The Editor's Offering

The South Pacific Underwater Medicine Society Journal is, from this issue, to be included in Excerpta Medica's index EMBASE. This is excellent news as searchers through EMBASE will be exposed to more underwater medicine sources. As an "Indexed Journal" papers published in the Journal will carry more weight in the author's CV (curriculum vitae).

The other Journal news is that the Editor, who has been associated with the production of this Journal since 1979 and Editor since 1990, will not be available for appointment to the position when his term expires at the Annual General Meeting (ASM)in 2002. Thus the Society will need to find someone to be appointed Editor, the only paid position on the Committee. At present the Editor carries out all the usual functions of an Editor, such as assessing papers submitted for publication and improving them so that they are ready for printing in the South Pacific Underwater Medicine Society Journal, but also those of typesetter, which in these days of desk top publishing is becoming part of many editors' duties, advertising manager, which it must be admitted is only a small portion of his duties as the Journal seldom carries more than two paid advertisements, and production manager dealing with the printer and mailing house. A large part of the duties of any editor is getting authors to complete their manuscripts in time for the proposed publication date. The Journal depends on papers presented at the Annual Scientific Meeting for much of its content. Unfortunately many of those who present papers fail to follow the instructions, given to every speaker at an ASM, to provide the Convenor or the Editor with the text, as printed word and illustrations (hard copy) and in electronic form. The Society records every speaker's presentation. This allows the transcribing of presentations which have not been provided as text and illustrations. Transcribing is not a rapid process and the costs are high. Then the Editor can either send the transcript to the author to be turned into printable English, or do the editing himself, which is very time consuming but often takes less time to publication. Much of what the current Editor does can be delegated to others, at a cost. The Editor has enjoyed the job of producing the South Pacific Underwater Medicine Society Journal and hopes that his successor will too. Readers interested in leading the Journal further into the 21st century should contact the Editor for a full list of the responsibilities of the position.

The European College of Baromedicine was founded in Malta during the European Underwater and Baromedical Society meeting in September 2000. A description of the new College and its aims is to be found in THE WORLD AS IT IS. The South Pacific Underwater Medicine Society Journal wishes the infant College a healthy growth curve and looks forward to its contributions to underwater and hyperbaric medicine.

In this issue are two papers prepared for the SPUMS Diploma of Diving and Hyperbaric Medicine. Dr Pauline Whyte discusses the seldom mentioned down side of the tuna farming industry, the incidence of decompression sickness. The costs to the South Australian Government of treating diving workers on Port Lincoln tuna farms were so high that government intervention insisting on proper training of these occupational divers took place. There has been a high cost in human injury to offset the financial profits from tuna sales to Japan. The other paper was by Lalith Ekanayake and David J Doolette on the effects of hyperbaric treatment on blood sugar levels in diabetics. This international effort, Surgeon Captain Ekanayake is a member of the Sri Lankan Navy, should be read with the paper presented to the 2000 ASM by Lynn Taylor and Simon Mitchell. The text, supplied by the authors, is not as entertaining as their question and answer presentation, but just a clearly makes the case for relaxing the current SPUMS ban on diabetics diving to requiring diabetics who want to dive to do a specially designed diving course which teaches safe diabetic management as well as diving. This theme is also touched upon in David Elliott's paper on restricted diving for the unfit.

For those who do diving medicals there is food for thought in Des Gorman's paper on health surveillance. When New Zealand changed over to an annual questionnaire for assessing occupational divers' health one unexpected finding was that divers were more truthful about their illnesses than in their previous annual medical. Another unexpected result was that the questions had to be reworked many times before they meant the same to divers and doctors.

Dr James Douglas, from Fort William in Scotland (the Society has members all over the world), sent the Editor a small piece about an unusual diving medical decision which made everyone happy. This bitter-sweet tale is reprinted by kind permission of BMJ Publishing Group.

The other must-read is the book reviewed by Douglas Walker which gives insights to the worlds of deep divers and cave and wreck divers. The Last Dive is a tragedy brought about by the characters of the two divers, their desire for recognition and finally by their stupidity in choosing to do a deep dive in appalling weather rather than miss a chance to identify the submarine wreck they were anchored over. Many recreational divers find their enjoyment in being underwater in comfortable conditions. Other divers seen to need a touch of danger to give them a greater thrill. Overhead environments and deep diving scare the Editor, so it was illuminating to read about these death-defying divers in a book written by another deep diver who nearly died, but made a full recovery, from decompression illness because he missed decompression.

ORIGINAL PAPERS

DECOMPRESSION ILLNESS IN THE TUNA FARM DIVERS OF SOUTH AUSTRALIA

Pauline Whyte

Key Words

Decompression illness, hyperbaric oxygen, occupational diving, risk, safety, treatment, treatment sequelae.

Abstract

The Hyperbaric Medicine Unit of the Royal Adelaide Hospital treated a total of 22 tuna farm divers with decompression illness (DCI) between 1992 and 1998. Overall two thirds of the divers were left with sequelae after treatment. The diving practices of the tuna farming industry, the likely reasons for DCI, the treatments used and the results obtained are discussed. In 1997 regulations were introduced to raise the standards of training and dive management in the industry. Since then the incidence of DCI has dropped but the clinical presentations are unchanged. The Royal New Zealand Navy scoring system for DCI severity and treatment response was used to describe the clinical course of these patients.

Introduction

In 1992, in response to a 67% reduction in the tuna catch quota in South Australia, fishermen in the Port Lincoln area began farming tuna and by 1998 fourteen tuna farming operations had been developed. From December to February tuna are caught in the Great Australian Bight and towed in cages, at approximately 1 knot, to Port Lincoln where they are transferred to stationary pens. The tuna are fed pilchards for 1-8 months before being hand harvested for the Japanese market where a 40 kg fish can earn up to $1,000.

Approximately 40 divers are employed full time, increasing to 60 during the catching season. They inspect, maintain and repair cages, remove dead fish and occasionally sharks from the enclosures and monitor the herding, feeding and hand harvesting of the tuna.

Farming procedures were developed by fishermen with little knowledge of diving. Divers usually had only recreational training, if any. Diving was conducted with little consideration of the risks of decompression illness (DCI). Divers relied almost solely on surface air supply from petrol driven compressors with no back-up systems, full-face masks or voice communications. Multiple ascents were typical, with divers coming to the surface repeatedly to receive or to give instructions.

By early 1995, WorkCover Corporation (South Australia's Workers Compensation Authority) had received 39 diving related claims, $1,475,326.00 in compensation had been paid and 17 divers had been treated for DCI at the Royal Adelaide Hospital (RAH).

In response, the Department of Industrial Affairs and WorkCover Corporation implemented strategies to raise the standard of diving. Inspections of the tuna farms and their diving practices were carried out during 1995. Training sessions were conducted for divers, supervisors and employers and safer diving procedures established. However, the death of an untrained scuba diver in March 1996 highlighted the need for further intervention and in March 1997 the Government introduced the Approved Code of Practice for Tuna Farm Diving based on AS2299 (Australian/NZ Standard 2299 for Occupational Diving). All divers are now required to be occupationally trained and the South Australian Underwater Training School, established in Port Lincoln in 1996, now operates under a Memorandum of Understanding with the Australian Fisheries Academy. The widespread introduction of full-face masks allows continual communication with the diving supervisor and surface crew, thereby reducing the need for multiple ascents. Surface supply gas now has a back up system and divers carry bailout bottles. These interventions have improved the standard and safety of diving and reduced the number of tuna farm divers presenting with DCI to the RAH.

This report details the nature and severity of decompression illness in the tuna farm divers and the long-term outcome of those affected.

Data collection

Approval for case note review was obtained from the Ethics Committee and Medical Staff Society, Royal Adelaide Hospital (RAH), and the review was conducted in accordance with the National Health and Medical Research Council Statement on Human Experimentation and Supplementary Notes-1992.

For each diver, age, date of presentation, delay to recompression and whether the diver continued to dive when unwell, signs and symptoms before each hyperbaric treatment, on discharge, at the six weeks follow-up visit and at yearly intervals thereafter, the number and types of recompression therapy received, adjuvant use of lignocaine, results of neuropsychological testing, and fitness to return to diving were noted.

Signs and symptoms were collated and divided into those at presentation, at any time and at the first and most recent follow-up visits. Signs and symptoms present at any time were compared with those of recreational and military divers.[1,2]

One diver presented on two separate occasions and as he made a complete recovery following both episodes of decompression illness, he is included twice in the data. Medical records could not be retrieved for one diver who presented in 1993. Therefore, although seventeen divers presented prior to WorkCover's intervention, data is available for sixteen divers only.

The neuropsychologist's findings were summarised as normal, unlikely organic impairment, possible organic impairment and significant impairment. The time to testing and the results of repeat testing were recorded.

Telephone follow-up established if those unfit to return to diving had found alternative work.

Tuna farm divers

Twenty-two male tuna farm divers, average age at presentation 29.4 years (range 19-43 years), were treated for DCI at the RAH between November 1993 and January 1998.

Divers typically had long delays between developing symptoms and seeking medical help (Figure 1). Six divers, who became unwell following a dive and promptly ceased diving, presented within five days. and, for the purposes of this study, were regarded as having "acute" DCI. Two were diving on tuna farms around Port Lincoln, approximately 650 km by road and 250 km by air from Adelaide, and presented to the local hospital. The others developed symptoms while tuna catching and the return to port took between two and four days. All six were retrieved by air, at 1 ATA, to the RAH and received normobaric oxygen and intravenous fluids during transfer.

The remaining 16 divers, referred to the RAH by their local doctors, presented between two weeks and nine months after developing symptoms and, with one exception, continued to dive while unwell. They were regarded as having "chronic" DCI. The term "chronic" does not refer to long-term problems.

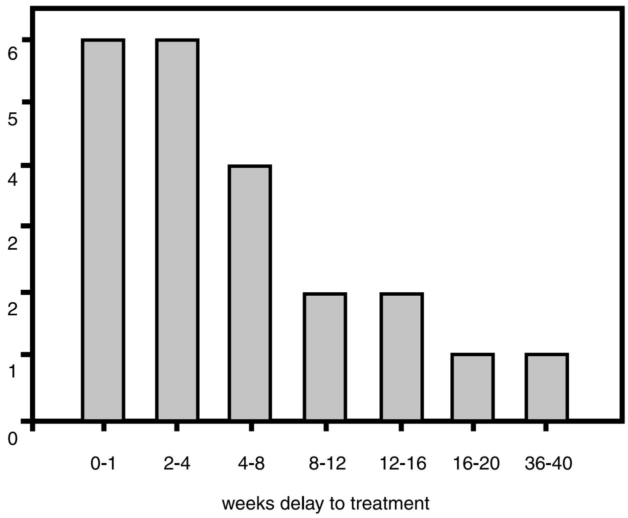

Figure 1. Bar chart showing the number of divers in various categories of delay in weeks between becoming unwell and seeking treatment.

TABLE 1

PERCENTAGE INCIDENCE OF PRESENTING SIGNS AND SYMPTOMS IN THREE GROUPS OF DIVERS

Signs and Symptoms	Tuna Farm Divers	DAN	Rivera
Pain	95	57	92
Paraesthesia	91	52	21
Lethargy	82	17	1
Cognitive change	77		
Objective sensory change	68	52	
Balance	59		1
Reflexes	59		
Headache	54	16	4
Mood change	50	3	2
Upper limb co-ordination	36		1
Lower limb weakness	32	22	21
Upper limb weakness	27	22	21
Dizziness	18	19	8
Tinnitus	14	2	
Urinary problems	14	33	2
Nausea	9	14	8
Lower limb co-ordination	9		1
Gait	4	10	

Clinical examination at presentation

At the RAH each diver was assessed. Pain, lethargy, cognitive impairment, paraesthesia and objective sensory change were the commonest manifestations of DCI, occurring in at least 60% of the divers (Table 1). In this study non-specific symptoms, such as lethargy and headache, cerebellar signs, such as balance and co-ordination and manifestations of nervous system damage, such as paraesthesia and objective sensory disorder, all occurred much more commonly than in 1,249 recreational or 935 military divers.[1,2]

The intensity of pain ranged from mild aches to severe pain requiring referral to a Chronic Pain Unit.

Treatment

Each diver received a series of recompression treatments until he became symptom free or showed no further improvement with two successive treatments. Three divers received intravenous lignocaine.

The divers received an average of 8 recompression treatments (range 2-14). All divers received a RN 62 as the first treatment table (Table 2) and treatment tables varied thereafter. Treatments 18:60:30, 10:60:30 and 14:90:30 are depth in m: time at depth: ascent time.

TABLE 2

RECOMPRESSION TREATMENT OF TUNA FARM DIVERS

Treatment table	Number and % of divers		Number of treatments
RN 62	22	100	1-3
18:60:30	20	91	1-10
10:90:30	12	54	1-8
RN 61	7	36	1-6
14:90:30	3	14	1-3

Progress

The incidence of all signs and symptoms had decreased by the first follow-up assessment, usually six weeks after discharge. However, by the time of the most recent assessment, the incidence of paraesthesia, lethargy, balance, reflexes, mood change, tinnitus, headache, co-ordination and urinary problems and weakness had increased. The incidence of cognitive impairment and pain remained unchanged and only the incidence of objective sensory disturbance continued to decrease.

As reported by Sutherland, the incidence of mood disorders, unlike other symptoms, increased over time and was attributed to chronic ill health and inability to return to diving.[3] Cognitive impairment, although present, was not regarded as a major concern by the tuna farm divers, who no longer relied on their memory and avoided situations requiring cognitive skills. The divers thought that lack of external marks decreased people's acceptance of their genuine illness. Many felt that they were regarded as malingerers by the diving community of Port Lincoln.

Hearing was not routinely measured in patients presenting with DCI and none of our subjects complained of hearing loss.

Assessment of gait often consisted of observation of the patient, as he walked to and from the chamber. Subtle changes, requiring walking on inclines or rapid turn around for detection, may have been missed. This may explain the anomaly between the percentage of patients documented as having poor balance or lower limb weakness and normal gait.

Although the previous health of the tuna farm divers was unknown, we can presume given their age and the demands of their occupation, that they were in reasonably good health. The higher incidence of many signs and symptoms amongst the tuna farm divers in comparison to the other diving groups may reflect the way in which data was collected or may represent widespread system involvement. The Divers Alert Network data is based on signs and symptoms reported to them. The experience of the examining physicians is unknown and signs or symptoms may have been overlooked. In contrast, the tuna farm divers were examined by hyperbaric specialists and the medical notes carefully reviewed. The majority of subjects who contributed to Rivera's data were military or commercial divers (96.7%).[2] Ninety-six percent received recompression treatment within 24 hours. Delay to treatment was found to be significantly related to outcome. Although the delay to recompression among recreational divers is unknown, it is likely to be days rather than weeks. In contrast, two thirds of the tuna farm divers waited weeks and months before seeking treatment and continued to dive despite being unwell. This repeated insult and failure to seek prompt medical intervention might account for their higher incidence of most symptoms and signs.

Long term sequelae

Pain, cognitive impairment, lethargy, mood swings and paraesthesia were the commonest long-term sequelae, persisting in 25-52% of the tuna farm divers. Divers underwent neuropsychological testing if cognitive impairment was suspected. Table 3 (page 5) lists the tests administered.

The timing of the testing varied from immediately post recompression therapy to seventeen months after presentation. Eight of the twelve divers tested had possible organic impairment and one was significantly impaired. Seven divers had repeat testing between one and two years later. Of these, one diver, with significant impairment on his first evaluation, remained unchanged, five showed improvement and one diver had deteriorated.

All the tuna farm divers suspected of cognitive impairment presented with chronic DCI. Although the other

TABLE 3

NEUROPSYCHOLOGICAL TESTING

Wechsler Adult Intelligence Scale–Revised	E.g. What piece of the picture is missing? E.g. How are two things alike?	Test of psychomotor speed, executive functions and construction.
Wechsler Memory Scale-Revised	Recall of newspaper type paragraphs read to subject.	Test of immediate and delayed recall.
Rey Auditory Verbal Learning Test	Five presentations with recall and recognition of a fifteen word list.	Measures immediate memory span, short-term and longer-term retention.
Rey Complex Figure Test	Immediate and delayed recall of a complex figure.	Test of constructional and memory abilities.
Trail Making Test	Part 1: draw lines to connect consecutively numbered circles. Part 11: alternates between consecutively numbered and consecutively lettered circles.	Test of visual conceptual and visuomotor skills.
Controlled Oral Word Association Test	Selecting an associated word within certain guidelines.	Test of fluency and self-monitoring.
National Adult Reading Test	50 phonetically irregular words.	Estimate of premorbid mental ability.
Hospital Anxiety and Depression Scale	Brief and well standardised self-report.	Measure of anxiety and depression. Excludes somatic symptoms.
Neurobehavioral Inventory	Questionnaire completed by subject and relative.	Measure of physical, cognitive and emotional symptoms.
Beck Depression Inventory	21 item scale.	Determines presence and intensity of depression.
Spielberg State- Trait Anxiety Inventory	Questionnaire	Measure of trait (temperament) and state (acute) anxiety.

tuna farm divers had no obvious cognitive problems at follow-up, neuropsychological assessment might have revealed otherwise unrecognised deficits. The sensitivity of such testing is increased when baseline data is available. However, in the absence of such data, repeated assessments for an individual diver may detect subtle deficits in the presence of a normal clinical assessment and can provide a measure of the diver's progress.

Clinical Scoring System

To describe the severity of decompression illness and to estimate the response to recompression therapy and time, the Royal New Zealand Navy (RNZN) clinical scoring system, designed as a prospective tool, was used.[4]

The RNZN system grades twenty-one signs and symptoms, shown in Table 4, on a scale of 0-3 (none, mild,

TABLE 4

THE TWENTY-ONE SIGNS AND SYMPTOMS USED IN THE ROYAL NEW ZEALAND NAVY CLINICAL SCORING SYSTEM

Lethargy	Cognitive disturbance	Gait
Mood change	Visual disturbance	Reflexes
Headache	Genitourinary function	Weakness
Hearing loss	Bowel dysfunction	Sensory loss
Nausea	Co-ordination	Rash
Tinnitus	Speech disturbance	Pain
Paraesthesia	Lymphatic involvement	Balance

moderate or severe) based on objective findings for signs and semantic anchors for symptoms.

Each symptom or sign is then weighted by a factor which includes specificity for DCI, natural history if left untreated, potential to incapacitate and co-dependence. Co-dependent symptoms or signs are those that prevent or invalidate the assessment of other symptoms or signs, thereby compromising the severity score. For example, lower limb weakness will interfere or prevent assessment of gait, balance and co-ordination. The dominant symptom or sign, as outlined by the scoring system, is retained and reweighted and the signs and symptoms which may be invalidated are removed. This score is then multiplied by a progression factor, which depends on whether the patient's condition is improving, relapsing remitting or static. A total score was obtained for each assessment.

Most symptoms were easy to grade according to the semantic anchors in the RNZN system. However, pain and fatigue were more difficult to assign a psychometrically sound score to. For pain, the RNZN system converts a visual analogue score of 1-10 to mild, moderate or severe. However, in this group of divers descriptions such as "aches", "stabbing pains", "twinges" etc. were recorded. To grade these descriptions of pain objectively, the descriptions recorded in the notes were listed, and hyperbaric consultants at the RAH were asked to divide them into mild, moderate or severe. Descriptions of fatigue were similarly graded. Signs had been recorded in objective medical terms and therefore easy to grade.

Although the initial history and examination were the most comprehensive, not all the signs and symptoms used in the RNZN system were recorded. Initially only signs and symptoms specifically recorded in the notes were used to determine the severity scores.

The patient's progress was often recorded using such terms as "slight improvement", "much better" or "no real change". However, when severity scores were plotted against time and compared with the impressions recorded, it became apparent that some low scores were the result of certain symptoms and signs not being specifically mentioned on that day, rather than an actual improvement in the patient's condition. To reflect the patient's progress more closely, modifications were required.

Although not mentioned specifically, the presence or absence of some symptoms or signs can be implied from general comments. Remarks such as "no change over last 24 hours" or "feels 100% today" allowed us to attribute a value to certain symptoms or signs, recorded as "implied " in the database.

Occasionally a symptom or sign was recorded on a particular day, not mentioned the next and recorded again the following day. As a result a lower score was calculated for the day in between, even though, judging from the notes, the patient had not improved. Certain features of DCI, such as headache, fatigue, mood or pain may vary from day to day and one cannot presume their presence or absence unless specifically alluded to. However, where balance, gait or co-ordination was recorded as poor on day one and day three with no obvious change on day two, we assumed a similar "interpolated" score for that day.

Scores that include implied and interpolated data were used for analysis as they reflected the clinical situation more accurately.

TABLE 5

SIGNS AND SYMPTOMS AT PRESENTATION AND FOLLOW-UP

Signs and Symptoms	Presented with %	First follow-up %	Most recent follow-up %
Patients	n=22	n=21	n=21
Pain	95	52	52
Paraesthesia	64	10	25
Lethargy	82	20	30
Cognitive change	73	35	35
Objective sensory change	59	5	0
Balance	45	15	25
Reflexes	41	10	15
Headache	41	0	10
Mood change	27	15	35
Upper limb co-ordination	27	5	10
Lower limb weakness	27	0	5
Upper limb weakness	18	0	5
Dizziness	9	0	0
Tinnitus	9	0	5
Urinary problems	4	0	10
Nausea	4	0	0
Lower limb co-ordination	4	0	5
Gait	0	5	5

Follow up

Unlike other groups of divers who are often lost to follow-up, 21 of the 22 divers continued to attend the RAH. One diver with residual symptoms flew to Hobart against medical advice. Although he is excluded from the first and most recent follow-up data, his general health and failure to recover from his decompression illness became known to us and he is included in the failure to return to diving data. Signs and symptoms at presentation, first follow up and most recent follow up are shown in Table 5

Although the incidence of all signs and symptoms decreased with recompression therapy, there were significant residual sequelae at the first follow-up visit. Fifty-two percent of the tuna farm divers complained of pain, 35% had some degree of cognitive impairment and 20% reported lethargy. Similar figures have been reported at one month[5] but few hyperbaric units provide details of residual sequelae and it is difficult to estimate whether the figures reported here are unusually high. After the six week assessment, the incidence of pain and cognitive disturbance remained unchanged and the incidence of many other signs and symptoms increased. Pain, cognitive impairment, lethargy and mood swings, the commonest long-term sequelae amongst the tuna farm divers, hindered the securing of alternative employment and contributed to domestic unrest. Mood disorders, the incidence of which increased over time, may have been a direct result of DCI or a reaction to the changes in health, occupation and personal relationships. Not only do many signs and symptoms not resolve with time, but many signs and symptoms return following an initial resolution. Therefore, to assess the efficacy of recompression therapies, longer-term follow-up studies are necessary.

Any diver who returned to diving had done so within ten months of discharge. Seven divers were asymptomatic at discharge and although two had temporary return of symptoms, all had returned to diving by ten months. Fifteen divers were discharged with residual symptoms. The three who returned to diving had done so by four months.

Comparison of acute and chronic groups

The tuna farm divers were divided in to two groups, acute and chronic, according to the delay to presentation. Their presentation scores, final scores and degree of recovery are outlined in Table 6. No statistically significant difference was found between the two groups, in presentation scores or final scores, using a two-tailed independent t-test. However, the difference in their final scores may be clinically significant, as the acute group made a statistically significant recovery (p=0.003) and this was reflected in the number of acute divers who were fit to return to diving (4/6 or 67%) compared with the chronic group (6/16 or 37%).

Assessment of severity

Results are presented as means ± standard deviations and as means + ranges. Comparisons between groups were made using independent two tailed t-tests, alpha = 0.5. Dependent t-tests were used for intra-group comparisons.

The changes in severity scores over time are presented graphically for groups and individuals. Assessments, which are depicted on the y-axis, are before each recompression treatment, at discharge, at the first follow-up visit, and at yearly intervals thereafter. Severity scores, obtained using the RNZN system, are depicted on the x-axis and are shown with standard deviations where appropriate. Divers were grouped for comparison according to whether their presentation was acute or chronic, whether they were fit or unfit to return to diving, and whether they presented before or after the intervention by WorkCover Corporation.

Some observations can be drawn from the graphs of "severity score and assessments" for all divers and individual divers. A quite dramatic improvement often resulted from the initial RN 62 which then continued at a lesser rate, with some patients becoming symptom free and others reaching a plateau with no further improvement with recompression The response to hyperbaric therapy and the course of the disease thereafter varied considerably between divers.

Figures 2, 3 and 4 depict the severity of DCI and its response to recompression therapy and time for all the divers, the acute group and the chronic groups respectively

Case reports

Case 1, who usually did 50-60 ascents a day, developed symptoms after a rapid ascent following compressor failure. He presented on the same day with pain

TABLE 6

PRESENTATION AND FINAL SCORES

	Acute (N=6)		Chronic (N=16)		P Value
Presentation score	29.9	(± 11.2)	23.2	(± 14.9)	p=0.601
Final score	3.0	(± 6.5)	114.6	(± 17.6)	p=0.111
Recovery (Presentation - Final) score	16.9	(± 9.2)	8.7	(± 21.0)	
P value of recovery score	p = 0.003		p = 0 133		
Return to diving	4/6 (66%)		6/16 (37%)		

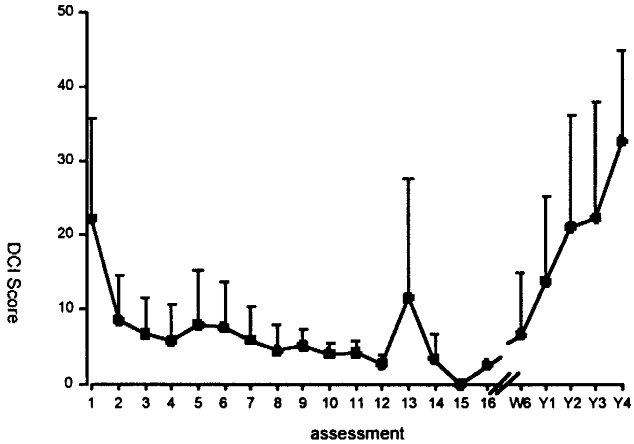

Figure 2. The average severity scores+SD for all divers in response to recompression therapy and time. Assessments before recompression treatments (1-16), at the six-week follow-up visit (w6) and yearly thereafter (y1-y4), where applicable, are represented on the x-axis. The severity scores are represented on the y-axis. Where no error bars are shown, n=1.

