South pacific underwater medicine society

Journal/*Newsletter*

C O N T E N T S

SPUMS JOURNAL/NEWSLETTER

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Editorial

Our appreciation of the world around us is the result of our personal prejudices, information being filtered through a complex mix of what we have been taught and what we have discovered for ourselves, with a natural disposition to get an answer that suits our purposes. Science no less than Art illustrates this, and anyone listening to a diver explain the deviation of his diving from "the book" will appreciate the individual factors that lie behind any simple incident. Only a flexible approach within a frame of guidelines seems appropriate when dealing with such an individualistic clientele. The time is past when absolute certainty could be offered, with an implied guarantee of perfect safety if instructions were followed with absolute rigidity. We now know that Nature is variable and risk always present to some degree. We also know that reducing the risk is worthwhile and that to ignore the guidelines of safe diving is to tempt disaster. The price of life is eternal vigilance, so the thinking man has a better survival chance. The Authors whose work appear in this issue offer more than facts, accurate and interesting though the facts are. They seem to have deeper meanings that relate to the underlying philosophy of life and especially of underwater problems. Each reader will find his own meaning, but as Editor I have first crack.

The apparent preponderance of overseas Authors is both an indication of the interesting work done there and a reminder of the dearth of articles from our own members, though they certainly have much of value to report. Our learned colleagues from that other semi-legitimate offspring of UMS, the EUBS, have provided us with a great example of what a Society such as our can undertake. Diving in its present form is an extremely young discipline with more dogma than knowledge can excuse. There is a great need to not only accumulate facts but also to discuss and evaluate them, a matter noted below.

Physiologists have long been aware of the narrow range of core temperature that is compatible with life. The significance of this knowledge for those who go to sea has only been recognised in recent years, and the significance of hypothermia for those underwater has been appreciated only following the expensive tragic fiasco of Sealab III and the "Greek Tragedy" of the Link submersible. It is hoped that the double fatality in a North Sea DDC from hyperthermia, an ironic cause in such a cold environment, will alert all those concerned with such chambers of the absolute requirement to monitor both upper and lower temperature readings. That hyperthermia has played a major role in at least one Australian Oil Rig fatality is known, but just how many others have occurred around the world is unlikely to become known. It is recognised that hypothermia is a hidden assassin elsewhere. Independent evaluation of Incident Reports could reveal such hidden dangers.

Our President's article concerning the Bone Survey of divers in Sydney can be related to the broader subject of using information to maximum benefit to both the individual diver and the increase in understanding of diving problems. It is suggested that centralisation of records will improve our chances of discerning the main factors is the onset and possible regression of Bone Necrosis in divers. In line with the suggestion by the EUBS subcommittee, it could be decided to make Sydney the central repository of such films and facts, with this or some other centre responsible for other areas of data assessment. SPUMS members might like to consider this suggestion. In view of the sometimes conflicting motives of the interested parties (Government, Employer, Industry, Divers, Unions, Insurance and the humble Sport divers) only the guarantee of complete security of reports would induce any party to reveal the total information if there was the slightest possibility of another party becoming privy

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SUBSCRIPTIONS

Members pay $15 yearly. Associate membership for those neither medically qualified nor engaged in hyperbaric nor underwater related research is available for $10. The journal is sent up to four issues yearly to both full and associate members. Those resident outside the immediate Australasian area should write for the special terms available.

Treasurer: Mr W Rehfisch, 5 Allawah Avenue, Frankston, VIC 3199.

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Notes to Correspondents and Authors

Please type all correspondence and be certain to give your name and address even though they may not be for publication. Authors are requested to be considerate of the limited facilities for the redrawing of tables, graphs or illustrations and should provide same in a presentation suitable for photo-reproduction direct. Books, journals, notices of Symposia, etc will be given consideration for notice in this journal.

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Disclaimer

All opinions expressed are given in good faith and in all cases represent the views of the writer and are not necessarily representative of the policy of SPUMS.

