.

In the context of diving medicine, the SRT appears to be a useful quantifiable sign. In the study by Fitzgerald, the substantial improvements (70%) in the SRT post-treatment scores indicate that DCI causes a deterioration in the SRT.²⁰ However, other factors which affect the balance system could also contribute to this deterioration of the SRT score. These are summarised below.

- a Divers conducting their dives from a boat out in open sea frequently experience persistent vestibular symptoms, described as a sensation of swaying motion, on returning to land. This might adversely affect the SRT performance of a diver presenting for assessment.
- b Improvements in the SRT score seen in divers being assessed in sequence (pre-, during and post-treatment) could be due to a learning effect rather than an indication of the actual resolution of the disease being treated.
- c Decompression per se (which is known to produce asymptomatic bubbles) or feelings of fatigue after diving could, in theory, affect the SRT.
- d Improvements in the SRT score during and after recompression treatment could be due to an effect of hyperoxia rather than a resolution of disease.
- e Alcohol consumption is common during most dive trips, and could confound the SRT score.

The aim of this study was to further define the usefulness of the SRT in diving medicine by testing the following hypotheses :

- 1 The SRT is resistant to the effect on the vestibular system caused by rocking motion of a boat.
- 2 Scuba diving and decompression per se has no effect

on the SRT

- 3 The recommended protocol used for scoring the SRT is not affected by practice
- 4 The normal feeling of fatigue post-dive does not affect the SRT score.

Attempts were also made to determine the SRT score or test method which could distinguish between the normal (non-DCI) and the DCI patients.

Methods

This study was conducted in three parts. The first part involved the prospective review of SRT scores in a group of volunteers from Naval and civilian personnel at the Naval Base in Auckland. This group consisted of both divers and non-divers. The second part involved the pre- and post-dive evaluation of the SRT scores in a group of divers. Finally, the SRT scores of the patients with DCI treated at the Slark Hyperbaric Unit (SHU), Auckland, between May 1996 to April 1997 were reviewed.

In part one of the study, the subjects were "captive volunteers" actively recruited by the author. Each subject received an explanatory letter and gave written consent for participation. Divers were entered into the study only if they had not dived for the past seven days and had no history of decompression illness. Exclusion criteria were the same as those in the study by Fitzgerald.²⁰ A subgroup of 47 participated in 2 separate tests: once in the morning (4 attempts) and once in the evening (4 attempts).

The second part of the study was conducted at the dive site. Divers attending a conference were briefed during registration and participation forms distributed. Baseline SRT scores for divers going for their dives were measured before the commencement of the diving activities. The post-dive SRT scores were recorded for the same individuals within 24 hours after their day of diving. All dives involved a boat ride to the dive location in open sea for the day. Sea conditions were mild to moderate for those dives. Participants were instructed not to consume alcohol for at least 12 hours prior to the tests.

Comparisons were also made between the scores of the control population and a retrospective group of DCI patients treated at SHU between May 1996 and April

1997.

The Sharpened Romberg Test in this study was done with subjects barefoot or wearing flat shoes standing on a flat surface. They stood heel-to-toe with their arms folded across the chest and eyes closed. The test procedure was similar to that proposed by Fregly²⁹ except that the best score of the 4 attempts was used. Timings were stopped once the subjects lost balance, opened their eyes, moved their feet to regain posture or when the required 60 seconds was attained. The test was discontinued when the score of 60 seconds was obtained on any one attempt. If the subject scored less than 60 seconds, the number of seconds attained was recorded and further attempts made until a score of 60 was attained or up to a maximum of four attempts had been made. Attempts scoring less than 5 seconds were considered as false starts and not recorded.

The data collected were entered into Microsoft Excel version 5.0 and analysed using SPSS for Windows. Distribution scores for balance tests are generally skewed. Statistical tests of significance for age were performed using T-Test while those for SRT scores were analysed using Mann-Whitney U Test and Wilcoxon Signed Rank Test for independent and paired samples respectively. An alpha level of 0.05 was set as the criterion for all tests of statistical significance.

Results

Sharpened Romberg Test data were obtained from 102 subjects. One subject with a history of lower limb pathology was excluded from the study. Forty eight of the subjects were divers with no known history of DCI and 53 were non-divers. Forty-seven subjects had two separate measurements of their SRT trials.