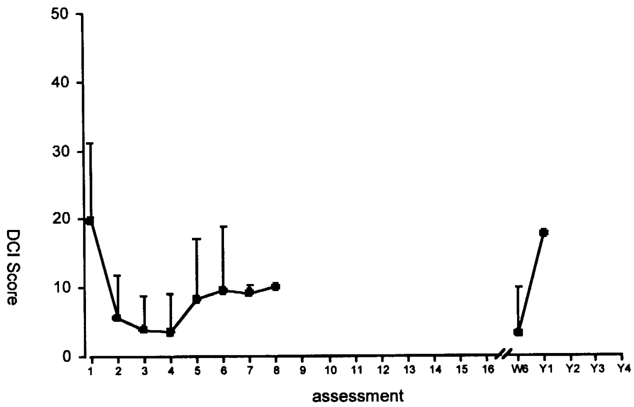

Figure 3. The average severity scores +SD over time for those divers who had symptoms for five days or less, i.e. acute decompression illness, before receiving hyperbaric therapy. No error bars are shown where n=1.

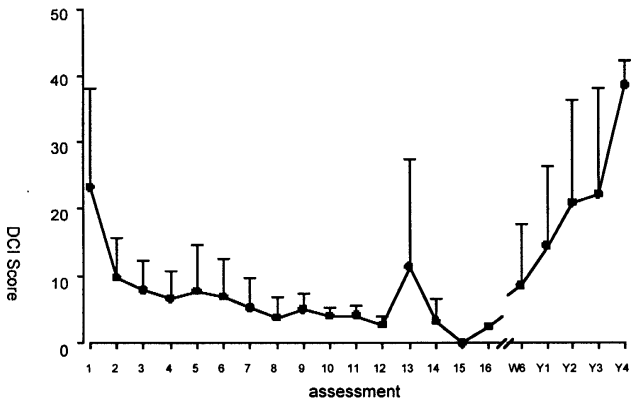

Figure 4. The average severity scores over time for those who had symptoms for two weeks or longer, i.e. chronic decompression illness, before receiving hyperbaric therapy. Where no error bars are shown, n=1.

in his knees and back, paraesthesia in his right foot and left hand, lethargy and headache. He had been well until this incident. After five treatments all symptoms resolved (Figure 5) and he returned to diving.

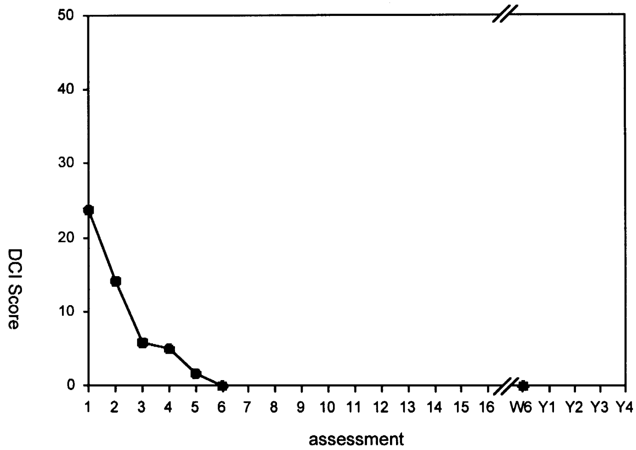

Figure 5. Case 1 who had complete resolution of his symptoms with recompression therapy and remained well.

Case 2 became unwell while harvesting at sea, forty eight hours after his last dive. His dive computer showed his most recent dive profiles to be within its no decompression limits. Returning to port took five days and when he reached the RAH, he was vomiting, had paraesthesia in both hands, pain in his arms, legs and chest, lower limb weakness, an abnormal gait, lethargy and cognitive difficulties. He received seven treatments and on discharge still suffered from lethargy, cognitive impairment, difficulties with balance and abnormal gait. All were unchanged at his six week review and the pain in his joints had returned (Figure 6). One year later his symptoms were unchanged. Although unable to return to diving he found alternative work.

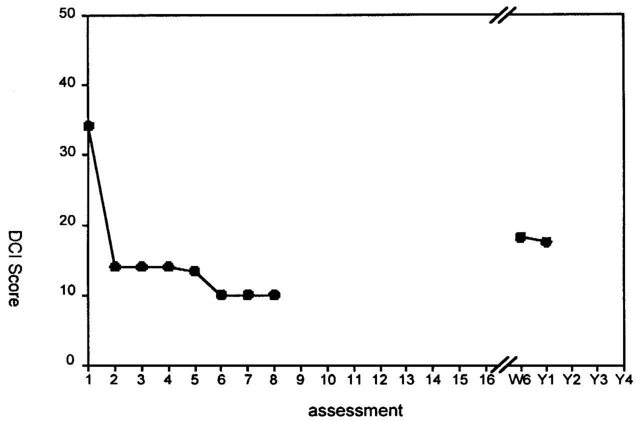

Figure 6. Case 2 who had an initial response to recompression therapy and then reached a stage where his symptoms were unaltered by further recompression. At his first follow-up assessment his severity score had increased and his condition remained unchanged one year later.

Case 3 presented to the RAH with a two-week history of aches in his knees and elbows, poor concentration. He was found to have poor co-ordination and impaired balance. He gave a history of 3-4 dives per day with multiple ascents and descents. After six treatments he became asymptomatic but at his first follow-up visit was again found to have poor balance and evidence of cognitive impairment. Neuropsychological evaluation found no evidence of organic impairment. His symptoms resolved over the next six months and although he returned to diving, he chose not to return to tuna farming (Figure 7).

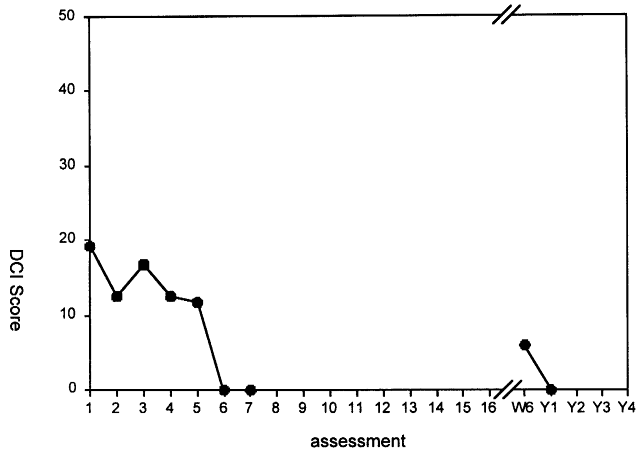

Figure 7. Case 3 who had a complete response to recompression therapy, had return of symptoms by the time of his first follow up visit and subsequently became symptom free again.

Case 4 presented with a six-week history of arthralgia, lethargy, headaches, and decreased libido, was found to have objective sensory loss over his arms. He reported diving 3-4 times per day with multiple rapid ascents. At discharge he was complaining of aches in his joints and occasional headaches. Within six months he was symptom free and had returned to diving (Figure 8).

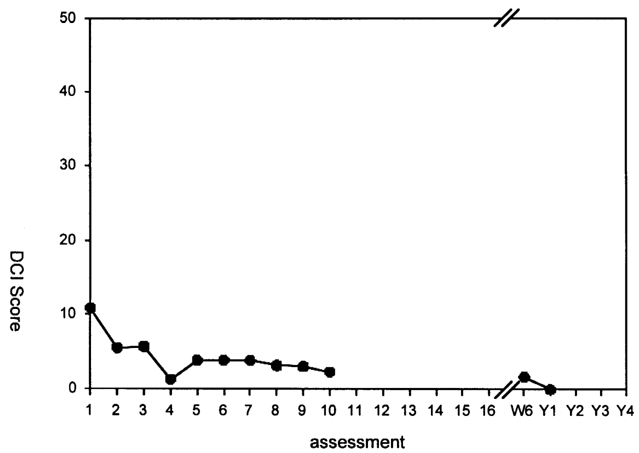

Figure 8. Case 4 who was symptomatic on discharge but became asymptomatic with time.

Case 5 had been unwell for 10 weeks, with pain in several joints, intermittent headaches and paraesthesia in both hands, was found to have impaired cognition, abnormal reflexes, poor co-ordination, objective sensory disturbance and difficulties with balance. He received 14 hyperbaric treatments and felt well on discharge. At his first follow-up visit he complained of arthralgia and short-term memory and concentration difficulties and four years later these symptoms persist (Figure 9). He was unable to return to diving but found alternative employment.

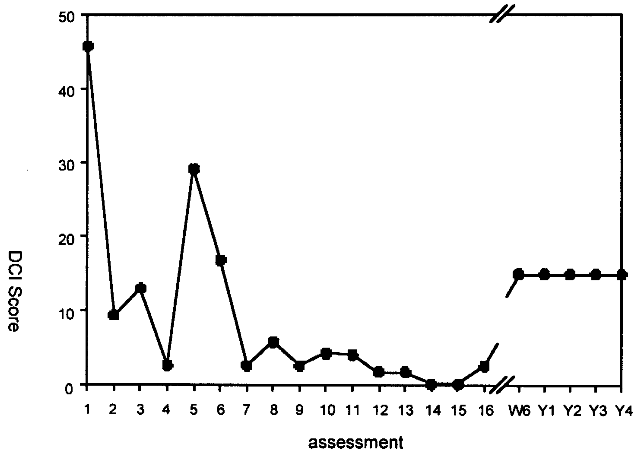

Figure 9. Case 5 who had severe decompression illness on presentation, had a fluctuating response to recompression therapy, was almost symptom free on discharge and although he deteriorated afterwards, still maintained a significant degree of his recovery.

Case 6 had been unwell for four weeks with pain in his left shoulder and right hip, intermittent paraesthesiae of both hands, lethargy, headaches and cognitive problems. On examination, he had impaired balance and objective sensory impairment. He received four recompression treatments and intravenous lignocaine and on discharge still had persistent pain, abnormal balance, cognitive impairment and lethargy, although his paraesthesiae had resolved. At his first follow up assessment, all symptoms were still present, his paraesthesiae and objective sensory abnormality had returned and he was anxious and depressed. Subsequent assessments showed impaired co-ordination, abnormal reflexes and decreased strength in all limbs. His neuropsychological assessment revealed possible organic impairment, with deterioration on repeat testing (Figure 10 page 10). He had severe pain necessitating referral to the Chronic Pain Unit at the RAH and was unable to return to any type of work.

Long term follow up

Seven divers were symptom free on discharge and all eventually returned to diving. Two of these had return of symptoms after discharge but had become symptom free

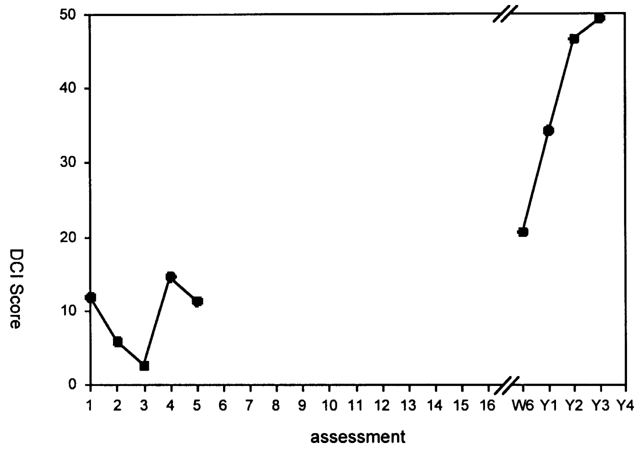

Figure 10. Case 6 who had a poor response to recompression therapy and deteriorated further over time.

again by ten months. Fifteen divers had residual symptoms on discharge and only three returned to diving. These three had become symptom free within four months of discharge. All those who returned to diving did so within ten months of discharge.

Approximately two thirds of the divers had residual symptoms on discharge and had received, on average, twice as many recompressions as those who were symptom free (Table 7)

In May 1999 twelve still remained unwell, of these six had found alternative employment, one was seeking a supervisory role, one had returned to study and three divers were unable to work because of severe residual symptoms. The status of the man who went to Hobart is unknown.

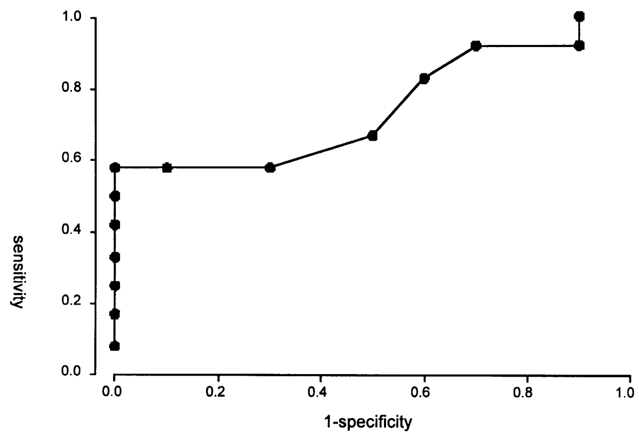

Figure 11. Receiver Operating Characteristic Curve based on various hypothetical presentation scores, represented by the black dots, and the calculated sensitivity and specificity of those scores in predicting which of the tuna farm divers would not be fit to return to diving. The point with the highest sensitivity and specificity (lowest 1-specificity) is the score that most accurately predicts which divers will be unfit to return to diving.

TABLE 7

SYMPTOMS ON DISCHARGE AND AVERAGE NUMBER OF TREATMENTS.

	Number of divers (%)		Average number of treatments (range)	
Symptom free	7	(32%)	4	(2-8)
Residual symptons	15	(66%)	9	(3-14)

The RNZN scoring system was used to create a Receiver Operating Characteristic Curve (Figure 11). The best fit is a score of 25 or greater which predicts, with a sensitivity of 58% and a specificity of 90%, that a diver will not be fit to return to diving.

By continuing to assess divers with DCI using the RNZN scoring system, a predictive score with increased sensitivity and specificity may be reached and changes in this predictive severity score may help gauge the efficacy of different treatment regimes.

Discussion

LONG-TERM HEALTH OF DIVERS

There is concern about the long-term health of both professional and recreational divers. International conferences held in Luxembourg 1978, Maryland 1981 and Stavanger, Norway 1983 addressed the issues of deep diving and its neuropsychological sequelae without reaching a consensus. Ten years later in Godoysund, Norway the focus shifted from the neurological effects of deep diving to the possible effects of professional diving on a divers health in general. The final statements included "there is evidence that changes in bone, the central nervous system and the lung can be demonstrated in some divers who have not experienced a diving accident or other environmental hazard. The changes are in most cases minor and do not influence the diver's quality of life. However, the changes are of a nature that they may influence the diver's future health".[6] Attention is now focused on two areas: anecdotal reports of cognitive and personality changes in persons exposed to hyperbaric conditions without experiencing overt episodes of decompression illness; and the persistence of signs and symptoms, especially neurological and neuropsychological, after recompression therapy for decompression illness.

In 1959 sequelae, including intellectual impairment, two years after treatment for DCI was reported in eighty six out of 100 caisson workers.[7] Subjective symptoms, such as irritability or headache, were present in the absence of any objective signs and often returned following an initial full recovery.

In 1976 neurological and neuropsychological examinations applied to 10 divers who had suffered DCI involving the central nervous system showed that nine were abnormal on at least one test, while seven were abnormal on both.[8] Similar tests applied to nine divers who had suffered near miss diving accidents, due to air embolus, hypoxia, CO_2 poisoning and DCI, led Vaernes and Eidsvik, in 1982, to conclude that a severe diving accident could lead to cerebral dysfunction.[9] The incidence of sequelae following decompression illness amongst military groups has been low and may be related to relatively short delays to treatment.[10-12] Recreational divers do not fare so well. Table 8 (page 12) summarises outcomes following decompression illness in 21 reports over 20 years.[3,5,10-28]

In 1993 a review of 11 Australasian hyperbaric centres revealed that up to 60% of those treated for DCI failed to recover fully following hyperbaric therapy.[29] The residual sequelae reported included depression, impaired cognition, motor and sensory disorders. Even the figures of resolution at discharge may be questionable. In 1988 Curley reported five cases of subtle cognitive impairment following hyperbaric therapy for decompression illness, with abnormalities barely discernible on standard neurological examination.[30] Routine use of neuropsychological testing might reveal an even greater incidence of sequelae.

The failure of decompression illness to resolve completely and its ability to recur after an apparent full recovery is widely accepted. What is less certain is the incidence of subtle residual cognitive changes post-recompression and whether long-term divers are susceptible to neurological or neuropsychological changes in the absence of decompression illness.

Several authors who contributed to a workshop on the effects of deep diving found little cause for concern.[31-33] Other studies have been less reassuring. A review of 82 saturation divers revealed more than 10% impairment of intellectual function on repeat testing.[34] As far back as 1976 Black stated that: "20% [of abalone divers] have chronic problems involving ear damage; 10% have suffered some brain losses according to our medical adviser".[35] A British report claimed that deep-sea diving experience correlated inversely with memory and reasoning skills.[36] While supporting data was lacking in these two studies, they echoed the belief that a dementia or "punch drunk" syndrome existed among occupational divers. Thirty professional abalone divers of New South Wales underwent neuropsychological testing and there was evidence of impairment of acquired intellectual capacity in eleven in the absence of obvious neurological deficits.[37] Another study of abalone divers, with fishermen as a control group, revealed no evidence of cognitive impairment.[38] However, a limited number of neuropsychological tests were used and the level of experience of those applying the tests varied. A postal survey of urchin divers revealed that 18% had chronic medical problems while only 2% gave a history of recompression therapy.[39] However the response rate was only 22% and the symptoms included those of barotrauma as well as DCI.

No consensus has been reached on the probability of long term neurological or psychological deficits in the absence of decompression illness. However, many occupational diving groups stray far from recommended dive practices so health and behavioural changes may simply be the result of unrecognised and untreated episodes of DCI.

CLINICAL AND NEUROPSYCHOLOGICAL EXAMINATION

No test exists for the diagnosis of DCI. It may occur following a dive within recommended limits for safe diving and in the absence of any known risk factors. Certain signs and symptoms are associated with DCI and the clinical examination is essential to its diagnosis and management. The distribution of symptoms and signs may differ between divers and may vary with treatment and time. Of particular interest are the symptoms or signs that fail to resolve and although many units publish figures on the percentage of divers who fail to make a complete recovery at discharge, residual sequelae and their evolution with time are not well documented.[29] Residual sequelae such as pain or paraesthesia may be easily recognised, whereas sequelae such as mild cognitive impairment or subtle personality changes may be less obvious, and may occur in the absence of any abnormality on standard neurological examination, magnetic resonance imaging or computerised tomographic scanning.[40,41]

Neuropsychology is an applied science concerned with the behavioural expression of brain dysfunction and neuropsychological testing has been proposed as a sensitive marker of cognitive impairment.[30] It has proved useful in determining the effectiveness of recompression therapy but there are limitations.[8,30] Testing requires the co-operation of the subject. The examiner must determine whether the subject attempts the tests to the best of his ability and the presence of depression or anxiety can obscure the existence of organic impairment. These tests have been shown to be valid and reliable in a non-diving population but it is only recently that normative data for various diving groups is being gathered.

COMPARISON OF FIT AND UNFIT TO RETURN TO DIVING

Table 9 (page 13) compares the presentation scores and response to treatment of those who were able to return to diving and those that remained unwell. As expected, the average final score of those who returned to diving was significantly lower than that of the divers who had

TABLE 8

RESIDUAL SEQUELAE AT DISCHARGE AFTER TREATMENT FOR DCI 1978-1998

Year	Author	Subjects	Number	Treatment	Comment	Residual Sequelae
1978	Bayne[10]	Military	50	USN O_2	One treatment	0
1980	Kizer[13]	Recreational	157	USN O_2	Delay>7 hours	17%
1982	Kizer[14]	Recreational	50	USN O2	Delay>12	34%
1986	Robertson[15]	Recreational	28	USN O_2	25 DCS 3 CAGE	20% 33.3%
1987	Gorman et al.[16]	Recreational	87	USN O_2	Loss of patients to follow-up may have caused bias	30/46 at one week 10/46 at one month
1988	Gorman et al.[17]	Recreational + Occupational	64	USN O_2	58 DCS 6 CAGE Mean delay 26.6 hours	54.5% DCS 33.3% CAGE
1989	Green et al.[11]	Military	292	USN 5 USN 6	Type 1 DCS	4.1%
1989	Wirjosemito et al.[12]	Military (Altitude)	133	USN O_2	Type 11 DCS	2.3%
1990	Bond et al.[18]	Recreational	347	Enhanced (165 or 60 fsw +extension) Regular 60 fsw or less	Significant improvement with regular tables	52% 37%
1990	Walker[19]	Recreational	50	USN O_2		40%
1990	Brew et al.[5]	Recreational	125	USN O_2	93 DCS 32 CAGE	60% at discharge 51% at one month 42% at discharge 50% at one month
1991	Lee et al.[20]	Recreational	374		Mean delay 5.2 hours	148
1991	Weinmann et al.[21]	Recreational	100	USN O_2		34%
1991	Todnem et al.[22]	Recreational	34		18 divers recompressed > 6 hours	41%
1992	Acott[23]	Recreational	20	USN O_2		15% at one month
1993	Sutherland et al.[3]	Recreational	25	USN O_2 tables	Questionnaire at 1 year +/-examination	48% at discharge 74% at one year
1993	Aharon-Peretz et al.[24]	Recreational	68	USN O_2 Comex 30	Spinal cord DCI	21%
1996	Gardner et al.[25]	Recreational 98%	100	USN O_2 RNZN Heliox Nitrox or Air/O_2	Mean delay 8 hours ±13.3	30%
1996	Lawler et al.[26]	Recreational	68		Questionnaire at 2 years	35%
1998	Francis[27]	Recreational 81% Military 6%	594			18%
1998	Richardson et al.[28]	Recreational 92%	95	O_2 RNZN heliox Nitrox or Air/O_2	Mean delay 67 hours	25%

TABLE 9

SCORES OF THOSE FIT AND UNFIT TO RETURN TO DIVING

	Fit to return to diving (10 divers)		**Unfit to return to diving** (12 divers)		**P value**
Presentation score	15.7	(±7.7)	28.4	(±15.9)	p=0.033
Final score	0.2	(±0.5)	21.3	(±16.9)	p=0.001
Recovery score	15.5	(±7.9)	7.1	(±24.7)	
P value of recovery score	p=0.0001		p=0.361		

continuing symptoms. However, those who recovered had significantly less severe disease on presentation and their degree of recovery was much higher.

The progress of the disease with treatment and time is represented graphically in Figures 12 and 13.

Although the course of DCI following hyperbaric treatment is uncertain, resolution over a period of years is not supported by this study, where all those who returned to diving had done so by ten months and four divers deteriorated with time. There was considerable variation between divers in their response to recompression and the course of the disease thereafter but the presence or absence of symptoms on discharge was a reasonable predictor of the likelihood of returning to diving.

Although there was no statistically significant difference in presentation or final scores between the acute and chronic groups, their response to treatment differed, with a higher percentage of the acute group returning to diving (67% v 37%). The poor response of the chronic group to recompression therapy may have been due to the delay to treatment or to the fact that this group continued to dive while unwell or both. For many years, interest has surrounded the relationship between delay to treatment and outcome with no clear consensus being reached. Early papers suggest that delay to treatment is an important predictor of outcome,[2,42,43] whereas more recent analyses found no significant correlation.[5,15,17] While one might expect a less successful outcome with delay to treatment, divers more severely affected may present earlier and still, as a consequence of disease severity, recover less fully.[25,29] However the delays in the these studies have been of the order of days, not weeks and months, as was the case with the chronic group of tuna farm divers. Recovery from DCI may be dependent on neuronal recruitment, a process that may be hampered by continuing to dive outside recommended limits.[17] The tuna farm divers, who continued to dive after developing symptoms of DCI, presumably exacerbated the pre-existing inflammatory process and may have hindered the development of compensatory mechanisms.

A good response to treatment may depend on a number of factors including less severe disease at presentation and relatively early presentation or ceasing diving after symptom onset. As the group who had a delayed presentation were also the group that continued to dive, it is not possible to separate the last two factors.

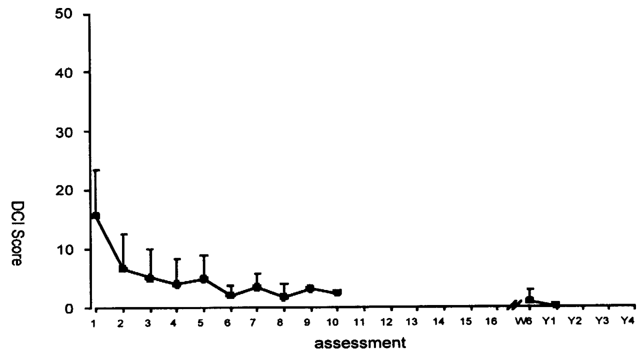

Figure 12. The average severity scores+SD over time for those fit to return to diving. Where no error bars are shown, n=1.