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HYPERTHERMIA IN HYPERBARIC CHAMBERS

Two divers died in a decompression chamber following a 400 foot dive. The cause of their death was not immediately obvious. Some of the evidence suggests that the immediate cause of death may have been hyperthermia (heat stroke).

The deaths occurred in a chamber with a volume of approximately 400 cubic feet. The partial pressure of oxygen in the chamber is estimated to have been 0.4 to 0.5 atmospheres. The balance of the mix was helium save for 0.8 atmospheres of nitrogen. The temperature of the atmosphere at the time of transfer is estimated to have between 110°F and 120°F degrees.

Man’s tolerance to high temperature may be related to his temperature sense, his ability to lose heat by regulatory sweating, and his ability to move heat from his body core by blood flow to the skin surface, where cooling is most effective.

Cooling by evaporation of the sweat produced makes short exposures to extremely hot environments tolerable. However, when the ambient vapour pressure approaches 44 mm Hg (ie. A dew point of 36°C or 97°F) or that typically found on man’s skin while sweating in the heat, tolerance is drastically reduced. A temperature of 50°C (122°F) may well be intolerable if the dew point temperature is greater than 25°C (77°F, 24 mm Hg) and if both deep body temperature and heart rate rise rapidly within minutes.

The proteins in the delicate nervous tissues in the hypothalamus of the brain which function in the body’s temperature regulation may be damaged if core temperature goes too high, ie. above 41°C (106°F). Inappropriate vasoconstriction, cessation of sweating increased heat production by shivering, or some combination of these may result. Such heat stroke damage is frequently irreversible and carries a high risk of fatality.

A heat storage by the body of 80 Kcal (320 BTU) (or a rise in body temperature of 1.4°C or 2.5°F degree) for an average sized man represents an average voluntary limit. Collapse can occur at about 160 kcal (640 BTU) of storage (2.8°C or 5°F degree rise).

A final problem is the hyperventilation which occurs predominantly in hot/wet conditions and results in washing out more of the CO_2 in the blood than is desirable. This can lead to sensations of tingling and numbness of the skin and result in vasoconstriction in the brain with occasional loss of consciousness.

Total sweat rates in excess of 2 litres per hour can occur in short exposures, but about 1 litre per hour is an average maximum level sustainable for an accliminated man.

The partial pressure of water vapour at 120°F (49°C) degrees is 88 mm Hg and has a specific volume of 203 cubic feet per pound.

A400 cubic foot chamber will hold 0.9 litres of water in the atmosphere at a temperature of 120°F (49°C) degrees.

Humidity control in the complex was normally accomplished by allowing the atmosphere to circulate by convection between the main chamber and the transfer chamber, the moisture condensing on the transfer chamber walls. The dew point temperature would be perhaps 50°F degrees or higher. (Vapour pressure 9 mm Hg).

When the door to the transfer chamber was closed humidity control stopped. If the divers started to sweat at the high rate of 2 litres per hour due to the high heat it would take 5 minutes for the vapour pressure to reach 44 mm Hg at which point skin cooling due to sweat evaporation would be negligible. This does not count water carried in from wet diving gear or water generated by the sodalime canister.

From the above it can be assumed that no skin cooling occurred due to sweat evaporation after five minutes.

A man doing work equivalent to house cleaning will produce heat at the rate of 180-300 kcal/Hour (800-1400 BTU/Hour). If all this heat is retained by the body a heat storage of 160 kcal could be reached as soon as 32 minutes resulting in collapse. If heat is being added through the lungs and skin, collapse can occur even sooner.

A man is breathing Helium/Oxygen at 300 feet with a ventilation rate of 1 cubic foot per minute and a gas temperature of 114°F, 16°F above body temperature, will add heat at a rate of 0.5 kcal/minute. If the breathing rate increases due to an increase of core temperature the rate of heat addition will increase more.