Table 1 summarises the age distribution of the study population. Divers in the under 40 age group were generally older than the non-divers. The age distributions of those in the 40 and over group were the same. A comparison of the SRT scores between the divers and the non-divers showed no significant difference (Table 2). This is despite the divers in the over 40 group having an older mean age.

TABLE 1

AGE DISTRIBUTION OF 101 CONTROL SUBJECTS

Age group	Subjects	Number	Mean Age + SD	t-test
< 40 yrs	Divers	29	30.34 + 7.44	p < 0.05
	Non-divers	40	22.45 + 6.68	
≥ 40 yrs	Divers	19	48.26 + 7.76	Not significant
	Non-divers	13	47.85 + 6.65	

Each subject was allowed 4 attempts per trial to attain a score of 60 seconds. From the study sample of 101 subjects it was found that 71% attained the required 60 seconds at the first attempt, 89% by the second, 93% by the third and 95% by the fourth attempts (Figure 1). A significant difference ($p < 0.001$; Wilcoxon signed ranked sum test) was found between the scores of the first and second attempts. Comparison of the scores between the second, third and fourth attempts showed no significant differences ($p > 0.05$).

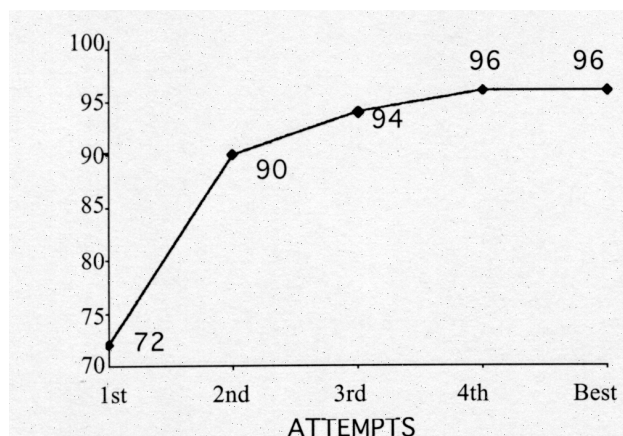


Figure 1. The number of controls scoring the maximum (60 seconds) in each of the four attempts during the trial.

TABLE 2

SIGNIFICANCE OF SHARPENED ROMBERG TEST SCORE DIFFERENCES

Ages	Subjects	Attempts	
		First	Best
< 40 yrs	Divers	*Not	*Not
	Non-divers	significant	significant
≥ 40 yrs	Divers	*Not	*Not
	Non-divers	significant	significant

**Mann-Whitney U Test*

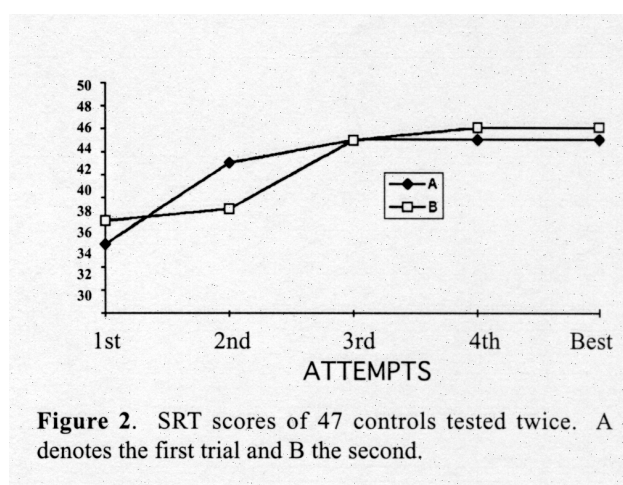


Figure 2. SRT scores of 47 controls tested twice. A denotes the first trial and B the second.

Figure 2 shows the subgroup (N=47) who had their SRT scores recorded on two separate occasions. No significant difference was found when scores of Trial A

(first) and B (second) were compared ($p > 0.05$; Wilcoxon Signed Rank Test).

Among the group of divers who had their pre- and post-dive SRT scores measured, the data (Figure 3) showed a post-dive decline in the scores of the first attempts ($p < 0.05$). The subsequent second, third and fourth attempts were not affected by diving.