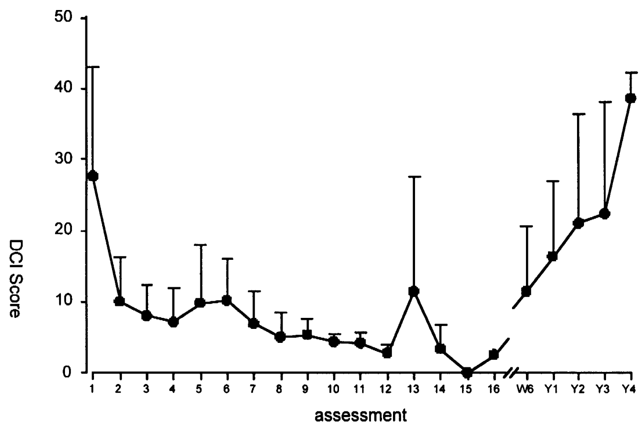

Figure 13. The average severity scores+SD over time for those deemed unfit to return to diving. Where no error bars are shown, n=1.

Conclusions

There was a high incidence of DCI among tuna farm divers, probably due to lack of knowledge of the risks of repetitive diving, of the symptoms of DCI and continuing to dive when unwell. The incidence has been reduced since intervention by the Department of Industrial Affairs and WorkCover Corporation emphasising safe diving and adequate training of divers. However, although there has been no difference in the severity of DCI at presentation nor in the delay to treatment the divers have made better recoveries and all have returned to some form of employment. This may be the result of fewer ascents and fewer divers now diving outside recommended limits, factors which are known to impede recovery.

Neuropsychological testing suggested the possibility of residual organic impairment among many of the tuna farm divers treated for DCI, but lack of base line data and the presence of depression or anxiety prevented more definitive conclusions. Reports from divers and their partners of changes in memory and concentration, together with the results of neuropsychological testing, suggest the presence of organic impairment after DCI .

The response of the divers to recompression treatment and time varied. Factors such as severe disease at presentation and waiting longer than two weeks before seeking help were found to be associated with a poor outcome. However those divers who waited two weeks or longer before receiving recompression treatment also continued to dive during this time and it is not possible to ascertain which factor was more significant.

The expectation that those with less severe disease on presentation would make a better recovery is supported by this study, where tuna farm divers who were able to return to diving had, on average, significantly lower presentation scores than those who remained unwell.

The incidence of residual sequelae was significant. Fifteen out of 22 divers had residual symptoms at discharge. None of these divers followed for more than a year showed any further recovery and four divers had more severe symptoms, several years after their illness, than on presentation. Twelve divers had long term residual sequelae and were unfit to return to diving and, of these, three had incapacitating symptoms and were unable to return to any form of work.

The RNZN scoring system[4] provided a useful index of disease severity and recovery, showing the variable response of DCI to treatment and the unpredictable nature of the disease over time, and facilitating comparison of subgroups and assessment of interventional strategies.

The inclusion of “implied” and “interpolated” data was felt to reflect the clinical situation more accurately and although it statistically altered the severity score (p=0.000003, DF =238), the product-moment correlation was 0.99. In other words, while the absolute figures were altered, the trends in the scoring system over time were similar.

A discussion of the effects of the intervention by the WorkCover Corporation and the Department of Industrial Affairs on the incidence, severity and sequelae after treatment of the tuna divers discussed in this paper has recently been published.[44]

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The above paper is an abridged version of the thesis presented by Dr Pauline Whyte MB, BCH, BAO, FFARCSI, Dip DHM, for the Diploma in Diving and Hyperbaric Medicine, awarded to her in July 2000 for work done as an Anaesthetic Fellow in the Hyperbaric Medicine Unit at the Royal Adelaide Hospital.

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EFFECTS OF HYPERBARIC OXYGEN TREATMENT ON BLOOD SUGAR LEVELS AND INSULIN LEVELS IN DIABETICS

Lalith Ekanayake and David J Doolette

Key Words

Diabetes, hyperbaric oxygen, hyperbaric research.

Summary

Hyperbaric oxygen (HBO_2) is commonly used to treat non-healing wounds in diabetic patients. Although anecdotal evidence from hyperbaric centres suggests that diabetics are vulnerable to hypoglycaemia when they are treated with hyperbaric oxygen, there has been little definitive human or animal research showing the effects of hyperbaric oxygen on blood sugar and insulin levels. Blood sugar levels and insulin levels in five diabetic and five non-diabetic subjects were measured both while breathing normobaric air and hyperbaric oxygen . Mean blood sugar levels decreased significantly by 3.5 ± 0.7 mmol/l during hyperbaric oxygen breathing in the five diabetics. Insulin dosage was not changed in either condition.

Introduction

Apart from treatment for diving related illness, hyperbaric oxygen (HBO_2) treatment has therapeutic value in many illnesses including non-healing wounds in diabetics. The use of hyperbaric oxygen treatment for diabetes (but not wounds) has its origins in the 1920s with the American physician Dr Orval J Cunningham, who used hyperbaric oxygen for the treatment of various illnesses (syphilis, pernicious anaemia, and cancer) including diabetes mellitus.[1] Anecdotal evidence from hyperbaric centres shows that diabetics are prone to develop hypoglycaemia when they are exposed to HBO_2.

Blood sugar levels (BSL) decreased in some[2] or all[3] insulin dependent diabetics after HBO_2 treatment. Insulin requirements are reduced during HBO_2.[4] Some additional evidence from underwater diving indicates that the long and short-term insulin requirements of diabetics decreased over a period of 7 days of diving.[5]

Although there is disagreement in the diving medical fraternity, a majority of experts believe that diabetes, mainly insulin dependent diabetes mellitus (IDDM), is a contraindication to recreational and commercial diving because hypoglycaemic signs and symptoms may be confused with other diving maladies, hypoglycaemia can cause unconscious underwater and there may be increased likelihood of decompression illness (DCI) in diabetics.[6-9]

The mechanisms of hypoglycaemia during HBO_2 treatment are unknown, but it has been postulated[10,11] that HBO_2 might:

1 increase tissue oxygen and increase aerobic metabolic energy generation (oxidative phosphorylation), driving up glucose consumption;
2 increase aerobic metabolism in the pancreatic Islets of Langerhans which may stimulate insulin secretion;
3 inhibit the actions of anti-insulin hormones (somatotropin and glucagon); or
4 increase tissue sensitivity to insulin.

BSL have not been previously reported for non-diabetics during HBO_2 treatment. However, if hypoglycaemia occurs during HBO_2 in diabetics but not in non-diabetics, this may result from failure, in diabetics, of the normal protective mechanism. For instance in non-diabetics during exercise, BSL is maintained by decrease in insulin and rise in glucagon and catecholamine levels. These mechanisms fail in some diabetics, mainly in IDDM patients, resulting in hypoglycaemia.[12]

This study investigates BSL and insulin in diabetics and non-diabetics during HBO_2 and normobaric air breathing. The specific hypotheses tested are;

1 HBO_2 increases insulin in diabetics but not in non-diabetics and
2 BSL decrease is a result of increase in insulin.

Method

This study was approved by the Research Ethics Committee of the Royal Adelaide Hospital and was conducted in accord with the National Statement on Ethical Conduct in Research Involving Humans.

Subjects

Five diabetics (3 males and 2 females) gave their informed consent to participate in this study. Four of them received HBO_2 for diabetic foot ulcers and the other for osteoradionecrosis. Mean age of the diabetics was 60 years (range 46–86 years). There were 4 IDDM and 1 Non-insulin Dependent Diabetes Mellitus (NIDDM). The mean diabetic duration was 22 years (range 7-40 years).

Diabetic group inclusion criteria were:

1 diabetes of more than 6 years duration but no hypoglycaemic events for the last 12 months;
2 no contraindication for venipuncture, lignocaine, or heparin;
3 no advanced diabetic complications such as autonomic neuropathy or nephropathy; and no concomitant liver diseases. Autonomic neuropathy was an exclusion criterion because it may mask the signs and symptoms of hypoglycaemia; therefore, patients with orthostatic intolerance (faintness or blood pressure drop on standing) and gastroparesis (nocturnal diarrhoea/ vomiting) were excluded.

Only well-controlled diabetics were selected because they were required to be assessed under hyperbaric oxygen breathing and normobaric air breathing conditions on separate days whilst diet, insulin or oral hypoglycaemics dosage and exercise remained unchanged.

There were 4 males and 1 female in the non-diabetic group and mean age was 65 years (range 53-75 years). Three of them received HBO_2 for sudden onset hearing loss, one for a poorly healing ulcer and one for osteoradionecrosis. The same contraindications as for the diabetics applied to this group. All the patients selected for this study were "medically fit" for HBO_2 treatment and underwent a full course of HBO_2 treatments.

Study design

This study consisted of four arms. Diabetics during normobaric air breathing (control) and during hyperbaric oxygen breathing (HBO_2) conditions, and non-diabetics under same control and HBO_2 conditions. The study occurred on two days. The HBO_2 day was the 3rd, 4th or 5th day of HBO_2 to minimise the other hormonal effects on BSL and insulin levels that might have occurred when subjects were stressed or anxious during first days of HBO.

On the both the control and HBO_2 day all subjects had an 18 gauge intravenous cannula (Insyte®, Becton Dickinson Vascular Access, Sandy, Utah) placed in the antecubital fossa or a forearm vein. The skin was locally anaesthetised with 1% lignocaine (Delta West, Perth, Western Australia) before insertion of cannula. This was connected to a short extension tube (Connecta®, BOC Ohmeda AB, Helsingborg, Sweden) attached to a 3-way tap and pre-filled with 10% heparinised saline (Astra, North Ryde, New South Wales). Five ml of blood was withdrawn to eliminate cannula dead space and then 1 ml blood samples were taken and the cannula flushed with 5 ml of heparinised saline. Samples were taken at 0, 15, 30, 45, 60, 75, 90 and 120 minutes.

The control day of the study took place on the day before the first HBO_2 treatment. It was performed in the Hyperbaric Medicine Unit treatment room. Although study order was not randomised, having the control before HBO_2 was thought to exclude any possible long-term effects of HBO_2 treatment on BSL and insulin.

The HBO_2 treatment protocol was compression to 10 msw (202 kPa or 2 bar) where 100% oxygen was delivered for 90 minutes (with a 5 minutes air break at 45 minutes) and followed by 30 minutes decompression while breathing oxygen. This was the standard daily treatment regimen for the patients' conditions and occurred in the multiplace hyperbaric chamber in the Hyperbaric Medicine Unit, Royal Adelaide Hospital.

On both days each diabetic subject received the same amount of insulin or oral hypoglycaemic and his or her exercise regimen and diet were unchanged. No food or drink was allowed during the two-hour study period. All the subjects were monitored for hypoglycaemia and oxygen toxicity during the treatment but no complications were encountered.

All blood samples were analysed for BSL (Hexokinase Method) and insulin (Abbott Insulin Kit Microparticle Enzyme Immuno Assay) at the Institute of Medical and Veterinary Sciences, Adelaide, South Australia.

Statistical analysis

In statistical analysis, BSL and Insulin data were treated identically. BSL were compared using 3-way analysis of variance (ANOVA) with one between groups factor and two within groups (repeated measures) factors. The between groups factor (diabetes) had two levels (diabetic and non-diabetic). The first within groups factor (oxygen) had two levels (control and HBO_2) and the other within groups factor (time) had 8 levels (0, 15, 30, 45, 60, 75, 90, and 120 minutes).

We rejected the null hypothesis if there was a significant F test (α=0.05) for the main effects of oxygen or time or any interaction of the main factors with time. Specific differences were identified by post-hoc analysis using Tukey honest significant difference.

Statistical calculations were performed using the general linear model module of Statistica for Windows V5.5 (Statsoft Inc., Tusla OK., USA)

Results

The 3-way ANOVA returned significant F tests for the main effects of diabetics and time and the interaction of diabetics and time. Post-hoc analysis showed there were no significant difference in BSL in the non-diabetics (see Figure 1). For diabetics there was no significant difference between mean BSL before HBO_2 and the normobaric control measurements at time 0. As can be seen in Figure 2, BSL declined over the two-hour measurement period under both normobaric (control) and HBO_2 conditions in diabetics, but more rapidly in the latter. Post-hoc analysis showed that this decline was significant for HBO_2 but not for normobaric air breathing. For instance, mean BSLs at all times beyond 45 minutes were significantly lower than mean BSL at time 0 during HBO_2. The mean decline in BSL in the 5 diabetics over the 2 hours was 3.5 ± 0.7 mmol/l. However, there was no significant difference between any time points in the normobaric group.

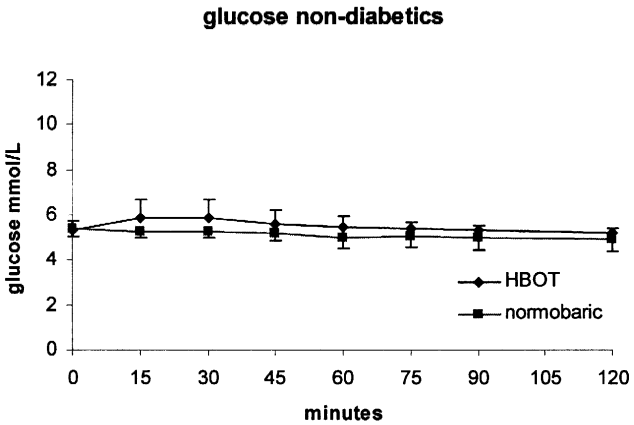

Figure 1. Mean BSL in non-diabetics, mmol/l plasma on the y-axis against duration in minutes of HBO_2 or air breathing on the x-axis. Error bars are one standard error of the mean.

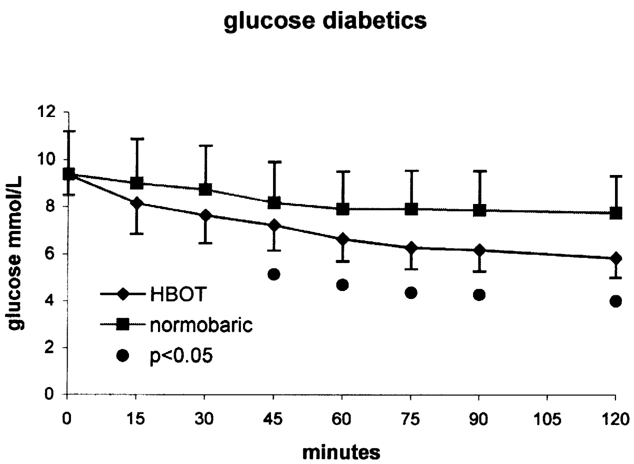

Figure 2. Mean BSL in diabetics, mmol/l plasma on the y-axis against duration in minutes of HBO_2 or air breathing on the x-axis. Error bars are one standard error of the mean. Circles indicate significant difference (2-tailed $p<0.05$) from time 0 for the HBO_2 group.

Insulin

Significant F tests were found for the main effect time and interaction of diabetes x HBO_2. However no consistent pattern emerged from post-hoc analysis as can be seen in Figure 3 and 4 indicating no change in insulin in any group.

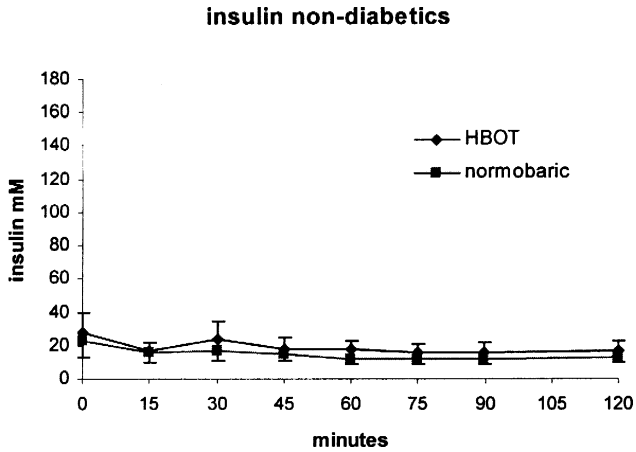

Figure 3. Mean insulin levels in non-diabetics, mU/l serum on the y-axis against duration in minutes HBO_2 or air breathing on the x-axis. Error bars are one standard error of the mean.

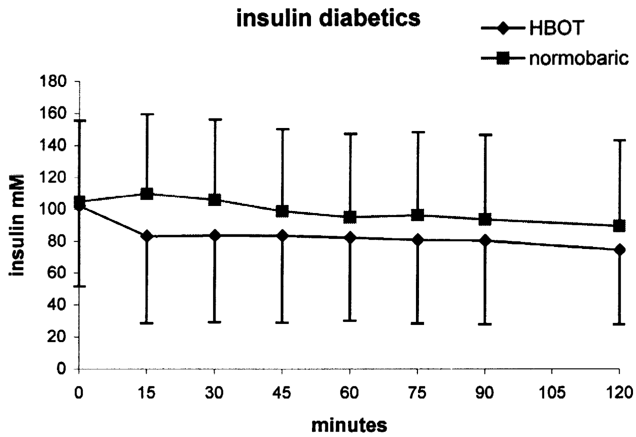

Figure 4. Mean insulin levels in diabetics, mU/l on the y-axis against duration in minutes of HBO_2 or air breathing on the x-axis. Error bars are one standard error of the mean.

One patient had hyperinsulinaemia and this accounts for the large error bars in Figure 4. However excluding this patient resulted in similar statistical conclusions.

Discussion

The decline in BSL in diabetics but not non-diabetics in the present study supports the anecdotal reports of hypoglycaemia in diabetics when they receive HBO_2 treatment.

This study confirms the previous brief reports of decrease BSL. These reported that whole blood glucose concentration decreased by an average of 2.8 mmol/l in 25 IDDM patients[3] and BSL dropped below 100 mg/dl in 26.4% patients after HBO_2 treatment,[2] decreases similar to the present study. However, in a study of diabetic underwater divers, although no hypoglycaemic episodes were encountered due to high BSL maintenance before the dive, insulin requirement dropped significantly with repeated dives.[5]

The high partial pressure of oxygen encountered in diving apparently does not lower serum glucose levels significantly in diabetic divers.[13] However there is a considerable difference in partial pressure of oxygen encountered by underwater divers and HBO_2 patients. In the present study subjects breathed almost 202 kPa (2 bar) oxygen partial pressure in contrast to 74 kPa partial pressure oxygen in the compressed air divers. Also, HBO_2 patients in the present study were at 202 kPa (2 bar) ambient pressure while the compressed gas divers were at 375 kPa (3.7 bar or 27 m) ambient pressure. This comparison confirms that it is the partial pressure of oxygen and not the ambient pressure that is responsible for hypoglycaemia in diabetics.

In the present study the decline in BSL was initially progressive during treatment but reached a plateau towards the end of treatment. This suggests that diabetics may be more vulnerable to hypoglycaemia in the second half of longer HBO_2 treatment protocols. An additional capillary BSL measurement in the middle of treatment might allow intervention to prevent hypoglycaemia in diabetics. However, one must be cautious about the accuracy of in-chamber glucometer testing.[14,15]

The average BSL drop in the five diabetics was 3.5 $\pm$ 0.7 mmol/l over 2 hours in this study indicating that patients with BSL 6 mmol/l or less before treatment would be at the greatest risk of hypoglycaemia during HBO_2 treatment since hypoglycaemic symptoms usually begin at a BSL of less than 2.5 mmol/l. Whether pre-HBO_2 glucose supplementation in such patients might reduce the risk of hypoglycaemia is an area for further study.

There was a non-statistically significant drop in serum insulin levels in diabetics during HBO_2 which may have been secondary to the hypoglycaemia. The fact that insulin levels did not rise excludes of some of the postulated mechanisms for HBO_2 induced hypoglycaemia. First, in Figure 4, the lack of increase in insulin levels in diabetics during HBO_2 indicates there was probably not a stimulation of insulin secretion. Secondly, since insulin levels did not change with HBO_2 in non-diabetics, insulin is not a mechanism of protection against hypoglycaemia in this group as it is in exercise; hypoglycaemia in diabetics cannot be a failure of this mechanism.

However, this study provides no evidence for the other postulated mechanisms of hypoglycaemia during HBO_2: increase aerobic metabolism or inhibition of anti-insulin hormones (somatotropin and glucagon).

It could be argued that BSL would be influenced by stress related to the HBO_2. However, it would be expected that stress hormones (catecholamines, cortisol, growth hormones etc.) would elevate BSL. In the present study, there was no rise in BSL. This suggests that there were no stress-related hormonal effects in either group under HBO_2 or normobaric conditions. However, direct measurement of stress hormones should be the subject of another study.

Conclusions

HBO_2 reduces BSL in diabetics by a mechanism other than insulin. Control of BSL is extremely important during HBO_2 treatment since signs and symptoms of hypoglycaemia mimic oxygen toxicity and can lead to convulsions or even unconsciousness in the chamber. Furthermore, patients with diabetic autonomic neuropathy with inadequate somatotropin response to hypoglycaemia may not manifest the warning autonomic symptoms, which normally precede those of central nervous system dysfunction (sweating, shaking, palpitation, paraesthesia, numbness etc).

Pre-HBO_2 glucose supplementation in any diabetic with pre-HBO_2 BSL of 6 mmol/l or lower and capillary BSL testing at the middle of HBO_2 treatment in diabetics may reduce the in-chamber risk of hypoglycaemia in diabetics.

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EFFECTS OF RECREATIONAL DIVING ON ATTENTION: A Preliminary Study

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Key Words

Recreational diving, research, risk, safety.

Abstract

The neuropsychological functions of healthy recreational divers with varied cumulative diving experience and across repetitive dives have not been investigated. This preliminary study was conducted:

1 to determine attentional and concentrational levels in a group of healthy recreational divers,
2 to investigate the effects of years of diving experience on attentional and concentrational skills, and
3 to test the effects of repetitive recreational dives on attentional and concentrational levels.

The subjects consisted of 22 individuals aged between 16 to 71. The mean years of diving experience was eight years. A battery of Digit Span Forward, Digit Span Backward, and the Stroop Test was administered before and after the first and second dive on sport dive boats. Our results revealed that attentional and concentrational skills of healthy recreational divers generally fell within normal limits, were unrelated to years of cumulative diving experience, and were not compromised across repetitive recreational dives.

Introduction

Previous studies have not investigated attentional and concentrational skills in healthy recreational divers. In addition, there have been no studies examining effects of years of cumulative diving experience and repetitive dives on neuropsychological functioning levels.

Most diving studies have focused on divers who have suffered from decompression sickness (DCS). Results of these studies have been contradictory. Specifically, selective neuropsychological deficits have been identified in professional divers with focal neurological manifestations of DCS.[1-3] On the other hand, Andrews et al.[4] found no evidence of cognitive impairment in abalone divers who showed evidence of DCS. While measures assessing attentional and concentrational skills were not directly administered, these functions are important to examine since they underlie all cognitive skills. Intact attentional and concentrational skills are necessary for safe self-monitoring of diving protocols. Andrews et al. suggested that professional and recreational divers who follow the appropriate safety protocols should not be at risk for progressive brain damage resulting from diving.

Neuropsychological functioning has not been thoroughly investigated in recreational divers. For example, Levin et al.[5] reported on two divers who were administered limited neuropsychological tests and neuroradiological examinations within the first month of sustaining DCS. These patients had negative medical and psychiatric histories before their episodes of DCS. Magnetic resonance imaging (MRI) results revealed paraventricular and subcortical white matter lesions in both patients. The neuropsychological screening indicated compromises across measures sensitive to information processing skills, visual-motor skills and selective verbal memory skills, as well as verbal and non-verbal fluency skills. The potential negative effects of depression and anxiety on cognitive skills were not fully considered.

Levin and colleagues were uncertain as to whether the MRI findings reflected the DCS injuries or the combined effects of acute illness, cumulative diving experience, or other cerebral insults.[5] They suggested that neuropsychological testing and serial MRIs be performed on a control group of divers without DCS in order to differentiate injury effects from chronic diving-related neurological insults. It is unknown whether there are chronic diving-related neurological insults in divers without evidence of DCS.

This study was designed to determine whether attentional and concentrational skills, foundational components of all cognitive skills, are compromised in healthy recreational divers with varied years of cumulative diving experience and across repetitive dives. It is hypothesised that attentional and concentrational skills of healthy recreational divers are within normal limits, are unrelated to cumulative diving experience, and are not compromised across repetitive dives.

Methods

SUBJECTS

The subjects consisted of 22 healthy, right-handed adult divers recruited from sport diving boats. Criteria for exclusion included a self-reported history of:

1 diving accidents,
2 psychiatric disorder,
3 learning disability,
4 epilepsy,
5 asthma within the past five years,
6 unresolved syncopal episodes,
7 chronic obstructive pulmonary disease,
8 spontaneous pneumothorax,
9 myocardial infarct within one year,
10 significant arrhythmia,
11 insulin-dependent diabetes,
12 demyelinating disease,
13 or substance use or abuse.

All subjects signed statements that they had not consumed a controlled substance nor alcohol for at least 24 hours before the testing. All subjects who answered "yes" on any of the above criteria were excluded from the study. All subjects reported no evidence of remarkable ongoing pathology with respect to ears, eyes, nose and throat, cardiovascular, respiratory, gastrointestinal, neurologic, or psychological systems. None of the female subjects indicated that they were pregnant. The demographic and diving parameters of the study group are shown in Table 1.

TABLE 1
DEMOGRAPHICS AND DIVING PARAMETERS OF SUBJECTS

Characteristic or Parameter	N	Mean	(±SD)	Range
Number of subjects	22			
Gender				
Male	14			
Female	8			
Education (years)		15.4	(±2.7)	10-22
Age at testing (years)		35.3	(±12.5)	16-71
Diving experience (years)		8.0	(±7.3)	1-26
Dive time dive 1 (minutes)		41.0	(±11.2)	24-69
Dive time dive 2 (minutes)		38.7	(±12.1)	9-68
Depth of dive 1 (m)		12.7	(±3.8)	8.2-18.2
Depth of dive 2 (m)		15.2	(±2.8)	10.4-19.8

INSTRUMENTS

A history and demographic questionnaire was used to determine if the subjects met the criteria for inclusion in the study. Five neuropsychological tests, sensitive to brief and sustained attentional and concentrational skills, were administered before and after the initial dive (dive 1) and after the second dive (dive 2).