Consider an extreme case with a breathing rate of 2 cubic feet per minute, and a gas temperature of 130°F degrees, collapse could occur as soon as 23 minutes after initial exposure.

One’s body must always be able to give up heat. At no time should chamber temperature be allowed to increase above 35°C (95°F) degrees.

John Boyce
OCEANEERING INTERNATIONAL
Aberdeen, Scotland

10th September 1975

Reference: ASHRAE 1972 Handbook of Fundamentals

AVASCULAR BONE NECROSIS IN DIVERS

Dr Ian P Unsworth

INTRODUCTION

The place of acute decompression sickness as one of the major problems of diving has now been taken by a far more potentially crippling condition, that of avascular bone necrosis. There is no effective known treatment at present time and only avoidance may be used to prevent it. It is a condition that affects not only standard and self contained divers, but also caisson workers, hyperbaric chamber workers and, rarely, aviators. Significantly, it is now been found in increasing incidence in sports divers. Previously, only professional divers had been investigated for this condition.

HISTORY

In 1888 Konig described "Silent Necrosis of bone". He was probably referring to 'osteochondritis dissecans', but he is credited as being the first to describe avascular necrosis of bone. Bornstein and Platt[1] in 1912 described a condition of bone affecting caisson workers, and in 1941 Grutszmacher[2] described necrosis of bone in standard divers. It was not until the late 1950's and early 60's that research workers started taking an immense interest in the bone necrosis affecting divers and from then on up until the present time, many surveys were conducted and are still being conducted, into bone necrosis affecting divers. The aetiology of avascular necrosis of bone is very varied as may be seen from Table 1.

The necrosis caused by increased corticosteroid administration for immunosuppression in organ transplantation and particularly that of kidney transplantation, has been causing an increased number of cases of bone necrosis to present. It has been known for a very long time that trauma such as fractures of the neck of femur, dislocations of the head of femur, fractures of the scaphoid, etc have been liable to cause avascular necrosis of bone but decompression is now being considered as one of the commonest causes of avascular necrosis of bone in the particular group of personnel that we have been considering and has merited the title of Dysbaric Osteonecrosis. There are a number of hyperbaric factors that have been associated with Dysbaric Osteonecrosis but none of them have been shown directly to be the cause of bone necrosis. Table 2 shows some of the factors concerned.

For example, in divers over the age of 35, necrosis has been found to be more frequent in those who have dived relatively deep or who have suffered some form of decompression sickness, but most of the evidence so far suggests relatively inadequate decompression as a precipitating factor whether or not that decompression lead to symptomatic acute decompression sickness[3]. In Table 3 some of the diving factors are shown, the lowest pressure as yet described as producing Dysbaric Osteonecrosis has been 38 feet of sea water. There have been cases reported of Osteonecrosis occurring after single exposures to pressure. There are, for example, the cases of Necrosis of the femoral and humeral heads in personnel escaping from the sunken HMS Poseidon in 1931[4] and there is well documented case occurring in a caisson worker who had only two exposures on different days at a pressure of 79 feet of sea water. It is undoubtedly true that there are many professional divers who have suffered attacks of decompression sickness, whose bones remain clear of any form of necrosis, and I would equate the onset of bone necrosis in many respects to the deadly game of Russian Roulette.

PATHOLOGY

There are many mechanisms that have been postulated for Dysbaric Osteonecrosis among these are vasculitis, coagulation defects, fat embolism, and gas embolism (Table 4).