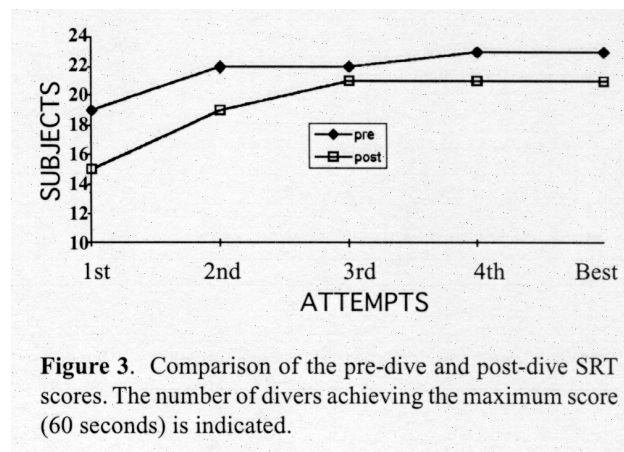


Figure 3. Comparison of the pre-dive and post-dive SRT scores. The number of divers achieving the maximum score (60 seconds) is indicated.

A total of 66 cases of DCI were treated at the Slark Hyperbaric Unit, Auckland in the period between May 1996 to April 1997. Case records were available for 55 patients.

Of the 55, five had no SRT scores recorded and these were not included in the study. Figure 4 compares the difference in distribution of the SRT scores between the control subjects and those with decompression illness. The performance in the Sharpened Romberg Test in all non-DCI subjects studied (n=101) showed a bimodal distribution with a large majority (95%) achieving a score of 60 seconds and 5% scoring between 16-35 seconds (Figure 4). The patients with DCI also showed a bimodal pattern, with 54% obtaining a score of 60 seconds. The 23 patients who had abnormal SRT scores did poorly with 16 (70%) scoring less than 15 seconds. The scores of all the patients with DCI who had abnormal scores were less than (or equal to) 35 seconds.

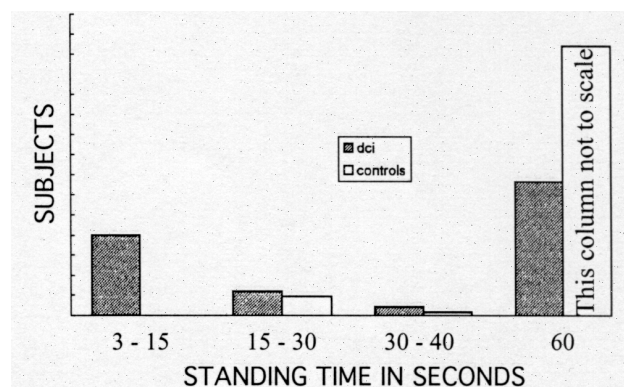


Figure 4. Distribution of SRT scores among patients with DCI and controls

Table 3 shows the SRT scores on admission and on completion of treatment. All patients in this series with abnormal SRT scores on admission had 'normal' scores (60 seconds) upon discharge.

TABLE 3

***SRT RESULTS IN 23 PATIENTS WITH DCI
PRESENTING WITH ABNORMAL SRT***

Number of patients	SRT scores	
	Admission	Discharge
9	<= 5 seconds	60 seconds
4	6-10 seconds	60 seconds
3	11-15 seconds	60 seconds
4	16-25 seconds	60 seconds
1	26-30 seconds	60 seconds
2	31-35 seconds	60 seconds

SRT scoring was the best of 4 trials or until 60 seconds were achieved.

Discussion

The Sharpened Romberg Test is commonly used in the assessment of divers with decompression illness (DCI). In DCI the balance system is involved in a large proportion of patients. Therefore, if found to be abnormal, the SRT is useful as a clinical sign to monitor the progress of the disease during treatment, especially when the patient has only subjective symptoms. However, interpretation of an abnormal SRT score in a diver requires that the attending clinician be aware of other factors which could or could not affect the SRT.

Balance tests are known to improve with practice,^{25,29,40} just like any other tests in which skills are involved. In our study population (N=101), the learning effect was evident only between the first and the second attempts within the trial. The subgroup (N=47) which had two separate trials assessed showed no significant difference in their SRT scores. The SRT protocol used appears to provide a good indicator of balance capabilities. Repeat administration of the test showed no learning effect and therefore will not bias the sequential assessment of a patient being treated for DCI.