The tests administered specifically assess attentional and concentrational skills. Digit Span is sensitive to general brain dysfunction and is considered a classic measure of attention.[6,7] The Digit Span Forward test taps passive and brief attentional and concentrational skills whereas the Digit Span Backward test relies on "working memory".[8,9] This latter task also involves double-tracking in that both the subject's memory and the reversal of the operation must work simultaneously. The Stroop Test is a selective executive systems measure that documents information processing speed, inhibition of habitual responses and the maintenance of a course of action despite visual distracters. The following cognitive measures were used:

1 Digit Span Forward: Digit Span Forward is a sub-test used in the Wechsler Adult Intelligence Scale – Revised .[9] The subject's task is to repeat two sequences of digits exactly as they are read by the examiner. When a sequence is repeated correctly, the examiner reads the next longer number sequence, continuing until the subject either fails a pair of same length number |sequences or repeats a nine-digit sequence correctly. The score utilised for this study is the maximum number of digits correctly repeated.

2 Digit Span Backward: Digit Span Backward is also a sub-test of the Wechsler Adult Intelligence Scale – Revised.[9] Digit Span Backward number sequences are two to eight digits long. The subject's task is to say a

sequence in reverse order after the examiner presents it. The test continues until the subject either fails a pair of same length sequences or correctly recalls eight digits in reverse order. The score utilised of this study is the maximum number of digits correctly repeated.

3 Stroop Test:[10] The test contains three parts. First, the subject is asked to read a 100 word list of colour names (blue, red, and green) printed in black ink as rapidly as possible (Stroop A). Then, the subject is asked to name the colour of 100 coloured blocks of ink as rapidly as possible (Stroop B). Last, the subject is required to name the colour of the ink in which the work is printed as rapidly as possible (Stroop C). This latter sub-test of the Stroop is the "interference" sub-test since the words are colour names printed in ink of a different colour (e.g., the word "green" is printed in red ink and the correct answer is "red"). Each of the individual subtests is timed. The score is the time to complete each sub-test.

Procedures

All subjects were administered the demographic information sheet, Digit Span Forward, Digit Span Backward, and the three sub-sets of the Stroop Test prior to the first dive by two experienced test examiners (Predive). The tests were also administered after dive 1 and dive 2 (Post-dive 1 and Post-dive 2, respectively). Immediately after each dive, subjects indicated the depth and actual dive time. In addition, the surface interval time was recorded for all subjects. The depth and time figures were confirmed with the diving tables as originally recorded by the dive master aboard the dive boats.

Statistical analysis

Intercorrelations between the dependent neuropsychological measures and diving experience listed in Table 2 were obtained using Pearson product-moment correlation analysis to predict whether cumulative diving experience affects neuropsychological performance. Independent sample t-tests were performed on the dependent measures grouped by gender. One-way analysis of variance with repeated measures was performed to determine the effects of repetitive dives. One-way analysis of covariance with repeated measures was performed to determine the effects of repetitive dives while statistically controlling for effects of the correlated diving parameter.

Results

HYPOTHESIS 1

Attentional and concentrational skills of healthy divers are within normal limits.

Analysis of individual scores predive indicates that all subjects performed within normal limits on all measures with the exception of one subject whose Stroop B performance and two subjects whose Stroop C performances were impaired for their ages (Table 2).

HYPOTHESIS 2

Attentional and concentrational skills of healthy divers are unrelated to years of cumulative diving experience.

Of the five measures collected over three time frames, only Digit Span Forward Post-dive 2 and years of diving experience were significantly correlated (r = +0.441, p = 0.040). Therefore, in subsequent analyses of Digit Span Forward the effects of the covariate years of diving experience were statistically controlled.

HYPOTHESIS 3

Attentional and concentrational skills of healthy recreational divers are not compromised across repetitive dives.

TABLE 2
PEARSON PRODUCT-MOMENT CORRELATIONS AND PROBABILITIES BETWEEN YEARS OF DIVING EXPERIENCE AND NEUROPSYCHOLOGICAL MEASURES COLLECTED OVER THREE TIME FRAMES

Measure	Predive r	(p-value)	Post Dive 1 r	(p-value)	Post Dive 2 r	(p-value)
WAIS-R[9]						
Digit Span Forward	0.222	(ns)	-0.074	(ns)	0.441	(0.040)
Digit Span Backward	0.084	(ns)	0.232	(ns)	0.075	(ns)
Stroop[10]						
A	0.079	(ns)	0.268	(ns)	0.243	(ns)
B	-0.001	(ns)	0.045	(ns)	0.005	(ns)
C	-0.196	(ns)	-0.193	(ns)	-0.050	(ns)

TABLE 3

OVERALL ANOVA OR ANOCOV AND SPECIFIC COMPARISON RESULTS OF NEUROPSYCHOLOGICAL TEST PERFORMANCE ON REPEATED TESTING

	Overall ANOVA or ANOCOV			Specific Comparison ANOVA or ANOCOV								
				Predive v Post Dive 1			Predive v Post Dive 2			Post Dive 1 v Post Dive 2		
Measure	**F**	**df**	**P**	**F**	**df**	**P**	**F**	**df**	**P**	**F**	**df**	**P**
WAIS-R[9]												
Digit Span Forward*	2.85	2,40	0.07	4.53	1,20	0.046	5.63	1,20	0.028	0.25	1,20	ns
Digit Span Back	2.22	2,42	ns	—	—	—	—	—	—	—	—	—
Stroop[10]												
A	1.68	2,42	ns	—	—	—	—	—	—	—	—	—
B	5.40	2,42	0.008	6.96	1,21	0.015	7.12	1,21	0.014	0.10	1,21	ns
C	15.08	2,42	0.000	14.11	1,21	0.001	18.84	1,21	0.000	4.87	1,21	0.039

*The effects of years of diving experience were statistically removed in the analysis of Digit Span Forward.

Digit Span Forward and Digit Span Backward: Results of ANOVA and ANOCOV are shown in Table 3. One-way analysis of covariance with repeated measures controlling for diving experience revealed a trend for repetitive dive effects for Digit Span Forward [F (2, 40) = 2.85, P<0.07]. Specific comparisons showed that when diving experience was statistically controlled, subjects had lower Digit Span Forward scores Predive than Post Dive 1 and Post Dive 2 [F (1,20) = 4.53, P<0.046; F (1,20 = 5.63, P<0.028], respectively, as illustrated in Figure 1. Digit Span Backward was not significant overall across repetitive dives.

Stroop Test: Results of the statistical analyses of the three Stroop sub-tests are presented in Table 3. One-way analysis of variance with repeated measures showed no significant repetitive dive effect for Stroop A. However, significant repetitive dive effects for Stroop B and C were revealed with one-way analysis of variance with repeated measures [F (2, 42) = 5.40, P < 0.01; F (2,42) = 15.08, P < 0.0000]. Figure 2 shows that subjects had significantly faster times to completion for Stroop B and Stroop C for each progressive dive. Stroop B statistical results were: [Predive versus Post Dive 1: F (1,21) = 6.96, P < .015; Predive versus Post Dive 2: F (1,21) = 7.12, P < 0.014]. Stroop C statistical results were: [Predive versus Post Dive 1: F (1,21) = 14.11, P < 0.0001; Predive versus Post Dive 2: F (1,21) = 18.84, P < 0.000]; and [Post Dive 1 versus Post Dive 2: F (1,21) = 4.87, P < 0.039].

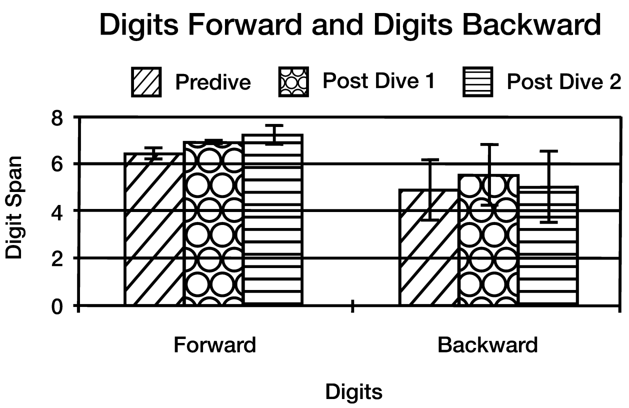

Figure 1. Adjusted means and standard deviations of Digit Span Forward and means and standard deviations of Digit Span Backward before and after two repetitive dives are illustrated. Performances on Digit Span Forward were adjusted for effects of diving experience.

Discussion

An earlier study noted the need to study the cognitive status of healthy divers in order to differentiate injury effects from chronic diving-related neurologic insults.[5] This investigation was designed to determine whether attentional and concentrational skills of healthy

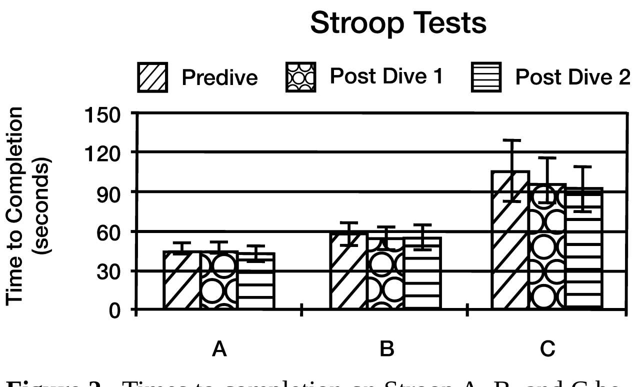

Figure 2. Times to completion on Stroop A, B, and C before and after two repetitive dives are shown. Means and standard deviations are plotted.

recreational divers fall within normal limits and whether these skills are compromised with varied years of cumulative diving experience and across repetitive dives.

Our findings indicate that most subjects performed within normal limits on measures sensitive to attentional and concentrational skills. While each of three subjects had one impaired score, more than 97% of all scores were within normal limits. Therefore, healthy recreational divers with varied years of diving experience generally had intact attentional and concentrational skills at baseline testing. In general, there was no relationship between cumulative diving experience and attentional and concentrational skills. However, there was a positive relationship between years of diving and one task tapping passive attentional and concentrational skills, Digits Forward Post Dive 2. The nature of this relationship is unclear, with further research needed to clarify the association.

The results also revealed that test scores were intact across repetitive dives. Specifically, measures tapping brief attentional and concentrational skills and sustained attentional and concentrational skills with and without interference fell within normal limits. While these findings confirm the hypothesis, there were unanticipated results: subjects' performances improved on both sustained attentional and concentrational measures with and without interference (Stroop B and Stroop C) and on a selective brief attentional and concentrational measure (Digit Span Forward) across repetitive dives.

Such improvement on selective attentional measures is atypical given the task demand of each measure. One might expect factors such as overall practice effects to generalise to all measures. However, our subjects improved not only on the least demanding task in the battery (Digits Forward) but also on the most rigorous attentional measure (Stroop C). The fact that these measures and Stroop B significantly improved across repetitive dives while Digit Span Backward and Stroop A did not improve leads one to analyse the task demands of each measure. Digit Span Backward involves more than the attentional and concentrational demands of the other tasks. Specifically, Digit Span Backward involves working memory as well as attentional span. This task taps double-tracking skills, that is, both memory and the reversing operations must proceed simultaneously.[6] Such memory skills are less impacted by practice effects because each trial is unfamiliar. Most tests that are affected by practice are those that have a speed component and a single solution. Digit Span Backward does not. However, Stroop A is a speed sensitive test in which one would expect a practice effect. It is unclear why improvement over repetitive Stroop A testing was not observed.

The fact that repetitive diving does not adversely affect attentional and concentrational skills has significant implications for divers' ability to follow safety protocols. This implies that healthy recreational divers making two dives during the course of a day should be able to maintain the necessary attention and concentration to self-monitor their diving profiles.

Limitations of study and future research directions

1 While this was the first preliminary study reported in the literature looking at healthy recreational divers' attentional and concentrational skills, other cognitive functions such as intellectual level, language, motor, sensory-perceptual, constructional, visual perceptual, memory, planning, and organisational skills were not examined. In addition, psychiatric variables were not objectively measured. Further investigation of this population is needed to better understand these cognitive and social-emotional factors.

2 A non-diving control group was not tested. Control group comparisons would determine whether the unanticipated improvement in selective attentional and concentrational performance across repetitive testing could be explained by a practice effect rather than a repetitive diving effect.

3 A replication study with a larger sample size that includes healthy recreational divers with more years of diving experience and assessment of other cognitive functions would be an important addition to the current study. Such a study would aid in the development of a more comprehensive understanding of the possible negative effects of cumulative diving experience and unstressful repetitive diving among healthy recreational divers. The positive relationship between years of diving and selective attentional and attentional skills should be further investigated by such future research.

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Acknowledgments

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SENSATION SEEKING PERSONALITY TRAITS OF RECREATIONAL SCUBA DIVERS

David McD Taylor, Kevin S O'Toole, Thomas E Auble, Christopher M Ryan and David R Sherman

Key words

Air, recreational diving, personality.

Abstract

Objectives

The sensation seeking personality traits of recreational scuba divers are poorly understood. This study aimed to use a validated measure to determine the extent to which divers' sensation seeking traits differ from the general population.

Methods

Thirty experienced recreational scuba divers were enrolled. Their sensation seeking traits, including thrill and adventure (TAS) and experience seeking (ES), disinhibition (DIS) and boredom susceptibility (BS), were assessed with the Sensation Seeking Scale, Form V.

Results

The divers scored significantly higher than the reference population on both the TAS and ES sub-scales ($p<0.001$ and $p=0.003$, respectively), and significantly lower ($p=0.010$) on the BS sub-scale. There was a trend for the divers to score lower on the DIS sub-scale ($p=0.076$). There was no difference between the divers and the reference population on "total" sensation seeking score ($p=0.511$).

Discussion

Divers in the study were thrill, adventure and experience seekers but not overall sensation seekers. The TAS and ES findings are consistent with the results of other studies of individuals who engage in risky sports. The DIS, BS and "total" score findings do not show this consistency and are attributed to the older age and more "establishment" personalities of our divers. Larger studies are required to further investigate diver sensation seeking and to compare subgroups within the diving population.

Introduction

In an extensive review of the role of personality in sports, Eysenck et al. concluded that those who engage in sports tend to be more extroverted than non-participants.[1] The relation between extroversion and sports is said to be mediated by narrower traits like sensation seeking, assertiveness, competitiveness, impulsiveness and high pain thresholds.[2]

Previous research has demonstrated that individuals who are currently active in risky sports, such as climbing, skiing and parachuting, are also likely to manifest higher levels of the psychological trait known as sensation seeking.[2-9] This trait has been characterised as a tendency to seek novel experiences that are varied, complex, lead to intense subjective feelings (e.g. a "rush"), and are associated with higher rates of risk-taking (physical, social, legal and financial).[2]

One might expect that recreational scuba divers, as a group, would also have elevated levels of sensation seeking in so far as scuba diving could reasonably be classified as a "risky" sport.[10] Not only are elevated rates of morbidity and mortality associated with diving related injuries (e.g. decompression illness, gas embolism and barotrauma) but exposure injuries (e.g. hypothermia, drowning and marine animal injuries) also occur.[10]

Although we were able to identify only one small study on the sensation seeking psychological characteristics of scuba divers,[4] one would expect that recreational divers, like other participants in risky sports, would score highly on measures of sensation seeking. The primary aim of this descriptive study is to use the Sensation Seeking Scale, Form V (SSS)[11] to determine the extent to which scuba divers differ from the general (reference) population on four components of sensation seeking.

Methods

The study was conducted in the Hyperbaric Unit of the University of Pittsburgh Medical Center (UPMC), Pennsylvania, USA, and approved by the Institutional Review Board of the University of Pittsburgh.

It was part of a larger study examining drugs in the hyperbaric environment that ran from March 1998 until March 1999. In this part of the study, subjects were examined under normobaric conditions and after the ingestion of one of the study drugs (pseudoephedrine, dimenhydrinate, placebo). These drugs were unlikely to affect the subjects' sensation seeking responses.

Thirty subjects were recruited, by word of mouth, from the local dive clubs and the UPMC medical and nursing staff. The subjects were required to be active scuba divers aged 18 years or more. Demographic and diving experience data was collected from each subject using a standard proforma.

Sensation seeking was assessed with the SSS developed by Zuckerman and his associates.[11] This self-administered questionnaire comprises 40 pairs of forced-choice alternatives and subjects are asked to choose which of the two statements best describes their interests and preferences. For example:

Item 3
- a) I often wish I could be a mountain climber
- b) I can't understand people who risk their necks climbing mountains

Item 24
- a) I prefer friends who are excitingly unpredictable
- b) I prefer friends who are reliable and predictable.

Items are assigned to one of four sub-scales that were previously identified empirically using factor analysis techniques. Each sub-scale is composed of 10 item pairs. The "Thrill and Adventure Seeking" (TAS) scale includes items that reflect a desire to engage in sports or other physically risky activities that yield sensations of speed or other atypical physical sensations (e.g. defy gravity). The "Experience Seeking" (ES) scale focuses on the desire to seek intellectually stimulating experiences (e.g. travel) or engage in socially nonconformist or rebellious activities. The "Disinhibition" (DIS) scale measures interest in engaging in exciting and/or unconventional social activities (e.g. wild uninhibited parties and excessive alcohol or drug use). The "Boredom Susceptibility" (BS) scale incorporates items that deal with routine or boring activities or people. The psychometric properties of the SSS are good, with internal reliabilities ranging from 0.56 – 0.65 (BS) to 0.77 – 0.82 (TAS) and 0.83 – 0.86 (total score). The three-week test-retest reliability is 0.94. The reference population, against which other groups are compared, is a group of 1,217 university psychology students. A detailed summary of the SSS can be found elsewhere.[2]

The SSS provided four sub-scale raw scores (0 to 10) and a total raw score (0 to 40). These raw scores were converted to T scores using the published norms.[2] These data were compared with the reference population values (mean ± SD: 50 ±10) using 1-sample t-tests (df = 29, two-tailed, level of significance 0.05).

It was considered that intelligence might be a confounder in this study. Hence, an estimate of each subject's intelligence quotient (IQ) was made using two sub-tests of the Wechsler Adult Intelligence Scale, Revised (WAIS-R).[12] The "Vocabulary" sub-test assessed the subjects' comprehension of 35 words. The "Block Design" sub-test assessed visuo-constructional and problem-solving abilities as subjects were timed while arranging blocks to correspond to a printed design.

Results

There were 19 male and 11 female study subjects. Mean age was 38.1 ± 10.9 years (range: 24-68). The mean years of diving was 8.9 ± 7.3 years (range: 1-30) and the mean number of dives was 188 ± 317 (range: 6-1,460). Mean subject IQ (adjusted for age) was 122.0 ± 10.8 (range: 97-139).

TABLE 1

MEAN SUBJECT SENSATION SEEKING SCALE AND SUB-SCALE RAW SCORES AND STATISTICAL ANALYSES (N=30)

Scale[1]	Raw score (mean±SD)	T score[2] (mean±SD)	Mean difference between subjects and reference population T scores	p value
TAS	8.5±1.5	55.2±5.5	+5.2 (95% CIs: 3.1, 7.3)	0.000
ES	6.1±1.7	54.5±7.6	+4.5 (95% CIs: 1.6, 7.3)	0.003
DIS	5.1±2.5	46.7±9.9	3.3 (95% CIs: -7.0, 0.4)	0.076
BS	2.7±1.6	46.0±8.1	-4.0 (95% CIs: -7.0, -1.0)	0.010
SSS	22.5±5.4	51.1±9.1	+1.1 (95% CIs: -2.3, 4.5)	0.511

Notes

1 TAS = thrill/adventure seeking, ES = experience seeking, DIS = disinhibition, BS = boredom susceptibility and SSS = sensation seeking scale (total of the four sub-scales)

2 The T score is calculated from the raw score. Reference population T score = 50±10

The results and the statistical analyses are presented in Table 1. The divers scored significantly higher than the reference population on both the TAS and ES sub-scales ($p<0.001$ and $p=0.003$, respectively), and significantly lower ($p=0.010$) on the BS sub-scale. There was a trend for the divers to score lower on the DIS sub-scale ($p=0.076$). There was no difference between the divers and the reference population on "total" sensation seeking score ($p=0.511$).

Discussion

As a group, our sample of recreational scuba divers was more likely than the reference population to endorse items indicative of seeking thrills, adventures and new experiences. These results are consistent with the results of other studies of individuals who engage in risky sports (e.g. bungy jumping, ski jumping and mountain climbing).[3-9] For example, Breivic found mean TAS scores of 8.3-9.1 and mean ES scores of 6.4-8.6 among white water canoeists, elite expedition climbers and parachutists.[4]

However, in contrast to these other high risk sports groups, our scuba divers scored significantly lower on BS than the reference population and showed a trend towards lower scores on DIS. One possible reason for these disparities may be demographic. Our sample tended to be older than most high risk sports participants. Also, most of our subjects were professionally employed and had a high IQ. Hence, the group may not have been representative of recreational divers overall.

It is plausible that our subjects were more "main-stream" or "establishment" personalities who would be less likely to endorse the types of items that are characteristic of high DIS scores (e.g. "enjoying the company of swingers" or "keeping the drinks full is the key to a good party") and more likely to endorse items that are characteristic of low BS scores (e.g. "I enjoy looking at home movies and travel slides" or "I enjoy spending time in the familiar surroundings of home").

Our failure to find a significant increase in total sensation seeking score was unexpected. Other studies have found high total scores among participants of risky sports.[2-9] Breivic found total scores of 24.8-28.7 in his study of canoeists, climbers and parachutists.[4] Although the total score for divers in his study (22.0) was similar to ours, Breivic examined only five divers.[4] Our finding may be an artefact of the additive nature of the total score calculation: the significantly elevated TAS and ES scores were cancelled out by the significant or near significant lower than normal DIS and BS scores.

This study had several limitations. Most of the subjects were experienced recreational scuba divers as evidenced by the number of years they had been diving and the large number of dives they had done. However, the group may not have been representative of experienced recreational divers overall. Also, the small sample size may have further contributed to selection bias. Finally, the student population used in the SSS to determine the reference standard may not have been representative of the general population.

It is recommended that the study be repeated using a much larger sample size and with subjects enrolled from populations with differing demographic, geographic and experience characteristics. Alternatively, a moderate number of divers could be compared to a control group matched for age, gender, education and socio-economic status. The sensation seeking personality traits of novice and experienced divers should be compared. It is well recognised that only a small proportion of those who complete scuba diving training continue as active divers for more than 12 months. It may be that personality traits contribute in selecting out divers who continue in the sport. Furthermore, a comparison between male and female divers would be of interest. It has been shown that, in activities where most of the volunteer participants tend to be men (like scuba diving), the women who do participate score much higher on the SSS score than other women, and the differences are larger than those found between male participants and male norms.[2]

Conclusions

Divers in this study were thrill, adventure and experience seekers but not overall sensation seekers. Larger studies are required to further investigate diver sensation seeking and to compare subgroups within the diving population.

Sources of Funding

The study was supported by a grant from the Pittsburgh Emergency Medicine Foundation.

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THE WORLD AS IT IS

THE EUROPEAN COLLEGE OF BAROMEDICINE

Ramiro Cali-Corleo and Peter HJ Mueller

Key Words

Hyperbaric research, qualifications, training, underwater medicine.

History was made at the Annual Scientific Meeting 2000 of the European Underwater and Baromedical Society (EUBS) September 14-17 in Malta with the foundation of the European College of Baromedicine.

Introduction

The concept of setting up an international academic institution with the aim of sustaining and improving the academic and professional qualifications of all those working in the field of underwater, aerospace and hyperbaric medicine has been supported by many of the members of EUBS.

The European Committee for Hyperbaric Medicine (ECHM) and the European Diving Technology Committee (EDTC) have been working to create harmonised European standards and the formation of a College to carry on this work and to provide for the requirements of modern medical science is a natural progession. A College would also enhance the credibility of Baromedicine in both national and international medical and political spheres.

The beginning

In 1999, during the EUBS annual meeting in Israel, a steering committee was formed with the task of putting together the necessary instruments and structures, such as statutes, registrations and working committees, with the ambitious target of setting up and launching the College in the following year.

The result

The College Steering Committee, under the Chairmanship of Professor Francis Wattel from France, succeeded in its task and during its first formal meeting the statute and statutory instruments were approved and the first College Council elected. The officers and members of the first Council and their positions are displayed in the box in the next column.

President
Prof. Francis Wattel (France)

Secretary General
Prof. Alessandro Marroni (Italy)

Secretary Academic Affairs
Prof. Daniel Mathieu (France)

Registrar
Dr. Ramiro Cali-Corleo (Malta)

Members
Dr. Costantino Balestra (Belgium)
Dr. Dirk Bakker (The Netherlands)
Prof. Peter Bennett (USA)
Prof. Alf Brubakk (Norway)
Prof. Giancarlo Cianfrone (Italy)
Dr. Jordi Desola (Spain)
Prof. David Elliott (United Kingdom)
Prof. Tomislav Jovanovic (Yugoslavia)
Prof. Igor Mekjavic (Slovenia)
Dr. Yehuda Melamed (Israel)
Dr. Joerg Schmutz (Switzerland)
Dr. Juerg Wendling (Switzerland)

The first General Meeting of the new College of Baromedicine was held at the beginning of the afternoon session of the Annual Scientific Meeting 2000 of EUBS on Saturday 16th September. After Professor Wattel addressed the meeting Dr Cali-Corleo gave a presentation on the structure, functions and aims of the College. At the end of the presentation, the attendees were invited to declare their interest to form part of the College by completing a form. The presentation was very well received and over 80 individuals completed and handed in a declaration of interest form. They will be sent more information from the College as well as a request for details of their professional status.

Aims and objectives of the College

The College is intended to function primarily as a certifying and registration body working with already established, and supporting new, academic and training institutions. Its primary and principal objective is encouraging, fostering and maintaining the highest possible standards in the teaching and practice of pressure related medicine as advocated by the European Committee for Hyperbaric Medicine.

The College will be working towards sustaining and improving the academic and professional qualifications of its members and for that purpose will be organising and supporting courses, examinations and continued medical education seminars. It will also take, or join with others in taking, any steps consistent with these activities such as the granting of diplomas or other certificates of proficiency or standards as an academic institution in its own right or jointly with universities and other academic bodies.

The College does not aim to replace or compete with national universities and training institutions but plans to work with them. This work will be especially important in those countries that are unable to sustain a regular academic program in Baromedicine due to the small numbers of applicants at any one time as well as the difficulties in putting together a faculty of experts to train them.

Another of its main aims is to safeguard, protect and promote the professional interests of its members. It will ensure that the speciality is coherent with present and future National and European regulations, especially with regard to the practice of the speciality. One of these requirements is the creation of a specialist register in Baromedicine. It will also conduct, direct, encourage, support or provide for research in matters relating to Baromedicine and promote publication.

Any person wishing to learn more about the College is invited to contact

Professor Marroni or
Dr Cali-Corleo
at the DAN Europe Foundation address:

Enfin, Marmora Str, St Julians SGN 10, MALTA
E-mail: <irocali@daneurope.org>.

Correspondence to Dr. med. Peter HJ Mueller, Editor, European Journal of Underwater and Hyperbaric Medicine (EJUHM). Dr Mueller's address is C/o HBO Rhein-Neckar, Speyerer Strasse 91-93, D-68163 Mannheim, Germany. E-mail <eubs@hbo-mannheim.de>.

SOUTH PACIFIC UNDERWATER MEDICINE SOCIETY NOTICES

South Pacific Underwater Medicine Society Diploma of Diving and Hyperbaric Medicine

Requirements for candidates

In order for the Diploma of Diving and Hyperbaric Medicine to be awarded by the society, the candidate must comply with the following conditions:

1 The candidate must be a financial member of the Society.
2 The candidate must supply evidence of satisfactory completion of examined courses in both Basic and Advanced Course in Diving and Hyperbaric Medicine at an approved institution.
3 The candidate must have completed the equivalent (as determined by the Education Officer) of at least six months full time training in an approved Hyperbaric Medicine Unit.
4 The candidate must submit a written research proposal in a standard format for approval by the Education Officer before commencing their research project.
5 The candidate must produce, to the satisfaction of the Education Officer, a written report on the approved research project, in the form of a scientific paper suitable for publication.

Additional information

The candidate must contact the Education Officer to advise of their intended candidacy, seek approval of their courses in Diving and Hyperbaric Medicine and training time in the intended Hyperbaric Medicine Unit, discuss the proposed subject matter of their research proposed, and obtain instructions before submitting any written material or commencing a research project.

All research reports must clearly test a hypothesis. Preference will be given to reports of original basic or clinical research. Case series reports may be acceptable if thoroughly documented, subject to quantitative analysis, and the subject is extensively researched and discussed in detail. Reports of a single case are insufficient. Review articles may be acceptable if the world literature is thoroughly analysed and discussed, and the subject has not recently been similarly reviewed. Previously published material will not be considered.

It is expected that all research will be conducted in accordance with the "Joint NH&MRC/AVCC statement and guidelines on research practice" (available at http://www.health.gov.au/nhmrc/research/nhmrcavc.htm). All research involving humans or animals must be accompanied by documentary evidence of approval by an appropriate research ethics committee. It is expected that research project and the written report will be primarily the work of the candidate.

The Education Officer reserves the right to modify any of these requirements from time to time.

The Education Officer's address is Dr David Doolette, Department of Anaesthesia and Intensive Care, The University of Adelaide, Adelaide, South Australia 5005. Telephone (0)8-8303-6382. Fax (0)8-8303-3909. E-mail <David.Doolette@adelaide.edu.au>.

THE 2001 ANNUAL SCIENTIFIC MEETING of the South Pacific Underwater Medicine Society

will be held from
May 26th to June 2nd 2001
in
Madang, Papua New Guinea

Guest speaker
Dr James Francis

Due to circumstances beyond our control
Dr Craig Conoscenti
will not be speaking at this meeting

Convenor Dr Guy Williams

Theme
Diving and the Lung

Workshop
Drowning/Near Drowning

Members wishing to present papers should contact
Dr Guy Williams
PO Box 190 Red Hill South
Victoria 3937, Australia
Tel + 61-(0)3-5981-1555 Fax + 61-(0)3-5981-2213
E-mail <guyw@surf.net.au>

Official Travel Agent is Allways Dive Expeditions
168 High Street
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Tel + 61-(0)3-9885-8863
Toll Free 1800-338-239
Fax + 61-(0)3-9885-1164
E-mail <allwaysdive@atlasmail.com>

MINUTES OF THE SPUMS EXECUTIVE COMMITTEE MEETING

held at the HTNA meeting in Brisbane on 2000/9/10

Opened 0915

Present

Drs R Walker (President), G Williams (Immediate Past-President), C Meehan (Secretary), J Knight (Editor), C Acott, D Walker (Committee Members), M Bennett (ANZHMG Representative)

Apologies

P Dupont (Treasurer), D Doolette (Education Officer), S Mitchell (Committee Member)

1 Minutes of the previous meeting (May 2000)

Moved that the minutes be accepted as a true record. Proposed J Knight, seconded D Walker, carried.

2 Matters arising from the minutes

2.1 Job description of the Convener.
A statement on the allocation of FOC (free of charge) airline seats and hotel rooms should be included, as well as discussion about providing a dive guide if necessary. Dr G Williams will do this and then circulate to the committee for comment.

2.2 Update on the SPUMS website given by the SPUMS administrator, Steve Goble, and Dr C Meehan. S Goble can now update most of the pages on the site, although some further software needs to be purchased. The home page has been redesigned to make movement around the site more efficient and this will soon be posted. The Journal index, which is downloadable, cannot be on the website as a searchable database except at considerable expense. Discussion has been made on the setting up of a new active server for the ANZ HMG. The Journal index could be housed on this site, along with Dr M Bennett's journal evaluations database.

2.3 SPUMS dive medical will soon be placed on the website in Adobe Acrobat portable document format (PDF) which will be accessible to those with Acrobat Reader, which is available free from the Adobe website.

2.4 Insurance for SPUMS equipment.
Most equipment will be covered by the home insurance of the individual caring for the equipment. There was discussion of this and the difficulty when taking equipment overseas or to different premises. At present it is not possible to have one SPUMS policy to cover all of these possibilities. Individual travel insurance would be needed to cover overseas travel as well as an all purpose insurance if equipment is removed from its usual location. The difficulty lies mainly with the data projector. Dr C Acott will discuss with the ANZCA the policy they have and see if SPUMS can incorporate some of its equipment in a similar policy.

2.5 Update by the Education Officer, Dr D Doolette, was circulated. The diploma has been awarded to 4 new candidates, Drs David Vote, Lalith Ekanayake, Pauline Whyte and Mike Bennett. Guidelines for the research papers have been circulated. The original diploma certificates have disappeared are to be reprinted if not found. An Academic Board has now replaced the Board of Censors.

2.6 Update on "Indexing the Journal". Current Contents and EMBASE indexing agencies are considering whether to add the South Pacific Underwater Medicine Society Journal to their databases.

2.7 GST update. The SPUMS administrator Steve Goble has this in hand.

2.8 SPUMS involvement with an UHMS meeting proposed in Sydney. No definite decision has been made by UHMS to date. SPUMS and HTNA will need to decide their involvement if the meeting goes ahead. It is possible that it could go ahead in 2004. There will need to be two years for organisation.

2.9 An update by the administrator on membership and finances was given.

2.10 The Secretary mentioned that the training agencies have introduced training courses which do not lead to certification and claim that, because they do not lead to certification, they do not need to observe the minimum age limit in AS 4005.1 (A4.2 Age). They have introduced courses with minimum ages as low as 10 years. The Committee reiterated that the SPUMS recommended minimum age for medical fitness to dive is 14 years.

2.11 Update on NZ Chapter. Dr Walker will communicate with Dr Kluger with regard to the winding up of the New Zealand chapter, including the accounts and library.

2.12 Update from ANZ HMG (Australian and New Zealand Hyperbaric Medicine Group). This was given by Dr M Bennett.

3 Annual Scientific Meetings

3.1 1999 ASM, Layang Layang.
Final figures for profit and loss are still to be provided.

3.2 2000 ASM, Castaway Island, Fiji.
Final figures for profit and loss are still to be provided.

3.3 2001 ASM, Madang, PNG.
The program is coming together. There has been a call for abstracts. There needs to be some

recommendation on malaria prophylaxis.

3.4 Future ASM. Suggestion were made including Iriki Island, Vanuatu

4 Treasurer's Report

The resignation of the treasurer, Dr P Dupont was tendered and accepted by the Committee. Dr Walker will discuss the situation with the accountant and the bank, and attempt to sort out the accounts.

5 Correspondence

3.1. Letter WHS. This letter was discussed.

3.2. Letter International Travel House Ltd. No action

3.3. Letter Guy Williams re GST on diving medicals. The AMA has clarified the situation which is that GST should be added to all diving medicals.

3.4. Letter Copyright Agency Ltd . This was discussed. No action to be taken at present.

3.5. Letter from College of Oceaneering. This was discussed.

3.6. E-mail from the Education officer with update and 3 attachments. These were discussed.

3.7. Letter from Dr Mike Davis. R Walker to reply.

3.8. Letter from Queensland Department of Employment, Training and Industrial Relations. C Meehan to reply.

6 Other Business

6.1. Postal charge for overseas members. Economy Air no longer applies to letters. All overseas members Journals will have to be Air Mailed. Dr Knight suggested that a postal charge equivalent to the GST for Australian members be charged to all overseas members.

6.2. 2299 medical form. There are some changes that need to be made to this form. These have been discussed with Dr I Miller, who designed the form.

6.3. Dr Knight gave notice that he would not be seeking appointment in 2002 when his term expires and suggested that the Committee start looking for the next Editor of the South Pacific Underwater Medicine Society Journal.

6.4. Suggestions for methods of handling the SPUMS finances were discussed.

6.5. Discussion as to whether the 2001 face-to-face meeting will be held at the next HTNA meeting in Fremantle.

6.6. The costs of producing the South Pacific Underwater Medicine Society Journal were discussed.

Closed 1430

Key Words

Meeting.

ROYAL ADELAIDE HOSPITAL HYPERBARIC MEDICINE COURSE

Medical Officers Course

Cost	
Basic Diving Medicine Course	**$825.00**
Advanced	**$440.00**
Hyperbaric	**$385.00**
Total for all three	**$Aust 1650/00**

October/November 2001

Basic	22/10/01	to	26/10/01
Advanced	29/10/01	to	31/10/01
Hyperbaric	1/11/01	to	2/11/01

Diving Medical Technicians Course

Cost of three unit course$Aust 1,375.00

July 2001

Unit I	2/7/01	to	6/7/01
Unit II	9/7/01	to	13/7/01
Unit III	16/7/01	to	20/7/01

October 2001

Unit I	8/10/01	to	12/10/01
Unit II	15/10/01	to	19/10/01
Unit III	22/10/01	to	26/10/01

Diver Medical Technician Refresher Courses

July 2001	9/7/01	to	13/7/01
October 2001	15/10/01	to	19/10/01

Cost **$Aust 550**

For further information or to enrol contact

The Director,
Hyperbaric Medicine Unit
Royal Adelaide Hospital,
North Terrace
South Australia 5000.

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	Overseas	+61-8-8222-5116
Fax	Australia	(08)-8232-4207
	Overseas	+61-8-8232-4207

LETTERS TO THE EDITOR

ADVANCED DIVING AND UNDERWATER MEDICINE COURSE 2001

<till.mutzbauer@extern.uni-ulm.de>
or <medicodent@yahoo.com>
Phone: +49-731-1710-0 (operator)
Fax: +49-731-53298
2001/1/15

Dear Friends of Diving Medicine,

It is a pleasure to be able to invite you to a special advanced course on diving and underwater medicine to be held on Bandos Island Resort, Bandos, Republic of Maldives.

Our educational program involves international experts, with outstanding expertise, in the field of diving and underwater medicine. The Intensive Care Transport of the injured diver will be a special consideration. Furthermore, a pre-course to be held at the Department of Anatomy, University of Ulm, Germany, offers you the opportunity to gain or refresh knowledge in the application of chest drains.

Divers and non-divers are eligible to participate. They will have an excellent opportunity to train in emergency medical procedures in this remote location environment.

We encourage physicians, nurses and hyperbaric medicine related personnel to register.

Your spouses and families are also welcome to join us on the beautiful Maldives for a wonderful vacation.

Join us for a unique experience. See you in the Maldives.

Registration enquiries should be addressed to:
Hamid Baé, CON MEDICO,
Kaiserin-Augusta-Straße 11,
D-12103 Berlin, Germany.
Tel.: +49-30-757 963-0 Fax: +49-30-757 96363
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Till S. Mutzbauer
MD, DDS.
Anesthesiologist
Diving Medical Officer (German Navy)

Key Words
Letter, meeting, underwater medicine.

BRITISH TUNNELLING SOCIETY 2002

The Institution of Civil Engineers
One Great George Street
London SW1P 3AA
United Kingdom
February 2001

Dear Editor

The British Tunnelling Society Compressed Air Working Group will be holding the *Second International Conference on Engineering and Health in Compressed Air Work* at St Catherine's College, Oxford, United Kingdom from 2002/9/25 to 2002/9/27.

The first international conference in Oxford (1992) provided a forum for the exchange of information on many features of Engineering and Health in Compressed Air Work and was published as *Engineering and Health in Compressed Air Work, Editors FM Jardine and RI McCallum,* in 1994 by F& FN Spon.

The 2002 conference will be attractive to everyone involved with the engineering, medical or regulatory aspects of compressed air working and also to all those with an interest in hyperbaric exposure.

The British Hyperbaric Association will be holding their annual conference at the same venue on 2002/9/28 to 2002/9/29 and it is intended that interested delegates will also be able to register for this event.

Papers and presentations are required on all aspects of Engineering and Health in Compressed Air Work. Prospective authors should express their interest and submit a synopsis of 200-300 words together with a short note explaining its interest and the topic to which it applies as soon as possible.

Invitations to submit papers will be issued by the organising committee by 31st July 2001. Draft papers are required by 1st November 2001.

Final manuscripts are then due by 28th February 2002 to allow them to be included in the conference pack to be distributed to all registrants.

For further information contact the writer. Phone +44-(0)-207-665 2314. Fax. +44- (0)-207-233-1743 E-mail. <rachel.coninx@ice.org.uk>.

Rachel Coninx
Senior Conference Executive

Key Words
Hyperbaric oxygen, letter, meeting, tunnelling.

SHARK FEEDING

72 Birdwood Terrace
Auchenflower Qld 4066

2001/2/6

Dear Editor

Feeding wild animals by humans is now generally discouraged. This is for two reasons:

1 Interfering with normal dietary intake and feeding activity contributes to health problems of the animals fed.
2 The increased risk to people from animal attack.

In June 1996 at a popular fish-feeding site on the Great Barrier Reef, a 21 year old female had her left arm shredded and subsequently amputated as a consequence of an unprovoked attack by a two-metre moray eel (J Johnson, Queensland Museum, personal communication, January 2001). In the same area a large potato cod seized a snorkeller by the head. The snorkeller drowned.[1]

Recreational entertainment for scuba divers by fish feeding is big business and one of the latest trends in dive tours. Each year in South Australia and South Africa many groups of divers experience thrilling encounters with the great white shark (*Carcharodon carcharias*). The great white can be observed from the relative safety of an underwater cage lowered from the stern of the boat. These huge carnivores are enticed to approach the divers and the boat by an appetising cocktail of blood, fish oil and raw meat. At some South Pacific dive destinations, feeding reef sharks follows similar lines. With this experience the sharks lose their natural caution and could be conditioned to associate humans with food.

Altered behaviour and movement patterns such as “downstream circling” has been observed in great white sharks.[2] Researchers using ultrasonic tracking devices found that following the cessation of chumming the sharks crisscrossed for several kilometres downstream of the baiting station for up to twelve hours, apparently searching for food. Veteran divers at some popular dive sites in Florida have reported highly aggressive shark behaviour.[3]

It may be argued that there is some “public relations”, as well as scientific, advantage in observing sharks at close quarters to understand their behaviour. However this endeavour must be balanced against the risks of producing familiarity. According to the International Shark Attack file, the number of great white attacks has increased steadily worldwide over the past few decades.[4]

The increasing practice of feeding marine animals should be seriously examined on the basis of potential injury to both humans and animals. The lessons of Pavlov’s dogs and Skinner’s rats appear to have been completely forgotten.

Bill Douglas

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Key Words
Injuries, letter, marine animals, recreational diving, risk.

BOOK REVIEWS

THE LAST DIVE
A father and son’s fatal descent into the Ocean’s Depths.
Bernie Chowdhury
ISBN 0-06-019462-6
Headline Book Publishing (UK). RPP £ 18.99
Distributed in Australia by Alliance Distribution Services. RRP $Aust 29.95.

Bernie Chowdhury has a writing style which is almost as if he was reminiscing spontaneously to a group of fellow divers. But this is the result of his skilled weaving together of several themes, his involvement in and description of the development of American cave exploration and deep wreck diving, the relatively closed world of such elite divers, their fanaticism and willingness to risk life and health to out-dive others, the painful development of safer diving practices and a sympathetic account of the 4 year course of a husband and son from pupils to their deaths. There has a similarity to a classic Greek tragedy in their story, the consequences of hubris. Or the search for the

Holy Grail, which in this case was to finally establish the identity of a WW II German Submarine in deep water off the New Jersey coast.

The author is able to describe events dispassionately and informatively because he has "been there and done that, in spades", as the common term has it. He was there, an elite cave diver, before Chris and Chrissy Rouse, father and son separated by only 17 years (there is an unfortunate similarity of names), first entered the water. They undertook a ten week initial training course and were so enthused that Chris persuaded his wife, Sue, Chrissy's mother, to learn. Her course was a single weekend one which was concluded by a poorly assessed check out dive, followed by her certification while extremely unprepared and lacking confidence.

Some readers may think back to the days when the BSAC training lasted months and was criticised for not being shorter. Chrissy suffered from Attention Deficit disorder and his father had realised how important it was to develop a strong bond between them. But he was a perfectionist and his son had a "close enough" mind set. In the (reconstructed) reported conversations between them there is mutual abuse and constant bickering, but they were so close in fact that Chris accompanied his son on their final fatal dive although aware of the danger of a 230 fsw dive using air in a rough sea into a wreck. They were, at that time, strapped for sufficient money to obtain and use mixed gas.

There is much, much more in this book, the Scapa Flow salvage in the 1920s, caisson work, the influence of Sheck Exley and others in persuading cave divers to recognise risky behaviour and follow safe diving principles (rule of thirds, use of lines, redundancy), records of some avoidable fatalities and of severe DCI, which the author himself suffered and was lucky to survive. There are even some instances of the successful recovery of divers, including one by Chrissy. The fever to collect trophies from wrecks and the early days of mixed gas diving by the deep wreck divers are well described. In addition there are events which are never officially reported, like the story of the dead diver kept on ice so as not to cause the aborting of an expensive live-aboard dive. There are personalities in plenty in this story, but this is essentially a warts and all, but sympathetic, description of a family which was intensely involved in the explosive expansionist phase of the evolution of cave and deep diving. While it is true that divers such as these are the cutting edge of advances in recreational diving, nevertheless they are accidents-in-waiting. They would pass our Medical Fitness to Dive checks, as fanaticism may only become evident after training has been completed and is certainly not listed as a reason for refusal, but they would surely scare the DAN Insurers!

It is more than a "good read", it is a painlessly educational one which all divers can read with benefit to their better understanding of those whose strengths, weaknesses and sometimes deaths have made it possible to dive more safely.

Douglas Walker

Key Words

Accident, book review, death, decompression illness, deep diving, wreck.

THE SEA DWELLERS
Bob Barth
Doyle Publishing Co., Inc., 180 pages
180 pages. RRP $US 16.95. Postage and packing extra.

DEATH OF AN AQUANAUT
William J Bunton
Best Publishing Company
69 pages. RRP $US 19.95. Postage and packing extra.

Both review copies provided by Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, USA. Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

The Sea Dwellers by Bob Barth is a typically good diver's yarn. The author describes himself as a professional grunt and guineapig, and is one of the many colourful characters who inhabit naval professional diving. He describes the development of Project Genesis and the Man-in-the-Sea, or Sea-Lab, experiments of the US Navy. He gives full acknowledgment to the ingenuity and expertise of Dr George Bond, who was considered the originator of saturation diving in North America.

The stories Bob Barth narrates are those typical of navy diving and navy divers throughout the world. He describes the development, and the ultimate catastrophe of the death of Berry Cannon, as seen by the working diver. His language is colourful, as one would expect, but sometimes lacking in accuracy. Examples involve the paucity of knowledge of activities elsewhere in the world, he does not mention the earlier development of the Conshelf experiments by Cousteau in France, and the even earlier use of saturation treatments in Australia and other places.

Nevertheless, it is a ripping good yarn, not an in-depth *sic* description of the physiological and psychological barriers that had to be overcome, and told with a healthy disrespect for bureaucracy, boffins and naval officers in general.

Bob Barth is the sort of guy one would want on one's team, accepting that he will be needed to overcome many obstacles, only some of which he has caused.

On the negative side, the publisher should be banned from ever producing another text. There are over 100 poorly printed photographs, but extremely valuable as regards illustrating the text, bundled up together at the end of the book. Thus one is ignorant of these valuable illustrations during the actual reading of the text. As the paper used for the black and white photographs is not of appreciably better quality than that used for the rest of the text, it is unconscionable for the designer and printer not to have interposed these photographs at the relevant sites throughout the text. It would have made the whole book far more interesting and informative.

Bob Barth does "name drop" throughout the text. This is inevitable and a characteristic of Naval and other divers. It does not detract from the text, as there is no doubt regarding the close relationship that he felt towards these people. Whether they are that close friendships as he implies, would need to be checked out with them.

Death of an Aquanaut, written by William Bunton, is the antithesis of *The Sea Dwellers*, even though both are written by divers, for the general population. Unlike Barth, Bunton is a humourless writer and a disgruntled observer of the Genesis/Man-in-the Sea projects. He was a member of the third team of the Sea Lab II project.

Again, unlike Barth's text, I could have put this book down at any stage, with the exception of the last three pages. There Bunton gives excerpts of private letters allegedly sent to him by George Bond, and inferring a conspiracy and sabotage of the project.

One does not get the impression that Bunton was a committed or highly respected member of the team. It is essentially a book written about one event, as its title implies, but it is an event at which Bunton was not present, and it seems as if most of the information has been derived from others, again entirely unlike the Barth text, where it is extremely personal and written by a very emotionally involved participant.

Bunton commences the very brief monologue with a description of his ability to urinate into a wetsuit, and the content does not improve greatly. He extracts a little drama by resurrecting a shark attack, which had absolutely nothing to do with the theme of the text, before passing on to a series of personal impressions and a prescient knowledge of forthcoming disasters, which apparently he was not prepared to influence by his actions. Complaints there were many, but constructions there were few. Again, the opposite of Barth's "can do" attitude. Bunton, of course, did not actually get to dive in the Sea Lab III project, although he was involved to some degree in its development. He is extremely critical, like Barth, of the bureaucracy and the administration of Sea Lab III. Although he does use the same name dropping technique of Barth, presenting Scot Carpenter and George Bond as close personal friends, one cannot escape the impression that Bunton was not a key player in this expedition, was not there at the time of the catastrophe, and was got rid of very rapidly afterwards. He describes himself as "stunned, humiliated and bitter beyond belief" when he was effectively demoted after the Inquiry, and resigned from the organisation.

The comparison of the two books could not be more obvious. I would have employed Bob Barth on any diving team, anywhere and any day, but not William Bunton. His criticisms, at least as presented in this text, are negative, not constructive.

The two books also are contrasting in their presentation. *Death of an Aquanaut* is beautifully presented, with excellent colour photographs interspersed throughout the meagre text. It has no index, befitting the quality of the written material. Despite that, it is a beautifully presented book. Without the photographs it would be a pamphlet. Best Publishing, as is befitting their reputation, presented the publication in a professional and attractive manner. It looks great, but is not.

Some of the photographs are from the US Navy archives, most of the others are either from Bunton, or about him. They thus are consistent with the text, a literary and photographic ego trip exonerating Bill Bunton.

It is perhaps unfair to compare the two books, without including the gold standard of *Papa Topside - the Sea Lab Chronicles* written by George Bond. Here was a master raconteur, brilliant scientist and the most knowledgeable man in this field. It is true that the *Chronicles*, as published, have been edited and perhaps a little has been lost in this, in comparison to the original George Bond papers (which I am honoured to have received directly from the big man over a drop or two of Old Milwaukee beer). His clinical insights were brilliant. He was the teacher par excellence to both divers and doctors.

If one ascribes a 5-star rating to the George Bond *Chronicles*, then *Sea Dwellers* received 3 stars, and *Death of an Aquanaut*, one. The width of vision and depth of knowledge from each of the texts is also proportional to this star rating.

Carl Edmonds

Key Words

Accident, book review, death, deep diving, history, saturation, saturation diving.

A GUIDE FOR TEACHING SCUBA TO DIVERS WITH SPECIAL NEEDS

Frank Degnan
ISBN 0-941332-64-0. Published 1998.
Best Publishing Company, P.O.Box 30100, Flagstaff, Arizona 86003-0100, U.S.A.
Price from the publishers $US 19.95. Postage and packing extra.
Credit card orders may be placed by phone on +1-520-527-1055 or faxed to +1-520-526-0370. E-mail <divebooks@bestpub.com>.

This is a book written by a Scuba Instructor who has extensive "hands-on" experience of teaching divers with disabilities to dive as safely as possible. He has also consulted widely and well. The book has an American focus, but the author's thinking and writing is sufficiently global.