The pre- and post-dive data (N=25) provided answers to three questions. First, decompression per se causes no deterioration in the SRT score. Therefore, the SRT is probably not a useful or sensitive indicator of decompression stress, be it asymptomatic venous bubbles or subclinical DCI. Second, the feeling of tiredness that divers often experience after diving had no effect on the SRT scores in our study population. Therefore the tiredness that accompanies scuba diving (after 2 dives a day in this context) and the fatigue commonly reported by divers with DCI appear to be pathophysiologically different. Third, the residual vestibular effect (sensation of

swaying) after a boat ride in open sea does not cause a significant deterioration in the SRT. However, exposure to severe storm conditions at sea is known to produce a deterioration in balance performance.⁴¹ Only the first post-dive attempts in the sharpened Romberg test were adversely affected (Figure 3). Performances in the subsequent attempts were unchanged from the pre-dive scores.

The distribution of the SRT scores showed a bimodal distribution in both non-DCI controls as well as in those with DCI (Figure 4). However, the majority of patients with abnormal SRT generally had very low scores, with 70% (16/23) scoring less than 15 seconds. There is a considerable overlap in those scoring between 16 to 35 seconds (7 in the DCI group and 5 in controls). It is noteworthy that none had scores between 36-59 seconds. All the subjects who scored more than 36 seconds initially managed to obtain the criterion score of 60 seconds within the allotted 4 attempts. 95% of the normal controls attained the required score, with 5% false positive rate.

The 2 x 2 contingency table in Table 4 attempts to define the validity of the SRT. Accepting a SRT score of <=40 seconds as being abnormal would have a sensitivity of 46%, specificity of 95% and a predictive value of 82%. If a score of <= 30 seconds is taken as abnormal, the sensitivity of the test would be reduced to 42% with little change in specificity (96%).

The SRT is resistant to the influence of the factors that were studied, namely practice effect, decompression stress (including post-dive fatigue or tiredness) and vestibular disturbance after a boat ride in mild to moderate sea conditions. Deterioration in SRT scores due to DCI was characteristically in the 16 seconds or less group. If the cut-off score is increased to 40 seconds the sensitivity will be increased to 46% and specificity 95% (Table 4). It is proposed that the scores of all the attempts should be noted down although only the best result is taken as the SRT score. This is to facilitate future research in this area.

TABLE 4

VALIDITY OF THE SRT IN DCI

	DCI	Controls	Total
Abnormal SRT*	23 (21)	5 (4)	28 (25)
Normal SRT*	27 (29)	96 (97)	123 (126)
Total	50	101	151

****Accepting a cut-off score of 40 seconds (in parenthesis) rather than 30 seconds will improve the sensitivity of the test. See text for details.***

The number of patients used in this study is small and therefore extrapolation of the results to diving medicine in general should be made with caution. For

practical reasons the SRT procedure used in this study imposed a limit of 60 seconds as the maximum score. Except for those who scored less than 60 seconds, the true SRT scores for those who attained the 60 seconds were probably much higher. This ceiling effect limits the ability of the SRT to detect small decrements in performance score.

Alcohol is another factor which may interfere with the SRT assessment of diving patients. Fregly and Graybiel found postural equilibrium to be highly sensitive to moderate doses of alcohol (2.2 cc 100-proof vodka per kg body weight).⁴² Hyperoxia per se, instead of disease resolution, could be another possible cause of the improvement seen in SRT scores of the patient treated in the chamber. Further studies should be conducted to evaluate the effect of hyperoxia and lower doses of alcohol on the SRT performance in normal subjects.

In summary, the Sharpened Romberg Test is a useful marker of Decompression Illness. The results of this study show that it is resistant to several potentially confounding factors which are often present during the assessment of a diver with DCI, namely, post-dive fatigue, decompression stress, vestibular disturbance resulting from exposure to swaying motion of dive boat and improvements due to practice or learning effect.

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This paper formed the thesis submitted for the Diploma of Diving and Hyperbaric Medicine awarded to Dr Lee in 1998. The study on which this paper is based was carried out when Dr Lee was on a clinical attachment at the Slark Hyperbaric Unit, RNZNH, Auckland.

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