Coverage of this still unfamiliar (to most of the dive industry) and challenging subject is detailed. It includes "Etiquette", "Medical Aspects", "Equipment", "Teaching Techniques", "Wheelchairs", "(teaching and training) Facilities", and "Developing Your Program". An "Introduction" contains insights into the author's philosophies and the subject generally, and ends with lists of (American) addresses of "Active Adapted Scuba Groups" (a term for dive clubs that teach divers with disabilities), "General Products for Individuals with Special Needs" and "Resources for Pool Access Devices". The book concludes with a Glossary (of terms) and a 4-page Index.

The text shows the high level of practical experience and teaching skill that the author has achieved. However I found his writing style somewhat long-winded, although friendly and engaging. Each chapter is organised to stand alone, under the headings "Chapter Overview", then headings in context, then "Chapter Summary", "Review of Main Points" questions on the chapter subject matter entitled "Applying Your Knowledge" and finally, and commendably, "References". The book is well referenced throughout. Black and white photographs, of only modest quality, complement the text quite well.

Safety is emphasised, if at times dealt with in "motherhood" language that is admittedly difficult to avoid, e.g. on equipment: *Never modify or configure gear in an unsafe manner.* Where the author considers safety is pivotal, his recommendations are in bold type.

However, I found the recommendation that if a diver with a disability cannot roll himself, or herself, onto his back on the surface, buoyancy compensators which roll the diver face up are only in the "should consider" category (p 4-23), disconcerting.

The illustrated section on "Rescue Breathing" in-water tends to convey that this as easily achieved. Anyone, even without a physical disability, who has attempted this in the ocean for real knows the intensive practice that this skill demands, preferably on an in-water manikin.

The book shows good insight into the etiquette and appropriate behaviour when relating to persons with disabilities, and these sections could be read with advantage by anybody. It conveys well the need by instructors not to regard persons with disabilities as being in permanent need of assistance and sympathy - a common misunderstanding.

As is pointed out, persons with disabilities not only may not regard themselves as "disabled", but some of these people may be fitter physically and psychologically (although not necessarily for diving) than so-called "non-disabled" dive students. There is also an appropriate emphasis on "theperson-before-the-disability" approach by instructors.

Disabilities addressed in detail are spinal cord injury, spastic cerebral palsy and amputation. The chapter on medical aspects is thorough and well informed, and includes a useful section on travel needs for divers with disabilities, a highly relevant subject nowadays.

There is reference to the lack of "scientific evidence" to date that claims persons with spinal cord injury are pre-disposed to decompression illness. Gastrointestinal diversion and dysfunction needs are well dealt with. Emphasis on consultation with diving medical physicians informed in the medical aspects of divers with disabilities is adequate, although the reviewer knows that such medicos are few and far between at present!

There are occasional typographical errors both in the text and in the Index, but not enough to detract significantly. Printing is small enough to be awkward for the "visually-challenged" (especially in the "Introduction")! The reviewer copy was soft cover, 13.25 x 21 cm. Page numbering employed the "chapter number-page number of chapter" system so total number of pages is not obvious. Overall the publishing presentation of the reviewer's copy was mediocre.

This book is to be recommended to all divers, but also to diving medical physicians (amongst whom considerable prejudice against this subject still exists), as an educational experience. For diving instructors who are serious about practising in this special and demanding area of responsibility, it is required reading.

John Williamson

Key Words
Book review, disabilities, training.

SPUMS ANNUAL SCIENTIFIC MEETING 2000

HEALTH SURVEILLANCE IN THE 21ST CENTURY

Des Gorman

Key Words
Health, occupational diving, risk.

Modern health surveillance

Conventional health surveillance has its origins in the screening of military recruits and in actuarial determinations for insurance companies. Consequently, such surveillance is often in conflict with various legislation and good medical practice.

The relevant legislation includes at least the following

1 Health and Disabilities Acts;
2 Human Rights Acts (which usually include statements such as "Employment cannot be denied on the basis of a disability unless....");
3 Health and Safety in Employment Acts (which state that "Employers must exercise a duty of care"); and
4 Privacy Acts.

The basis of good health surveillance

Good health surveillance requires the assessment to have a functional orientation and that the primary risk taker needs to be the primary risk acceptor.

A functional orientation is essential if the health surveillance is to be either sensible or if it is to comply with Human Rights and Disabilities legislation.

For example, the Royal New Zealand Navy (RNZN) has a screening procedure for career divers that requires them to be able to run 2 miles in less than 11 minutes. This excludes almost all women.

Is this good health surveillance? To answer this question one has to ask another question. What is it about naval diving that requires a diver to run 2 miles in less than 11 minutes? The answer is quite simple, nothing. This is an example of inappropriate surveillance, unless the object of the test is to exclude women from becoming divers.

In this context, an example of good health surveillance would be a screening test that required the candidate to swim 400 metres against a 1 knot current. This is a test which is directly applicable to being able to be an efficient naval diver.

Design of health surveys

Before any health survey can be designed, a functional task or job description is required. Unfortunately a conventional job description defines responsibilities and does not include how to carry out responsibilities.

A functional job description defines what tasks are required to undertake a job and is the basis of vocational rehabilitation. But how are such functional job descriptions translated into a health survey?

Screening requirements

Firstly, to be worthy of screening, a health condition (disease and or its treatment, state of aerobic fitness, anthropometric measure etc.) must be important. There are four questions to be asked

1 Will the condition impair the person's ability to do the job?
2 Will the job make the condition worse?
3 Will the condition compromise the person's or their workmate's safety when doing the job?
4 Will the condition predispose to a job-related illness or injury?

If the answer is "Yes" to any of these the health condition is important.

Using asthma and diving as an example, when one asks these questions the answers would be:

1 Yes: a person's ability to do the job is affected by a reduced exercise tolerance.
2 Yes: the condition is worsened by exercise, anxiety, breathing cold dry gas and or a salt water aerosol.
3 Yes: safety can be compromised by reduced exercise tolerance and drowning.
4 Yes: air-trapping will predispose divers to lung injury.

Secondly, a health condition must be prevalent. Another example of a poor health survey in this context was the Royal Australian Navy (RAN) AIDS screening "program". A decision was made, without considering the existence of the latent period after HIV infection nor the very low clinical incidence in the service, in the 1980s that to maintain the RAN as a blood bank "on the hoof" every member of the RAN was to be tested for HIV every year. This was never achieved. What was achieved was a number of false positive test results, many more than the true positives, which ruined the lives of those misdiagnosed.

When selecting a health condition for screening, a screening tool with a good predictive power needs to be chosen. This is easy for parameters such as height, visual acuity, colour vision and hearing. However for most conditions, no such screen exists.

Common traps in screening

One of the most common mistakes is medicalisation of a physical competency. An example is the RAN Obesity Screening "Program" carried out after the sinking of HMAS Voyager. The reason for this program was the belief that many of those who were trapped below and drowned were trapped because they could not get through the escape hatches. This disability was mistakenly attributed to obesity rather than to the size of the person. The jamming factor in a hatch is not the size of the person's fat abdomen, which is compressible, but the distance across the shoulders which are relatively incompressible. Many sailors had their lives made miserable, and many hours of medical staff time were wasted, in attempts to thin down overweight people. The correct solution to the problems would have been to weed out those who could not fit through an escape hatch by requiring all personnel to be observed passing through an escape hatch. That physical competency test (PCT) would have solved the problem.

Is a person with an internally fixed fractured femur fit to dive? This is not a problem that can be resolved in a doctor's rooms. The relevant questions are, can the person swim satisfactorily with fins, handle the necessary equipment and climb out of the water? Again a PCT and not a medical process will provide the answer.

Is a person with a total hip joint replacement fit to work in a store where ladders may have to be climbed? Only a PCT, based on ladder climbing, will provide an answer.

Another common trap is reliance on a medical examination. This is illustrated by a long standing defence force medical activity, annual medicals. Most of them show that there is very little change from year to year. However these examinations allow the medical officers to meet their patients when they are fit and sometimes allow early diagnosis of hypertension. But the yield of abnormal results is low.

In an attempt to avoid wasting medical and patient time, questionnaires have been promoted as a suitable replacement for medical examinations. However there is the problem of invalid questionnaires, those where the questions mean something different to the person filling it in from the meaning the composer of the questionnaire used. When we in New Zealand considered whether to do away the annual medical for occupational divers we tested out questionnaires on occupational divers. To our horror most of the questions were misunderstood by our target population. It took over a year, and four or five revisions of the wording, to reach the stage where our divers actually understood and answered the questions we were asking. It is essential that any questionnaire be tested for interpretation validity on the population which will be surveyed. In other words it must mean the same to the examiner and the respondents, who will almost certainly use different words to describe the same phenomenon.

Recurrent screening of phenomena that are not affected by age or activity etc. is extremely unlikely to produce useful results and can be described as a waste of time.

Useful health surveys

The basis of good health surveillance includes the need for assessment to have a functional orientation and the fact that the primary risk taker needs to be the primary risk acceptor. The choice of assessment must be made with consideration of the strengths and weaknesses of prescribed and discretionary assessments of fitness.

Prescribed assessments of fitness

An example of prescribed assessments of fitness in the world of diving is AS/NZS 2299 Part 1 (1992). Here the doctor is faced with a series of yes or no decisions. This is the strength of the system as there is no need for a medical practitioner to have had any training. However the weaknesses are that the primary risk taker is excluded, there are inconsistent outcomes as many conditions can not be defined for prescription and there is non-sensible certification. A method of audit and arbitration are needed for fairness.

Non-sensible certification

Diving is an excellent example of such certification. A poorly water-adapted terrestrial air breathing mammal such as man can never be fit to dive.

Discretionary assessments of fitness

The strengths of discretionary assessments of fitness include the fact that the primary risk taker is central to the process. Also there is appropriate medical practice and sensible medical certification (less medico-legal risk).

The weaknesses include the fact that the medical practitioner needs expertise. In addition to general training in occupational health surveillance and in the specific occupational environment, there is also a need for continuing medical education and for ongoing audit. Other weaknesses are that other risk takers are potentially excluded and that objective data may not exist so precluding quantitative advice.

The modern approach is to identify those conditions that are thought by the appropriate society to be incompatible with the activity (e.g. diving) and to prescribe against them. In diving this would include epilepsy, insulin dependent diabetes mellitus, active asthma, ischaemic heart disease etc. Otherwise the approach is to allow discretion.

Does such an approach work?

The New Zealand Occupational Diving Medical Directorate adopted this approach in 1999. Acceptance is high from:

1 Divers, whose replies to the questionnaire shows increased veracity.
2 Medical practitioners, who avoid "wasting time" on annual medicals but who might suffer a loss in income.
3 Employers, whose costs are reduced.

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RESTRICTED DIVING FOR THE UNFIT

David Elliott and Christopher Edge

Key Words

Diving medicals, fitness to dive, medical conditions and problems, recreational diving, standards.

Definitions

We have already defined for our purposes that a person fit to dive is a person in whom no medical condition has been found that is incompatible with unrestricted diving as an amateur within the recreational envelope. A time limit upon this clearance might seem wise but is rarely given. Although the boundaries of that envelope may vary between individual divers, according to their training, physical abilities and diving skills, the hazards within this activity envelope are very similar and so the required medical standards should be the same.

It is then easy to define the category of *unfit* as everybody else.

This category includes those in the conventional category of "Disabled Diver". These are typified by those with major amputations or the wheel-chair divers who are fit to dive, other than being also challenged with probably some autonomic deficits. Their limitations can be assessed and they dive in accordance with guidelines made by one of many organisations dedicated to diving for the disabled. For the purposes of our discussion persons who have primarily physical limitations of any kind ranging from quadriplegia to hearing deficits, need no further consideration at this stage.

The unfit divers to be considered further here are those who would fail the initial self-declaration form and who then, rightly or wrongly, may be unable to get a doctor's fitness certificate for *unrestricted* recreational diving. As a whole, the medically disabled can be categorised in several ways:

CAPABLE OF INDEPENDENT UNRESTRICTED DIVING

We have already discussed that some persons with a history of asthma may be excluded from diving by some organisations but, in accordance with particular criteria, are accepted by others.

They should have a time-limited clearance but, once declared fit, need no further restrictions upon their activity.

THOSE WITH A PHYSICAL DISABILITY AND MAY BE DEPENDENT ON OTHERS IN THE WATER

The disabled diver with no medical complications.

RESTRICTED DIVING BUT NEEDING NO OTHER CONSIDERATION WHEN IN THE WATER

This group includes those who for some reason, such as previous decompression illness, have been told that they should confine themselves to diving with safer decompression schedules.

RESTRICTED DIVING BUT CONDITIONAL ON THE PRESENCE OF A SUPPORT TEAM

An example is that of the stable insulin-dependent diabetic who has met the strict medical criteria of the UK Sport Diving Medical Committee (UKSDMC) and who complies with its special procedures.

Restricted only, with no other in-water consideration

Occasionally, the restriction of a diver to only shallow diving is wrongly recommended by hospital doctors who do not know about diving. They may not understand that Boyle's Law is at its worst near the surface and that the air-water interface can be physically very challenging. Such decisions need to be made by a doctor who is familiar with the hazards of the diving environment.

Nevertheless, a restriction to shallow diving may be appropriate for some. Consider the ex-commercial diver who had a bad spinal bend with residua, but who has no functional deficits. Consider the sport diver who had an "undeserved" and very mild neurological decompression illness after a correctly followed decompression dive and who is then found to have a PFO. A shallow diving limit may be appropriate but, as will be discussed in a later presentation, there are other recommendations that might be more practical.

One might wish to consider the elderly here but, in the absence of any specific medical problem, their diving should be subject to self-imposed limitations. However, a lack of insight may need to be corrected by others.

Restricted but dependent on a support team

Occasionally a person is allowed to dive without proper medical screening, e.g. the uninitiated tourist trying his/her first diving experience. The dive is brief and is planned to be under the immediate supervision of competent divers, but the volunteer's fitness is not always known. Is this wise? No, but it happens.

An example that provides a better test of the principle of restricted diving in the presence of a support team is provided by diabetes. Again, many papers and reviews have been written but first it is worth looking at the current guidance.

Diabetes

THE UK HEALTH & SAFETY EXECUTIVE (FOR WORKING DIVERS)

"Glycosuria would require investigation. Insulin dependent diabetes mellitus or non-insulin dependent diabetes controlled by oral hypoglycaemic agents are contraindications. Non-insulin dependent diabetics treated with diet alone should be assessed on an individual basis bearing in mind the type of diving required. In such cases restricted certification should be used."

UKSDMC GUIDELINES

The UKSDMC has decided that diabetic divers may be allowed to dive provided that they are able to pass the standard UKSDMC medical examination and in addition, satisfy the following criteria:

1 The diabetic diver has not experienced any hypoglycaemic attack within the last year.
2 The diabetic diver has not been hospitalised for any reason connected with diabetes in the last year.
3 The physician in charge of the diver at the diabetic clinic must consider the level of control to be satisfactory. This implies that the long-term control of the diabetic condition must be good. A guide to this may be obtained from the HbA_{1c} or fructosamine level. The physician must also be able to state that he or she considers the potential diabetic diver to be mentally and physically fit to undertake the sport of diving.
4 There must be no microalbuminuria present. Any degree of retinopathy beyond background retinopathy is not allowed. There must be no evidence of neuropathy (sensory, motor or autonomic), nor of vascular or microvascular disease beyond the background retinopathy in the eye.

However, besides annual re-evaluation, there are additional administrative conditions and important diving precautions that carefully restrict the diver and that together are considered to control the risk.

THE SPUMS DIVING MEDICAL

"Dip-stick test of urine shall be performed and urine tested for albumin, sugar, and blood. Glycosuria calls for investigation before acceptance. … Diabetes requiring medication with insulin is a contraindication to diving."

THE RSTC GUIDELINES

"Absolute Contraindications

The potentially rapid change in level of consciousness associated with hypoglycaemia in diabetics on insulin therapy or oral anti-hypoglycaemia medications can result in drowning. Diving is therefore contraindicated."

So, what restrictions should there be?

No diabetic diver, whether diet-controlled, tablet-controlled or insulin-controlled should dive without proper assessment. Modern thinking about diabetes recognises that, whilst those who take insulin or oral hypoglycaemics to control their diabetes are the divers who are at risk of becoming hypoglycaemic underwater, ALL DIVERS WHO ARE DIABETIC have an increased risk when diving due to the long-term complications of diabetes.

These complications may affect the diver underwater (such as cardiac disease) or may lead to complications at the surface (such as periphal neuroptath when considering whether a diver is suffering from decompression illness).

It is agreed that only diabetics controlled by diet alone should be considered fit for unrestricted diving and it is acknowledged by some that, with special training and diabetic management procedures, selected individuals with insulin -dependent diabetes can be allowed to dive under specified conditions. Note that those on oral medication who become hypoglycaemic may be more difficult to manage than those who become so on insulin.

The UKSDMC advises diabetic divers to dive only once or twice each day and generally not to dive more than three days consecutively.[1] It is helpful both to the diabetic diver and to the club to which the diver belongs that the diabetic should give an annual lecture to the club on the problems of diabetes and diving. They must also give a demonstration of how they administer glucose to themselves and how they monitor their blood glucose. Pre-dive, the diving diabetic should be as fit and mentally prepared to dive as any non-diabetic diver. They should preferably be wearing a bracelet to state that they are both a diabetic and a diver, and that the possibility of decompression illness should also be considered. The dive marshal for the dive should be aware that the diver is diabetic and should be informed of the profile of the proposed dive. The diabetic diver's buddy should be their regular diving partner and familiar with the diabetic's individual problem. Alternatively, the buddy should be a trained medic or paramedic who understands diabetes. The buddy must not be a diabetic. Additionally, most divers will take with them a small kit, containing either oral glucose tablets or preferably oral glucose paste. The other items of equipment include an emergency intramuscular injection of glucagon, also glucose testing sticks together with the necessary kit and instructions for the use of such testing kit. The normal diver safety equipment should be carried with one or more of the following items: surface marker buoy, flag, personal flares and/or an emergency beacon. Diabetics should plan to carry their glucose tablets or a tube of glucose paste with them in a small waterproof bag during the dive. The diving buddy must know the whereabouts of these and be able to administer these and, if necessary, be able to administer the intramuscular injection of glucagon once on dry land. Adequate hydration of the diabetic is also essential and, before diving, diabetics should take extra glucose to ensure they have a higher blood level.

The UKSDMC states that a diabetic diver should not dive deeper than 30 m. Hypoglycaemia could be indistinguishable from nitrogen narcosis. He or she should remain well within the tables and have more than two minutes no-stop time left on any dive computer. On return to the boat or shore after a dive the diabetic should check his or her glucose level and correct it in the appropriate manner. The UKSDMC also says that any adverse symptoms or signs should be reported immediately to the diving buddy or dive marshal. Nothing should be passed off as "part of diving". The diving officer and all concerned must recognise that the symptoms of low blood sugar may mimic those of neurological decompression illness. In this situation first aid therapy should be given as though both conditions are present i.e. 100% oxygen and treatment for low blood sugar. In the case of an unconscious diabetic diver the blood glucose level should be quickly measured using the diabetic person's glucometer.

As of November 1999, a study currently being conducted by the Diving Diseases Research Centre (Plymouth, UK) had deposited data into a database from 230 diabetic divers (190 males, 40 females). The age range of the divers was 19-69, with 10.4% having non-insulin dependent diabetes mellitus (NIDDM). The total number of dives logged by them was 5,348, with one diabetic diver logging more that 1,200 dives. Over this period from 1991, 83 divers have ceased diving for a variety of reasons, but none of them has reported having problems associated with diabetes while diving. The deepest dive recorded in the series is to 40 m. Eleven respondents had episodes of hypoglycaemia in the past year. Manual investigation of these records (which included telephoning each of the 83 divers who had ceased diving) established that 7 of the hypoglycaemic attacks were not in any way diving related. Three divers had had diving incidents of a non-medical nature and one had had a mild hypoglycaemic attack underwater that was successfully managed.

Conclusions

Of the four categories of fitness for recreational diving for those who have some relative contraindication, those who require of competent support team will have more difficulty in arranging to undertake a modest dive than those with other types of unfitness.

1 Those divers with conditions such as asthma may either be fit for independent unrestricted diving, at least while they remain stable, or they are not fit at all. These divers have no medical restrictions once they get in the water.

2 Those with a physical disability but with no medical complications, represent the conventional disabled diver. They may be dependent on others in the water to a greater or lesser degree but their assessment is straightforward and so should present no major medical problems.

3 Those who should confine themselves, for instance, to shallow diving would tend to be following self-imposed restrictions. Provided that the underlying reason for this is not incompatible with diving, they should be able to dive as competently as those who are unrestricted.

4 Those divers whose diving is dependent on the presence of a support team with some medical responsibilities are probably confined to diving within a club structure. In the case of diabetic divers, there is greater awareness of their needs as a result of programs such as the one mentioned above, and more dive centres throughout the world are prepared to accept these divers into their community.

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DIABETES AS A CONTRAINDICATION TO DIVING: SHOULD OLD DOGMA GIVE WAY TO NEW EVIDENCE?

Lynn Taylor and Simon Mitchell

Key Words

Diabetes, drugs, risks, safety.

Abstract

Background

Diabetics, particularly those who require insulin, are usually considered unfit to undertake compressed gas diving. This judgement has been based on concerns over hypoglycaemic events, hypoglycaemia unawareness, increased risk of DCI and ambiguity between diabetic symptoms and those of DCI. A SPUMS “Statement” released in 1992 proscribed diving by diabetics. Since this time there has been a progressive shift from prescriptive toward discretionary diving fitness evaluations, and this has been paralleled by increasing pressure from diabetics to be “allowed” to dive. We undertook a contemporaneous review of the issue.

Methods

A review was undertaken to locate relevant material. This included a Medline search, and contact with authorities known to have an interest in the issue such as Divers Alert Network (DAN) and the British Sub-Aqua Club (BSAC).

Results

Few papers published in the indexed literature address this issue. In contrast, textbooks and popular press diving publications contain numerous references. Few articles of any type contain relevant original data. The proscription against diving by diabetics is based largely on theoretical concerns, opinion and some case reports of diving accidents involving diabetics. In contrast, several data sets describing diving activity by diabetics suggest that some can dive at an acceptable level of risk. A voluntary DAN survey reported 48,663 dives by 110 diabetic respondents with only 1 case of DCI. Hypoglycaemia had been experienced by 15% of respondents at some time during diving, but no case had ended adversely. The BSAC has prospectively followed more than 230 diabetic divers who had completed 5,348 dives to November 1999. There have been no deaths, no episodes of DCI and 4 hypoglycaemic events, all of which were corrected with glucose paste. While these data must be interpreted with caution since they describe the activity of selected populations, they do suggest that focused diabetics can dive safely. There are also prospective studies addressing specific training of diabetic divers, and the occurrence of hypoglycaemia in chamber and open water dives.

Conclusions

If issues of selection and training can be addressed, it may be appropriate for SPUMS to modify its 8 year old recommendation that currently prohibits all medicated diabetics from diving.

Introduction

Diabetes mellitus, and the insulin dependent form in particular, has been described as a contraindication to diving in many major contemporary diving medicine or diving fitness texts.[1-6] Moreover, in the most recent “official” policy statement from SPUMS it was suggested that both insulin-dependent and medicated non-insulin-dependent diabetics should be advised against diving.[7]

However, there is increasing evidence that focussed and properly trained diabetics can and do dive with a low risk of diabetes-related complications. It is notable that the United Kingdom Sports Diving Medical Committee has permitted diving by selected insulin dependent diabetics since 1991.

There has been thoughtful analysis[8] and outright criticism[9] of the SPUMS diabetic diving policy from within the Society, and it is now 8 years since the policy statement was issued. The intervening period has seen a gradual shift in diving fitness assessment philosophy away from a prescriptive approach toward a more discretionary paradigm of fitness evaluation in which appropriate candidates make risk acceptance decisions after appropriate counselling. With this background, and since the theme for the 2000 SPUMS Annual Scientific Meeting is “Fitness for Diving”, it is an appropriate time to review the issue of diving by diabetics.

Methods

A literature review was undertaken to locate relevant material. This included a Medline search, gleaning of references from the bibiliographies of others and contact with authorities known to have an interest in the issue, such as the Divers Alert Network (DAN) and the British Sub-Aqua Club (BSAC).

Very little material was obtained from the Medline search. In contrast, it was possible to locate many published opinions and recommendations from other sources. Unfortunately, very few papers presented any relevant original data. There seemed little merit in presenting a repetitive account of the unsubstantiated opinion encountered in the search. It follows that this review does not claim to be a comprehensive treatment of all that is written on the subject. Rather, the references cited are either those that contained relevant data, or that were important for the development of particular arguments.

Concerns about diving by diabetics

Diabetics suffer a deficiency of insulin secretion, or insensitivity to the effects of insulin, leading to an elevation of serum glucose. Although the classification is debated, diabetics are commonly divided into either of two groups: Type I or Type II. Type I diabetes typically starts precipitously during childhood but may also arise in adults. These diabetics (insulin dependent) are dependent on administration of exogenous insulin to avoid ketoacidosis. Type II diabetes typically occurs insidiously during adulthood, but this pattern of disease may also be seen in the young. These diabetics (non-insulin-dependent) are often treated with oral hypoglycaemic agents, but may also require insulin.[10] Diabetics with either form of the disease are prone to acute and chronic complications.

HYPOGLYCAEMIA

The most worrying of the acute complications in the diving context is hypoglycaemia. This is most commonly a complication of Type I diabetes, but may also occur in Type II patients. Hypoglycaemia usually results from an imbalance between those factors that lower serum glucose (insulin administration and exercise), and dietary glucose intake. If uncorrected, hypoglycaemia may cause impairment of mentation and unconsciousness.[10] There are usually early warning signs which include a cold sweat, tremor and tachycardia. However, some patients, usually Type I diabetics of long standing, suffer a phenomenon known as "hypoglycaemia unawareness". This is attributed to hypothalamic desensitisation to falling serum glucose, and results in delay or failure of the autonomic activation that produces premonitory symptoms.[11]

Slowing of thought or loss of consciousness due to hypoglycaemia could clearly have catastrophic consequences during diving. Moreover, it has been suggested that exercise and thermal stress in the underwater environment may predispose to hypoglycaemic events.[2,5] Indeed, compression and oxygen administration in a hyperbaric chamber may cause plasma glucose to fall in the absence of exercise or thermal stress.[12] Hypoglycaemia may be harder to recognise when immersed,[3] and there is the potential for confusion between the symptoms of hypoglycaemia and decompression illness (DCI).

These are not just theoretical concerns. Thomas and McKenzie reported the case of a Type I diabetic diver who missed a meal before diving and became hypoglycaemic and lost consciousness during the dive.[13] Fortunately the diver was rescued and resuscitated with oxygen and intravenous glucose. Betts reported the case of a Type I diabetic diver who surfaced and became unconscious.[14] Those attending, aware of the diver's diabetic condition, attributed the problem to hypoglycaemia. The true diagnosis of DCI was not made for some 10 hours by which time the diver was paraplegic. This latter case precipitated a prolonged ban on all diving by diabetics under the auspices of the British Sub Aqua Club.

HYPERGLYCAEMIA

Chronic poor control of plasma glucose levels predisposes to the long term complications of diabetes.[10] In the short term, high plasma glucose results in osmotic diuresis and this may lead to dehydration. Although there are data to the contrary,[15] recent high quality in vivo work supports dehydration as a risk factor for DCI (D Dromsky personal communication). Thus, hyperglycaemic diabetics may be predisposed to DCI. Untreated hyperglycaemia in Type I diabetics may lead to the life threatening condition of ketoacidosis. Diabetics with ketoacidosis are acutely unwell and unlikely to present themselves for diving.

CHRONIC COMPLICATIONS

Most diabetics will develop complications of diabetes at some stage in their lives. These complications include peripheral and autonomic neuropathy, retinopathy, nephropathy, and both macro and micro-vascular disease. A full review of the nature and implications of these complications is beyond the scope of this paper. However, it is certain that they may reduce exercise capacity and produce symptoms that could be confused with DCI. It is also possible that they might predispose to DCI. Although this is largely hypothetical rather than proven, it is often mentioned. For example, Betts suggested that increased platelet adhesiveness and aggregability in diabetics might contribute to increased risk of DCI.[14]

Has the problem been overstated?

Notwithstanding the occasional adverse case report, most of the above concerns about diving and diabetes can be described as “dogma-rich but data-free”.[8] Moreover, these concerns evolved from a period when diabetic management was less refined than now and when the technology for accurate portable capillary blood glucose measurement did not exist. It is not surprising that the validity of “banning” diving by diabetics has been questioned, especially given the contemporary climate of advocacy for their participation in a wide variety of adventure pursuits.[9] In spite of the ban, some diabetics have continued to dive, or through various means have trained as divers, and there is now a growing body of data suggesting that the hazards may have been overstated.

In 1994 the Diver Alert Network published the results of a voluntary survey of diabetic divers.[16] Questionnaires were distributed to 90,000 DAN members and diabetic members were invited to anonymously provide information about their diving histories. One hundred and ten diabetic divers replied, of which 79 were using insulin to control plasma glucose. These divers had completed a total of 48,663 dives. There was only one reported case of DCI, implying that the DCI incidence among this group was lower than that calculated for the general diving population.[17] Hypoglycaemia had been experienced by 15% of the divers at least once while diving, but it appeared that no episode had ended adversely. Although not clearly stated, almost certainly, it can be assumed that few of these divers had any special training in diabetic diving. This voluntary survey data can be criticised for describing the activities of a self-selected population of survivors and for a tendency for respondents to under-report problems. Nevertheless, the apparently low rate of DCI in this group is encouraging, and the data do suggest that some diabetics dive with little apparent risk of complication.

There are more convincing (prospective) data that describe the activities of diabetic divers who have been identified and followed by the BSAC. In 1990, some years after the imposition of a ban on diabetic diving within the BSAC, an unpublished survey of BSAC members revealed that a number of diabetics had continued to dive. The survey revealed “no increased incidence of DCI”, nor had any diabetic diver “suffered from hypoglycaemic attacks whilst diving”.[18] This led to a decision by the BSAC to allow diving by diabetics who met strict medical criteria.[18] Relevant data about those diabetics who had registered and prospectively followed were reported by Edge et al.[19] and by David Elliott and Chris Edge at the 2000 SPUMS Annual Scientific Meeting.[20] In November 1999, 230 diabetics (aged between 19 and 69, 190 male and 90% using insulin) were being followed. This group had conducted 5,348 dives, with 1,200 dives by 1 diver. No cases of DCI had been reported. Only 4 cases of hypoglycaemia associated with diving have been reported, and all were managed without incident.

Another prospective study has investigated the fall in serum glucose that occurs during normal diving activities by diabetics. A DAN group measured serum glucose levels in a group of 16 diabetics using insulin during a one week period of unrestricted diving.[21] Most divers completed 2 dives a day to an average depth of 18 m with a total of 131 dives. The mean fall in serum glucose was 3.1 ± 2.8 mmol l^{-1} and did not differ between single or repetitive dives. No complications due to hypoglycaemia arose during or after the dives. Clearly, serum glucose levels in diabetics do fall during diving, though it is not clear which particular aspect of a dive is responsible. Edge et al. reported that there was no difference in the fall in serum glucose that occurred during and following exercise by diabetics at 1 bar and 3.73 bar (absolute) in a hyperbaric chamber.[19] These results suggest that pressure, of itself, may not be important; but factors such as thermal stress or other effects of immersion may contribute.

In addition to these surveys and experiments, purpose designed diver training regimens have been applied successfully among small groups of diabetics. The most thoroughly documented of these was published in the SPUMS Journal in 1996.[22] Lerch et al. described a 1 week customised diabetic diving course in which 7 diabetics using insulin and 7 non-diabetic trainees participated. The course emphasised the manipulation of diet and insulin administration in order to achieve a safe pre-dive serum glucose level (target 9 – 12.5 mmol l^{-1}). The diabetic divers completed 77 dives with no episodes of in-water hypoglycaemia. Daily insulin requirements tended to fall and both carbohydrate and fluid intake requirements rose over the 6 consecutive days of diving.

Notwithstanding the limitations of the data, these reports do suggest that properly selected and trained diabetics may dive without unreasonable risk. Hypoglycaemia appears to be uncommon, recognisable and easily managed, and there does not appear to be any evidence that the risk of DCI is higher in diabetics. It follows that a case can be made for a relaxation of the total ban on diving by diabetics.

The way ahead

Any suggestion that all diabetics should be allowed to dive after completing a normal diving course is not supported by the available data, and would not meet with the approval of the diving medical community. If diabetics are to dive, the focus must be on development of appropriate selection and training protocols.

SELECTION

It must be acknowledged that some diabetics with poor control of serum glucose levels, or with diabetic complications, will not be suitable for diving. Indeed, most published selection protocols for diabetic divers focus carefully on these two issues: glycaemic control and complications.[18,22-24]

An appropriate selection protocol would begin with a diabetologist consultation. Unless also a diving physician, this practitioner would not be asked for an opinion on fitness to dive, but rather, he or she would provide a detailed report on the diabetic's level of glycaemic control and the status of any diabetic complications. This consultation should include examination for retinopathy, neuropathy, and vascular disease; and tests for renal function and microalbuminuria. The second phase of the assessment would be carried out by a diving physician who would assess the likely impact of the patient's diabetes on diving. Certain criteria would need to be met, as suggested in other protocols[18,22-24] including: the demonstration of a good understanding of the diabetic condition; no recent tendency to hypoglycaemic events or hypoglycaemia unawareness; an HbA1c within the normal to good control range; and no recent change in insulin requirements. It is unreasonable to stipulate that there must be a complete absence of diabetic complications, since there would then be debate over how assiduously one must look for them. However, the likely impact of any complications readily identified should be carefully considered. BSAC policy is to exclude candidates with detectable neuropathy, nephropathy or clinically obvious vasculopathy; whereas a mild degree of background retinopathy is tolerated.[17] In other respects, normal fitness standards would apply.

The diving physician would not be expected to teach the diabetic how to manage their diabetes in relation to diving. However, a critical component of the consultation would be the frank discussion of the particular risks implied by diabetes, to ensure the candidate goes no further in the process without being an informed risk acceptor. As practiced by the BSAC, any approval to undertake diabetic diver training should only be valid for one year. In view of the potential for change in the illness and the progressive nature of diabetic complications, diabetic divers should undergo an annual medical assessment.

TRAINING

Specific "diabetic diver" training is certain to reduce the risk of diving with diabetes, and will be mandatory if the medical profession is ever to broadly accept diabetic diving. The blueprint for such courses already exists. For example, the protocol published by Lerch et al. appears to have merit.[22] Any diabetic diver course would, as a priority, focus on the adjustment of insulin administration, carbohydrate intake and fluid consumption on the day of diving to optimise serum glucose levels and hydration. In particular, there would be a protocol for sequential pre-dive serum glucose measurement, and established procedures to be invoked in response to the readings. Post-dive monitoring would also be necessary in order to avoid delayed hypoglycaemia. The course would incorporate training in emergency procedures, such as consumption of glucose paste underwater, and administration of glucagon intramuscularly in the topside setting. Non-diabetic diving buddies would be encouraged to complete such training along with the diabetic diver, and it might be reasonable to deem such informed buddies as mandatory for diabetic divers. Qualification would be valid for only one year, and renewal dependent on completion of an annual medical assessment.

A significant conundrum in relation to training of diabetic divers relates to who would provide it. Clearly, a diving instructor with no medical training is not suitably qualified to impart the required knowledge. One plausible possibility is to develop a "diabetic diver" specialty course under the auspices of one of the major training organisations. A qualified diving instructor who has undergone specialty course instructor training would conduct the course, and the active participation of a doctor with knowledge of diving medicine would be mandatory. Precedents for such an arrangement already exist. For example, the Level 2 DAN Oxygen Instructor courses offered by DAN South East Asia Pacific are conducted by a DAN Instructor Trainer with mandatory assistance from a diving physician. It is acknowledged that such courses would be unlikely to become widely available and would be more costly. However, most focussed diabetics who wish to dive would be prepared to travel if necessary in order to obtain good training.

Summary

Despite the medical profession's discouragement of diving by diabetics and the essential non-existence of formal training in "diabetic diving", it is clear that many diabetics do dive. Moreover, although much of the data describing the activity of this group is subject to bias, it does appear that focussed diabetics may dive with an acceptably low risk of diving mishaps related to their diabetes. It follows that a revision of the medical edict against diving by diabetics may be appropriate, providing that appropriate selection and training procedures are put in place. Unfortunately, deferring any change in medical policy pending development of such procedures creates a circular argument, since they are unlikely to be developed while the medical profession remains firmly against diabetic diving. An intermediate step may be necessary. For example, if SPUMS was to acknowledge its likely endorsement of diving by carefully selected, fully informed, and properly trained diabetics, provided the protocols developed for these purposes were acceptable, this might create an impetus for development of such protocols by the training organisations. Almost certainly, any continued unselective medical ban on diving by diabetics will result in greater numbers of diabetics who dive without any diver training, let alone "diabetic diver" training.

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AUDIENCE PARTICIPATION

Henrik Staunstrup (Denmark)

I am not quite clear why you want a special dive course for diabetics. Of course we should have some medical information for them and teach them how they should control their blood sugars. But why a special dive course, because the way to dive is the same for everyone?

Lynn Taylor

I think there would be some additional elements within the dive course. The actual practicalities of diving would be the same but there would be other practical aspects such as the monitoring of the blood glucose, pre- and post- dive.

Henrik Staunstrup (Denmark)

You want a non-doctor to teach them that?

Lynn Taylor

Who should teach them was one of the issues that we put up for discussion. Lerch et al. gave them special log books where they recorded all the medical things. Monitoring hydration, making sure they do take the extra litres of fluid prior to diving and blood testing. They can be covered in the theory but I think it is better that it is done in the field, in the practical parts of the diver training as well.

David Elliott

The reason why I think the British Sub-Aqua Club has been successful is because it is a club so it is the same people, the same team, every time. They make sure that the buddy does know what to do if anything goes wrong and it is up to the diabetic to make sure of this. The essence of the BSAC approach is that it is a group dive of which one or two persons may be diabetic.

Vanessa Haller (Melbourne)

I feel that the diabetic side of the course should be taught by doctors but unfortunately endocrinologists in Melbourne all have different views about diabetics and diving and diabetics who dive all have different protocols of how they use their insulin! A protocol for diabetics diving that is agreed by all is needed.

Cathy Meehan (Cairns)

When Claudia Lutrop ran the course in Papua New Guinea they had a registered nurse, who was a diabetic educator, who did the training on how to measure the blood sugars and hydration. I think that is probably the most appropriate person to do that part of the training for the diabetic divers.

Simon Mitchell

The content of the course and what would need to be taught would not be left to people's individual opinions. It would follow the PADI paradigm of a very clearly structured course with the information that had to be disseminated clearly specified so I think the point about different opinions is important. It may well be that if the information could be put in a form that was like the PADI course materials then doctors or at least someone with paramedical knowledge would be the most appropriate person to teach it.

Henrik Straunstrup (Denmark)

If we set up a special course for diabetics, they might be regarded themselves as disabled divers, like someone who is quadriplegic. They would probably ask "Why should I have a special diving course?". They obviously need to get some medical information about how to dive with diabetes, but not a specialty course, just a normal diving course to which is added some medical information from a nurse or a doctor.

Simon Mitchell

Your point is well made, but if you look at Michael Lerch's course, which is reasonably fully described in the SPUMS Journal,[22] you will see that it is quite a complex issue teaching these people to dive from scratch in a way that we can be reasonably sure that they will do it safely. We stand by our decision that there should be a special course.

David Elliott

In that course was there a depth limit of 30 m. Could they later dive deeper than that? As far as I am concerned, they were divers with restricted diving. They were not free to go and dive any old how within the recreational envelope.

Simon Mitchell

From what I can remember, it was very similar to an open water course. So the actual depth limit at the end of that one week course was 18 m. And the other guidelines that I grabbed say everything seems to point to the actual depth limit of 30 metres thereafter. Claudia is an instructor with the International Handicap Association of Divers and so the course was run within the restraints of the guidelines of the international handicapped divers.

Henrik, just another point to your comments, part of the reason for a specific course is to embrace some of the philosophies that David has passed on from the British Sub-Aqua Club. We want to create is an environment where there is a focus on diabetic diving and perhaps non-diabetics who will be the diabetic diver's buddy in future come and form a support network of people who would all dive together. That may be part of the requirements of their diving. In order to get that kind of support network together you are going to need a special environment in which it is fostered.

Henrik Staunstrup (Denmark)

I see your point that they are going to dive in an environment like that and I fully agree with that. But I do not see the need for difference between diabetics, and how we are going to handle them in the future, and how during the last five years we have handled the asthmatics, who we teach the normal way to dive but give them guidelines when they are in our office to get a medical.

John Knight (Melbourne)

I would like to support Cathy Meehan's remark about the nurse-diabetic teaching these people. I learnt long ago that if, as a doctor, you go and talk hyperbaric medicine to a group of divers they will not believe a word unless they know that you are a diver yourself. Actually diabetics, on the whole, know much more about diabetes and how to handle it than even the doctors who tell them what to do, because they live with it. And certainly a diabetic teaching diabetics will be believed. One difficulty of doctors giving medical information to non-medical people is that we tend to lapse into jargon and lose the audience.

Lynn Taylor

One final comment on the relationship between teaching diabetics and teaching asthmatics. I think there is a lot more practical application needed when teaching diabetics. There are two things which need to be integrated, the actual practical diving, teaching them to dive, and the theory and practice of controlling their blood sugar levels. I think that perhaps it is simpler than that for asthmatics.

THE PSYCHOMETRIC AND CARDIAC EFFECTS OF PSEUDOEPHEDRINE AND ANTIHISTAMINES IN THE HYPERBARIC ENVIRONMENT

David Taylor, Kevin O'Toole, Thomas Auble, Christopher Ryan and David Sherman

Key Words

Cardiovascular, drugs, hyperbaric research.

Abstract

STUDY OBJECTIVES

Pseudoephedrine (Sudafed®) and dimenhydrinate (Dramamine®) are often used by recreational scuba divers to avoid ear barotrauma and to control seasickness, respectively. However, these drugs have been little studied in the hyperbaric environment. This study examines the psychometric and cardiac effects of pseudoephedrine and dimenhydrinate at one (100 kPa, sea level) and three (300 kPa, 20 m) atmospheres absolute (bar).

METHODS

A double-blind, placebo-controlled, crossover trial was carried out in the monoplace hyperbaric chamber of a university hospital. Thirty active divers (mean age 38 years) were studied.

A bank of seven tests was used to assess cognitive function during four different dive combinations: placebo/ 1 bar (100 kPa, sea level), placebo/3 bar (300 kPa, 20 m depth) , drug/1 bar (100 kPa, sea level)and drug/3 bar (300 kPa, 20 m depth). Heart rate and cardiac rhythm were recorded during all compressions (dives). Repeated measures ANOVA was used to analyse the effects of drug, depth and the drug-depth interaction.

RESULTS

There were no significant, independent effects of pseudoephedrine on any of the seven psychometric tests scores ($p>0.05$), although the drug tended to increase Anxiety scores ($p=0.092$). Increased depth (pressure) resulted in a significant increase in Anxiety scores ($p=0.021$) and a significant decrease in Verbal Fluency test scores ($p=0.041$). Pseudoephedrine caused a significant increase ($p=0.036$) in mean subject heart rate while depth (3 bar) caused a significant decrease ($p=0.013$). Dimenhydrinate resulted in a significant decrease in scores of mental flexibility (Trail Making, part B) ($p<0.05$). It had no effect upon mean subject heart rate ($p>0.05$). Depth resulted in a significant decrease in Verbal Memory test scores ($p=0.001$) and a significant decrease in mean subject heart rate ($p<0.001$).

CONCLUSION

Pseudoephedrine does not cause significant alterations in psychometric performance at 3 bar pressure (300 kPa, 20 m) that might increase the risk of diving. Dimenhydrinate adversely effects mental flexibility at depth. This effect, when added to the adverse effect of depth on memory, may contribute to the dangers of diving. Depth causes significant adverse effects upon anxiety levels and semantic memory at 3 bar.

Introduction

When compressed air is breathed by the scuba diver, nitrogen narcosis (euphoria, cognitive and motor dysfunction) may be precipitated.[1,2] Narcosis may be seen at depths of 20 m (66 ft) of sea water (3 bar) or greater and can increase significantly the risk of the underwater environment, especially if the symptoms are not recognised. At shallower depths, relatively harmless sub-clinical effects of narcosis are present.[1,2] The hyperbaric environment may cause other physiological effects, including cardiac effects.[3-6] Both bradycardia and a decrease in conduction velocity have been described as effects of hyperbaric pressure on the heart.[3-6]

Many drugs, including non-prescription drugs, have undesirable side effects which may be modified in the hyperbaric environment, even at depths as shallow as 15 m (50 ft).[7,8] Nitrogen narcosis is thought to interact and change the usual side effects of these drugs.[9] Some drugs effects are potentiated, some are antagonised and others produce entirely different effects from those observed at sea level.[5,8] Unfortunately, few scientific studies have examined the effects of drugs in the hyperbaric environment and it is generally recommended that divers avoid all drugs before diving.[8]

One of the most common drugs taken by scuba divers is the decongestant pseudoephedrine (Sudafed®, Warner Welcome).[8] Pseudoephedrine alleviates nasal and sinus congestion[8,10,11] and helps to avoid sinus and middle ear barotrauma while diving.[8,10] At sea level and in normal doses, pseudoephedrine has been reported to cause side effects of mild central nervous system (CNS) stimulation including nervousness, anxiety, excitability and restlessness.[12] Cardiac side effects of tachycardia, palpitations, ventricular ectopic beats (VEs) and, rarely, atrial fibrillation have been reported.[12,13] Few studies have examined the effects of pseudoephedrine in the hyperbaric environment[8,10] although some small, early studies have reported that pseudoephedrine can produce detectable slowing of judgment and some impairment of co-ordination.8 It is hypothesised that pseudoephedrine might cause changes in cognitive function when combined with sub-clinical nitrogen narcosis in the hyperbaric environment. It is also hypothesised that pseudoephedrine will increase heart rates.

Dimenhydrinate (Dramamine®, Pharmacia and Upjohn), is an antihistamine often used by divers to control seasickness. Few studies of its effects in the hyperbaric environment have been conducted although decrements in learning have been reported.[7] At sea level and in normal doses, antihistamines are known to cause drowsiness, dizziness and motor dysfunction and may enhance the effects of other central nervous system depressants.[8,12,14] Few cardiac side effects have been reported with dimenhydrinate, although palpitations and hypotension have been described, possibly due to altered vasovagal reactivity.[12] It is hypothesised that dimenhydrinate might cause changes in cognitive function when combined with sub-clinical nitrogen narcosis.

This study compares the psychometric and cardiac effects of pseudoephedrine and dimenhydrinate with placebo, at one and three bar (Surface and 20 m or 66 ft). We make recommendations regarding the safety of these drugs during recreational scuba diving.

Methods

The study was approved by the Institutional Review Board of the University of Pittsburgh and conducted in the Hyperbaric Unit of the University of Pittsburgh Medical Center (UPMC), Presbyterian, Pittsburgh. The hyperbaric chamber was an "HBO 1" monoplace facility (Nautilus Environmental Systems).

STUDY SUBJECTS

Thirty subjects were enrolled, mostly recruited from Pittsburgh scuba diving clubs. All subjects were required to be active scuba divers and aged 18 years or more. Exclusion criteria included any contraindication to pressurisation (obstructive lung disease, lung scarring, claustrophobia, a history of middle ear surgery or pneumothorax, current respiratory infection or sinusitis), a contraindication to pseudoephedrine or dimenhydrinate (allergy, hypertension, heart disease, diabetes, thyroid disease, symptomatic prostatic enlargement, glaucoma, phenylketonuria), neurological disease (psychomotor deficit, nerve, brain or seizure disorder, psychiatric illness) and pregnancy. Subjects were asked not to ingest alcohol, drugs or medication on the day of a testing session, to have no caffeine-containing food or beverages within six hours, and no food within two hours of a session.

STUDY DESIGN

The study used a double-blind, placebo-controlled, crossover design. Each subject presented for three testing sessions, separated by at least one week. Each session proceeded as follows:

1 ingestion of a "drug" capsule,
2 a drug absorption period (45 minutes) followed by
3 Dive A (30 minutes),
4 a rest period (45 minutes) and
5 Dive B (30 minutes).

The order of the dives was randomised and single-blinded. One dive was to 3 bar (20 m or 66 ft) and the other, a sham dive, was to just over 1 bar (1 m or 3 ft). The 3 bar deeper dive was considered to be representative of an average recreational scuba dive. The chamber was pressurised with air for all dives. Each subject was assigned to one of three investigators for the duration of the study. The investigators operated the chamber, administered the "drug" capsules and collected all data.

The "drug" capsules were prepared by the hospital pharmacy department. They were gelatine casings containing either a crushed "over-the-counter" tablet of pseudoephedrine (60 mg), or dimenhydrinate (50 mg) or lactose powder (placebo). Each subject received a different "drug" at each of the three testing sessions. Drug administration was randomised and double-blinded. The Investigational Drug Service of the UPMC pharmacy department approved the use of the study drugs and held the key to their randomisation.

During each dive, the subjects were connected to a cardiac monitor which gave a continuous readout of heart rate and rhythm. Heart rate and a 30 second cardiac rhythm strip were recorded four times during each dive: at zero, seven, 14 and 20 minutes after pressurisation. The mean of the four heart rate recordings was used to represent each subject's heart rate for each dive. The four rhythm strips (total of 2 minutes recording) were examined by one of the physician authors for cardiac arrhythmias, atrial and ventricular ectopic beats.

Psychometric tests

To assess higher brain function, the subjects performed seven psychometric tests during each compression. The validity of the tests for this use is well established.[15,16] Validated alternate and comparable versions of each test (except the Grooved Pegboard) were used to minimise the learning effect from repeated testing.

STATE ANXIETY INVENTORY

This is a non-timed self-report test, assessing relatively small increases (or decreases) in anxiety. The subjects read 20 statements (eg. "I feel nervous", "I feel calm") and responded to each on a four-point ordinal scale ("not at all" to "very much so"). Each response had a predetermined weight (from 1 to 4) and the score was the total of the weights. A high score indicated a high level of anxiety.

VERBAL FLUENCY TEST

This test was used to assess retrieval from semantic memory. The subjects were required to generate as many words as possible that began with a predetermined letter. Two trials of 60 seconds were undertaken, each with a different letter. The score was the total number of words generated in both trials.

VERBAL MEMORY TEST

This was used to assess the individual's ability to consolidate new information and to retrieve it, on demand, after a brief (15 minute) interval. At the beginning of each dive, the subjects heard five simple words which they were required to repeat. After the interval, they were asked to recall as many words as possible. The score was the number of words recalled.

DIGIT VIGILANCE TEST

This test assessed sustained attention. The subjects scanned a page of random single-digit numbers and crossed out as many of a given number (target) as possible within two minutes. The scores were the total numbers scanned (speed) and the percentage omission rate (100 x targets missed/targets scanned).

RECURRING WORDS TEST

This test assesses the individual's ability to update working memory. The subjects viewed a series of 104 four-lettered words, each on a separate card, and had to indicate whether the word was "new" (had not previously been presented during that test) or "old". The score was the number of correct responses. This test was not timed.

TRAIL MAKING TEST (PART B)

This was used to assess mental flexibility. The subjects were presented with a page of randomly scattered numbers and letters and had to draw lines to connect them alternately and sequentially (eg. 1-A-2-B). The score was the time taken to complete each trail correctly.

GROOVED PEGBOARD TEST

This test is used to assess spacial concepts and hand/eye coordination and concentration. The subjects were required to orientate 25 metal pegs to slot into a grooved pegboard. The scores were the time taken to correctly insert all pegs using first the dominant and then the non-dominant hand.

Estimate of confounding factors

An estimate of each subject's intelligence quotient (IQ) was made using two sub-tests of the Wechsler Adult Intelligence Scale, Revised (WAIS-R). The Vocabulary sub-test assessed the subjects' comprehension of 35 words. The Block Design sub-test assessed visuoconstructional and problem-solving abilities as subjects were timed while arranging blocks to correspond to a printed design.

Statistics

The end points used to test our hypotheses were significant changes ($p<0.05$) in the subjects' psychometric function, heart rate or rhythm at depth, after the ingestion of pseudoephedrine, dimenhydrinate or placebo. For statistical purposes, each subject acted as his/her own control. Data were analysed using a repeated measures multivariate analysis of variance procedure. The "within subject" factors were drug and depth. The ANOVA analyses generated p values and effect sizes (Eta^2, the proportion of total variability attributable to one factor). The latter summarised the effects of drug, of depth and the drug x depth interaction, on the performance of each psychometric test and mean heart rate.

Results

The study subjects were 19 males and 11 females. Mean age was 38.1 ± 10.9 years (range 24-68), mean weight was 81.3 ± 14.1 kg (178.9 ± 31.0 lbs) (range 52.7-111.4 kg, 116-245 lb or 8 stone 2 lb-17 stone 7 lb) and mean height was 1.74 ± 0.09 m (68.5 ± 3.4 in) (range 1.6-1.98 m or 63-78 in). Mean subject IQ (adjusted for age) was 122.0 ± 10.8 (range 97-139). The mean number of years of diving was 8.9 ± 7.3 years (range 1-30) and the mean number of dives done was 188 ± 317 (range: 6-1,460). One subject became ill before his third (pseudoephedrine) testing session and required daily digoxin therapy. It was thought that residual digoxin on the day of testing might affect this subject's cardiac function and his results were not included in the heart rate analyses.

Psychometric tests

The mean subject scores for each psychometric test and the mean subject heart rates are shown in Table 1. The independent effects of drug, depth and drug x depth interaction are shown in Tables 2 and 3 (pseudoephedrine and dimenhydrinate, respectively).

PSEUDOEPHEDRINE

There were no significant, independent effects of pseudoephedrine on any of the seven psychometric tests scores ($p>0.05$), although the drug tended to increase Anxiety scores ($p=0.092$). Increased depth (3 bar) resulted in a significant increase in Anxiety scores ($p=0.021$) and a significant decrease in Verbal Fluency test scores ($p=0.041$).

TABLE 1

MEAN (±SD) SCORES FOR EACH PSYCHOMETRIC TEST AND HEART RATE

(30 SUBJECTS)

Test or parameter	Placebo		Pseudoephedrine		Dimenhydrinate	
Pressure	1 bar	3 bar	1 bar	3 bar	1 bar	3 bar
Anxiety	32.3 ± 6.3	34.5 ± 8.4	33.9 ± 8.1	36.1 ± 8.7	33.3 ± 6.9	34.0 ± 7.6
Verbal fluency	34.6 ± 8.6	32.5 ± 10.4	33.7 ± 10.1	31.6 ± 10.6	34.2 ± 9.0	33.0 ± 7.6
Verbal memory	4.3 ± 1.2	3.4 ± 1.7	3.7 ± 1.8	3.9 ± 1.1	3.7 ± 1.3	3.4 ± 1.5
Digit vigilance (speed)	775.8 ± 136.3	808.7 ± 144.0	791.8 ± 145.0	812.1 ± 146.3	778.9 ± 147.4	798.5 ± 125.8
Digit vigilance (% omitted)	4.4 ± 3.5	4.8 ± 4.7	3.8 ± 3.9	4.3 ± 4.9	5.1 ± 4.6	5.7 ± 7.2
Recurring words	85.4 ± 9.0	85.3 ± 7.2	84.5 ± 9.8	83.9 ± 8.9	85.1 ± 9.2	85.7 ± 7.5
Trail making test (part B)	52.2 ± 17.1	50.0 ± 17.2	49.4 ± 16.5	50.6 ± 16.1	58.4 ± 30.2	62.0 ± 30.0
Pegboard (dominant hand)	59.4 ± 10.9	59.9 ± 10.4	59.2 ± 8.8	60.4 ± 11.0	60.6 ± 13.7	59.7 ± 11.5
Pegboard (non-dominant)	63.9 ± 13.0	65.2 ± 11.4	64.9 ± 11.2	65.1 ± 11.3	65.4 ± 13.9	64.6 ± 12.5
Mean heart rate	74.4 ± 11.2	72.4 ± 11.9	*77.5 ± 9.9	*75.8 ± 11.2	75.1 ± 12.1	71.8 ± 11.1

1 bar = 100 kPa = pressure at sea level. 3 bar = 300 kPa = pressure at a depth of 20 m (66 ft) of sea water.
*One subject was withdrawn from this analysis because of a possible residual digoxin effect. So only 29 subjects.

There were no significant effects of depth on the other five psychometric tests (p>0.05), although depth tended to decrease Verbal Memory test scores (p=0.056) and increase Digit Vigilance Speed scores (p=0.06). There was a significant interaction between the effects of drug and depth on Verbal Memory test scores (p=0.012). There were no significant interactions between the effects of drug and depth on any of the other six psychometric tests (p>0.05).

DIMENHYDRINATE

Dimenhydrinate resulted in a significant decrease in performance of the Trail Making test (p=0.015). The mean time increased with dimenhydrinate at 1 bar and 3 bar, compared with placebo. Dimenhydrinate did not affect scores in the remaining six psychometric tests (p>0.05). Depth resulted in a significant decrease in scores in the Verbal Memory test (p=0.001) but did not affect scores in the remaining six psychometric tests (p>0.05). There were no statistically significant interactions between the effects of drug and depth for any of the psychometric tests (p>0.05).

Heart rate and rhythm

PSEUDOEPHEDRINE

Pseudoephedrine resulted in a significant increase

TABLE 2

PSEUDOEPHEDRINE
P VALUE AND (ETA^2 VALUE) RESULTS OF ANOVA ANALYSIS FOR EACH TEST AND HEART RATE

Test or parameter	Drug at 1 bar (Surface)		Drug at 3 bar (Depth)		Drug x Depth interaction	
	p value	Eta^2 value	p value	Eta^2 value	p value	Eta^2 value
Anxiety	0.092	(0.095)	0.021	(0.169)	0.978	(0.000)
Verbal fluency	0.371	(0.028)	0.041	(0.136)	0.968	(0.000)
Verbal memory	0.892	(0.001)	0.056	(0.120)	0.012	(0.199)
Digit vigilance (speed)	0.341	(0.031)	0.060	(0.117)	0.527	(0.014)
Vigit vigilance (% omitted)	0.398	(0.025)	0.495	(0.016)	0.819	(0.002)
Recurring words	0.267	(0.042)	0.653	(0.007)	0.687	(0.006)
Trail making test (part B)	0.620	(0.009)	0.793	(0.002)	0.231	(0.049)
Pegboard (dominant hand)	0.853	(0.001)	0.387	(0.026)	0.711	(0.005)
Pegboard (non-dominant hand)	0.571	(0.011)	0.345	(0.031)	0.508	(0.015)
Mean subject heart rate	0.036	(0.148)	0.013	(0.201)	0.692	(0.006)

(p=0.036) and depth resulted in a significant decrease in mean subject heart rate (p=0.013). There was no significant interaction between the effects of drug and depth (p=0.692). All subjects, except one, maintained normal sinus rhythm, with no ectopic beats, throughout all dives. The one subject who did not had frequent unifocal ventricular ectopic beats (VEs) during all sessions. The VEs were more frequent during the pseudoephedrine session (9.8 VEs per minute versus 3.8 per minute with placebo).

DIMENHYDRINATE

Dimenhydrinate had no effect upon mean heart rate (p=0.946). However, depth resulted in large and significant decreases in mean heart rate (p<0.001). There was no significant interaction between the effects of drug and depth (p>0.05). The subjects showed few changes in cardiac rhythm. Four subjects had a single atrial ectopic beat: one with dimenhydrinate at 1 bar, one with dimenhydrinate at 3 bar, and two with placebo at 3 bar. Unifocal ventricular ectopics (VEs) were more common but were seen only among three other subjects.

One subject averaged 5.5 and 3.8 VEs per minute during the dimenhydrinate and placebo sessions, respectively. Two other subjects had VEs only after ingesting dimenhydrinate: one averaged 3.5 and 0.5 VEs per minute during the 1 and 3 bar dives, respectively, and the other had no VEs during the 1 bar dive but averaged 4.5 VEs per minute during the 3 bar dive.

Discussion

PSEUDOEPHEDRINE

Our findings indicate that pseudoephedrine does not significantly affect psychometric performance among divers and it is unlikely to put the diver at increased risk. The lack of change in anxiety scores after pseudoephedrine is consistent with the mild CNS symptoms reported with this drug.[12] However, divers are likely to be faced with many other more anxiety-provoking stressors such as currents, claustrophobia, disorientation, marine animals and fatigue.

This study demonstrates that depth had independent and significant adverse effects upon anxiety levels and semantic memory. The significant interaction between the effects of pseudoephedrine and depth in the Verbal Memory test is of interest. This interaction was largely attributable to the decrease in Verbal Memory test scores at depth. These findings are consistent with the well recognised effects of nitrogen narcosis as a retardant of higher mental processes.[1,2] From a clinical perspective, exposure to nitrogen narcosis is inevitable during any scuba dive. As the depth of the dive increases, so do the effects of narcosis.[1,2] Hence, the psychometric effects of narcosis, including the adverse effects on anxiety and semantic memory as shown in this study, will likely increase as the diver continues to descend. Divers must be cognisant of this problem and should limit the depth of their dives in order to avoid the potentially dangerous adverse effects of narcosis.

TABLE 3

DIMENHYDRINATE
P VALUE AND (ETA^2 VALUE) RESULTS OF ANOVA ANALYSIS FOR EACH TEST AND HEART RATE

Test or parameter	Drug at 1 bar (Surface)		Drug at 3 bar (Depth)		Drug x Depth interaction	
	p value	Eta^2 value	p value	Eta^2 value	p value	Eta^2 value
Anxiety	0.815	(0.002)	0.180	(0.061)	0.241	(0.047)
Verbal fluency	0.977	(0.000)	0.134	(0.076)	0.583	(0.011)
Verbal memory	0.193	(0.058)	0.001	(0.312)	0.092	(0.095)
Digit vigilance (speed)	0.792	(0.002)	0.066	(0.112)	0.621	(0.009)
Digit vigilance (% omitted)	0.278	(0.040)	0.534	(0.013)	0.780	(0.003)
Recurring words	1.000	(0.000)	0.778	(0.003)	0.627	(0.008)
Trail making test (part B)	0.015	(0.186)	0.790	(0.002)	0.213	(0.053)
Pegboard (dominant hand)	0.685	(0.006)	0.834	(0.002)	0.353	(0.030)
Pegboard (non-dominant hand)	0.615	(0.009)	0.789	(0.003)	0.207	(0.054)
Mean subject heart rate	0.946	(0.000)	0.000	(0.485)	0.323	(0.034)

The significant increases in heart rate following ingestion of pseudoephedrine are consistent with the reported side effects of this drug.[12,13] However, the absolute changes in rate were small (4-5 beats per minute) and unlikely to put the diver at increased risk. The finding that almost all subjects had no other rhythm disturbances or ectopic beats is consistent with the reported effects of pseudoephedrine.[12] However, the greater number of VEs seen in one subject after pseudoephedrine is consistent with the reported effect of VE induction in susceptible subjects.[12] The significant decreases in mean heart rate at depth are also consistent with earlier studies.[3-6] The magnitude of these changes were also small and unlikely to be clinically significant.

DIMENHYDRINATE

The results indicate that dimenhydrinate caused an independent and significant deterioration in performance of the Trail Making test, a sensitive measure of mental flexibility.[15,16] Furthermore, the tendency towards a greater standard deviation in this test, after dimenhydrinate, supports the reported finding of a wide range of individual subject susceptibility to this drug.[7] The Trail Making test requires the subjects to move rapidly between two tasks. It is cognitively demanding and sensitive to small transient changes in cognitive function.[16] These findings are consistent with the side effect of drowsiness which is often reported after the use of this drug.[12] Our findings indicate that dimenhydrinate, in the laboratory setting, does have significant adverse effects upon psychometric performance. However, these effects are seen only with sensitive tests where the cognitive demands are large.

The finding that depth causes a significant adverse effect upon memory, as evidenced by the Verbal Memory test, is consistent with the well recognised effects of nitrogen narcosis.[1] As well as affecting mood, behaviour and balance, narcosis has been described as a retardant of higher mental processes.[1,2] Specifically, narcosis has been shown to produce cumulative slowing in memory and learning.[17,18]

Exposure to nitrogen narcosis is inevitable during any scuba dive. As the depth of the dive increases, so do the effects of narcosis.[1,2] Hence, the psychometric effects of narcosis, including the adverse effect on memory as shown in this study, will likely increase as the diver continues to descend. Of concern, is the potential for additional adverse psychometric effects from ingested drugs.[9] This study indicates that depth and dimenhydrinate adversely affect different cognitive functions. From the clinical perspective, it is likely that these adverse effects, in combination, may increase the risk of diving. Although the magnitude and clinical significance of this risk is difficult to quantify, the routine and widespread use of dimenhydrinate prior to scuba diving is not recommended.

The finding that dimenhydrinate had no effect upon mean heart rate is consistent with the reported effects of this drug.[12] However, the development of frequent VEs in two subjects, only after ingestion of dimenhydrinate, is not consistent with reported side effects and the significance of this finding is uncertain. The finding that depth significantly decreased mean heart rates is consistent with earlier studies.[3-6] However, the absolute magnitude of the heart rate changes were small and depth did not appear to be associated with VEs or other arrhythmias. It is concluded that dimenhydrinate and depth are unlikely to have any effects upon heart rate that might put the scuba diver at increased risk. Larger studies are needed to investigate the possible association between dimenhydrinate and VEs found in this study.

This study had several limitations. It was undertaken in a simulated diving environment (monoplace recompression chamber) that may not accurately reflect the effects of drugs or depth seen during an actual underwater dive. The number of subjects enrolled was small and limited by the time intensive nature of the study. Furthermore, the older mean subject age of 38 years and the high mean subject IQ may not be representative of the general diving population. Most subjects in this study were established Pittsburgh professionals and unlikely to be representative of recreational scuba divers generally. The high mean subject IQ may have been an important confounder in this study. It is conceivable that the subjects had a large degree of “cognitive reserve” and were less likely to show performance decrements when brain efficiency was challenged by the study drug and depth.[19] Finally, the effects of pseudoephedrine in combination with dimenhydrinate or other drugs was not examined. The study only examined performance at an ambient pressure of three bar. Although this depth may be representative of an “average” recreational dive, many divers exceed this depth.

Conclusion

This study concludes that pseudoephedrine, at depths down to 20 m (66 ft), is unlikely to cause alterations in cognitive or cardiac function that would increase the risk to a scuba diver. The study also concludes that the nitrogen narcosis at this depth has adverse effects upon diver anxiety and semantic memory. These effects may increase the risk to the diver.

It is also concluded that dimenhydrinate adversely effects mental flexibility and that depth adversely affects memory. It is likely that these effects, in combination, will increase the risk to a scuba diver. Finally, for those divers who suffer from severe seasickness, the use of dimenhydrinate may be necessary to avoid the miseries of this condition. For these divers, it may be wise to incorporate extra margins of safety into dive planning.

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The above paper, presented at the SPUMS Annual Scientific Meeting in May 2000, is based on two papers, "The Psychometic and Cardiac Effects of Pseudoephidrine in the Hyperbaric Environment." (Pharmacotherapy 2000; 20 (9): 1045-1050) *and* "The Psychometic and Cardiac Effects of Dimenhydrinate in the Hyperbaric Environment. (Pharmacotherapy 2000; 20 (9): 1051-1054), *and appears in the SPUMS Journal by kind permission of the Editor of Pharmacotherapy.*

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ROYAL NEW ZEALAND NAVY NAVAL HEALTH SERVICES DIVING MEDICINE COURSE 2001

This year the course will held at the Naval Base in Auckland, from (am) Saturday 28th April to (pm) Tuesday 2nd May 2001.

The course introduces candidates to the principles of diving and hyperbaricmedicine and focuses on the assessment of an individual's fitness for divingand hyperbaric exposures, and on first aid for the common diving illnesses.

The course is recognised by the New Zealand Department of Labour, the United Kingdom Health & Safety Executive and by the Academic Board of the South Pacific Underwater Medicine Society.

The fees are $NZ750 (inclusive of GST); this includes a complete set of course notes, and morning and afternoon refreshments.

A maximum of 15 places will be available on the course and early enrolmentis advised. This requires payment of $NZ150 deposit (please make chequespayable to NZ Defence Force - Navy).

Another course will be offered in 2002.

For further information, including information about accommodation in the Devonport area, please contact:

Angie Smith, PA to the Director of Naval Medicine
Naval Base, Private Bag 32 901, AUCKLAND
Tel: + 64 (0)9 4455 972. Fax: + 64 (0)9 4455 973
E-mail <navyhosp@ihug.co.nz>

ARTICLES OF INTEREST REPRINTED FROM OTHER JOURNALS

PALLIATIVE CARE AND SPORTS MEDICINE: CAN THE DECISION MAKING PROCESS EVER OVERLAP?

James Douglas

Key Words

General interest, medical conditions and problems, reprinted.

The voluntary medical standards of the UK Sport Diving Medical Committee are supported by a small network of medical referees for specialist opinion, of which I am one. In October 1996, a 37 year old woman presented for a sport diving medical. She had metastatic malignant melanoma treated six months previously by pneumonectomy and chemotherapy. She was already an experienced diver and wished to go on a Red Sea holiday with her partner, before trying diving in Scotland again. Her partner accompanied her at the medical and was intelligent, articulate, and had a good understanding of the risks involved.

She was on no medication and her remaining lung showed normal function. The obvious theoretical risk in such circumstances is pulmonary barotrauma and arterial gas embolism. A stiff tethered lung might easily collapse and cause a fatal tension pneumothorax (she proved her exercise tolerance in the swimming pool). She felt physically cured and she wanted to be mentally cured by achieving her sporting goal.

However, medical reality suggests that metastatic malignant melanoma is never physically curable. What are the risks of sporting diving and can they be quantified precisely? In diving medicine, like many branches of medicine, there are few certainties, many grey areas, and not enough numbers to support decisions.

Faced with such circumstances, a doctor returns to first principles. Hippocrates said “First do no harm”. I had no certain evidence to say it definitely would cause harm and indeed denying the opportunity of rehabilitation may prove harmful. Secondly, apply palliative care principles that revolve around quality of life rather than quantity of life. Thirdly, apply the principle of informed consent to the potential sportswoman and for her partner. He also had to understand the risks as the dive buddy and potential rescuer in a crisis.

I passed her fit and she returned 12 months later to recount her stories of the Red Sea and the West Coast of Scotland. She thanked me further for taking the medical risk and helping another patient with metastatic melanoma.

She was full of life but only lived six months, when she sadly died from cerebral metastases.

Sport diving does not have the sporting heroes of competition sports. This sporting patient inspired many people in her short life and remains my personal sporting hero.

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Dr J D M Douglas is a General Practitioner with a with a long standing interest in the medical challenges of sport and commercial diving. He has published on treatment and medical standards in diving. His address is Tweeddale Medical Practice, Fort William, Scotland PH33 6EU, UK. Phone +44-01397-703136. Fax +44-01397-700139. E-mail <jd@jdmdouglas.co.uk>

BHA RESPONDS TO INCREASING BENDS PROBLEMS

Key Words

Accident, decompression illness, recreationa diving, reprinted, treatment.

Numbers of recompression treatments of sport divers have risen over the past six years, according to the British Hyperbaric Association. Figures for treatments by its member-chambers were 262 in 1994, 270 in ’95, 258 in ’96, 349 in ’97, 323 in ’98 and 330 in ’99.

Now, in response to this and other concerns, the BHA has launched a major campaign to give divers the best possible chance of overcoming decompression illness. Measures include introduction of two national 24-hour help lines, manned by diving doctors at all times, in England and Scotland; and production of a credit card sized advice card, giving details of the new phone numbers and simple advice on recognition and first-aid treatment of DCI. The association also plans seminars for sport divers to improve awareness of decompression illnesses, plus attendance at diving exhibitions and conferences.

“One of the big problems we have to overcome is the number of sport divers who present themselves late for treatment,” Dr Andrew Colvin Chairman of the BHA, tells DIVER. “Our data suggests that the average delay of treatment in sport divers is in the region of 10-19 hours.”

Delay by divers in either recognition or reporting of symptoms was the problem, he said. “It is well recognised that apparently minor symptoms in acute decompression illness can resolve completely with oxygen administered by a facemask, only for a relapse to occur or recurrence of more serious symptoms some hours later.

"Early appropriate advice from a competent diving doctor has tremendous benefits in reducing the consequences of DCI."

Some cases can be even more deceptive, with no symptoms perceived on site, only for problems to develop once a diver reaches home.

"While serious cases of DCI with quick onset of severe symptoms will usually lead to rapid evacuation, some 20% of our treatments involve divers who are on shore, perhaps even back home some hours after diving before the penny drops that something is wrong." says Dr John Harrison, Medical Director of a recompression unit which treats 40-50 divers a year.

"The more that can be done to alert divers to the finer points of DCI recognition, and encourage earlier first-aid treatment, the better." We back this initiative to the hilt.

According to Dr Colvin increasing incidence is the result of more people going diving, particularly adventurous diving. "High risk groups include relatively inexperienced divers and serious amateurs, technical divers who are diving deeper and longer and more often. They in particular should think about where the nearest chamber is and be prepared to react quickly to symptoms. But any diver, beginner or experienced, can suffer from DCI, even while diving within the tables."

The new helpline for England, Northern Ireland and Wales is 07831 151523, and goes through to the Royal Navy Doctor. In Scotland the line is 01224 681818. to Aberdeen Royal Infirmary.

Both lines operate round the clock 365 days a year. A diver or buddy can speak with the diving doctor and receive advice on how to proceed and treat on site. The casualty will be directed to the nearest appropriate hyperbaric treatment facility, with emergency service transport arranged when required.

Enquiries should be addressed to Dr Colvin, BHA, North Sea Medical Centre Ltd, 3 Lowestoft Road, Gorleston-on-Sea, Great Yarmouth, Norfolk NR31 6SG (Phone: 01493414141).

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DIVING DEATHS IN BRITISH WATERS

Key Words

Accident, deaths, decompression illness, recreationa diving, reprinted, treatment.

Seventeen diving fatalities in British waters are recorded in the BSAC's statistics on diving incidents for the year October 1999 to September 2000. Six involved BSAC members. The total reflects the average figure for the past five years (17.8).

Four of the deaths involved deep dives, though in three cases the diver might have gone to an unplanned depth. Two involved air supply problems: two the use of rebreathers; one a solo diver; and one a diver who tangled in ropes. In remaining cases the cause could not be established.

One area of concern surrounds the number of incidents of decompression illness, which rose by 45%, from 86 in 1999 to 125, with a number of suspected bends from other, less well-documented incidents.

"Such a rise in cases of DCI is of concern," states the report, which blames poor buoyancy control as being "at the heart" of the problem, especially in the critical last 10 m zone of an ascent.

Dives to more than 30 m occurred in 47% of the incidents; rapid ascents 46%; missed decompression stops 30%; and repeat diving 24%. The report called for better training of club divers, and for care to be taken in familiarising sufficiently with new equipment.

A cause for celebration was a fall in surface and boating incidents, from 114 to 99. This was attributed to a 20% decrease in cases involving lost divers (from 51 in 1999 to 40) which, says the report, indicates that divers and dive marshals are taking more care about diver location.

Good engine maintenance still appears to be a blind spot, however, with 53 breakdowns, almost half of all surface incidents.

The report concludes that of all incidents recorded, most "could have been avoided had those involved followed a few basic principles of safe diving practice".

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BANDOS INTERNATIONAL COURSE ON ADVANCED DIVING AND UNDERWATER MEDICINE 2001
Sponsored by DAN Europe/DAN Maldives
Approved by the European College of Baromedicine and the German Diving and Hyperbaric Medical Association
August 3rd - August 16th 2001
Bandos Island Resort, Bandos, Republic of Maldives

Pre-course on Treatment of Pulmonary Barotrauma
Including Practical Exercises
Department of Anatomy
University of Ulm Medical School, Ulm, Germany
August 2nd 2001

The fourteen-day course is designed primarily for physicians, emergency medical personnel and nurses with special interest in diving and underwater medicine.

The goals of the course are:

To provide basic and advanced knowledge necessary for the handling of diving medical emergencies such as decompression illness with special focus on the peculiarities of remote locations.

To provide an update of current management and treatment procedures.

To discuss special problems exclusively with international experts in the field with a large operational experience.

To provide extended knowledge of the requirements and management procedures of medical evacuation of dive accident victims from remote locations to treatment centres.

Diving will be provided at an exceptional rate including equipment. During the dives a special insurance (conditions and coverage upon request at the dive base) will be provided free of charge. Diving medical emergency training will be conducted during the dives and on the boats. Those who are not diving are welcome to these sessions free of charge.

In addition the course participants will have the excellent opportunity to discuss special problems in detail with international experts. A free admission to the International DAN Maldives Dive Safety Day held on Bandos Island Resort will also be provided for participants and spouses.

Inquiries concerning registration should be addressed to:
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