As far as Dysbaric Osteonecrosis is concerned, there is no evidence for vasculitis or coagulation defects. However, the mechanism of avascular bone necrosis in steroid therapy has been shown to be due to fat embolism[5]. In these patients there is no evidence of osteoporosis and the histology of femoral heads and humeral heads removed at operation shows fat embolisation. No evidence of vasculitis or vascular obstruction is shown in these people although intravascular fat emboli have been demonstrated. In divers, I believe the pathology is related to the so-called silent bubbles that has now been demonstrated to occur in very many asymptomatic decompressions following pressurization[6]. The use of the Doppler by Spencer among others, has shown that micro-emboli of 20 micron diameter or greater can be demonstrated in the venous return through the heart. It can be shown that interruption of blood supply to the bone cortex for between six to nine hours results in an area of necrosis in that part of the bone. This, however, is not detectable by radiological means for some three to four months. I envisage the formation of venous gas emboli within the blood supply of bone. In cortical bone, capillaries are continuous with those of the medulla and flow is unidirectional and evidence points to this as being centrifugal. I suggest that venous gas bubbles form in the nedullary sinusoids, and even in the cortical sinusoids, thereby interrupting the flow of blood from the medulla through the cortex to the interfascial and intramuscular venous drainage system surrounding the bone. This results in an interrupted oxygenation of cortical bone and thereby paves the way for the necrotic process. The pathology of necrosis varies slightly as to whether the site is that of the head of the long bones (the femur and the humerus) or whether it occurs in the shaft of the long bones. Figures 1 and 2 illustrate a postulated pathological process.

The sites that have been shown to be affected in divers and compression workers are the shoulders, the hips, the lower end of the femur, the upper end of the tibia and very occasionally other sites. The problem sites are those immediately beneath the articular surfaces of the femoral head and the humeral head. It has been shown that it is in these situations where the joint cartilage may be maximally affected, resulting ultimately in secondary osteoarthritis. Where the lower end of the femur or upper end of the tibia are effected, it has only been shown in four cases throughout all world literature that the knee itself is affected. In surveys conducted by many research workers, there have been an interesting disparity between the major site affected. For example, in free swimming divers, such as surveyed by Ohta and Kawashima, 1973 it was found that in 450 divers, the vast majority of lesions occurred in the hips. However, other surveys conducted on professional divers who may use mainly their arms and also caisson workers, have suggested that the shoulders may be the more affected. I believe this is due to the increased usage of one joint over another with a corresponding increased blood supply, and therefore the increased risk of gaseous emboli forming in or around that joint. There has been a trend showing through one survey taken in Australia (Williams and Unsworth, 1976) that the dominant shoulder of professional diver is more often affected than the non-dominant shoulder.

RADIOLOGY

In 1966, well defined criteria for the radiological classification of bone necrosis was laid down by McCallum, Walder and others[7]. This divides the radiological appearances into types A1 to 5, (those lesions concerned with juxta articular areas) and types B1 to 4 (those lesions occurring in the head, neck and shafts of long bones). These criteria and classifications have been adopted internationally and certainly aid in the diagnosis and interpretation of bone lesions in divers. The original medical research council classification relied upon straight x-ray films. In more recent surveys[12], polytomography have been used with some substantial success, particularly in delineating cysts and spherical lesions.

The incidence of bone necrosis (Table 5) shows widely differing results. I believe this is due to the different type of diver concerned. Elliott and Harrison[8] for example dealt with 350 Royal Navy self-contained divers. The Medical Research Decompression Sickness Registry[9] dealt with over 1600 caisson workers, where Kawashima[10] dealt with 450 self contained Japanese shell divers. The US Navy[11] on the other hand restricted their survey to Naval divers alone and Williams and Unsworth[12] have started a survey in Australia looking at, not only professional, but also - and this is believed to be of some significance - sports divers. Figure 3 shows the break-up of Williams' survey taking 110 divers and compression workers. He showed the incidence of 24% with bone lesions, of which 7% were in the sinister position of juxta-articular. Of these juxta-articular, five affected the shoulder joint and only 3 the hip joint. It is believed that this ratio is due to the higher incidence of working divers who would be using their arms and shoulders more than their hips as in swimming. However, the increased incidence of femoral head, neck or shaft lesions over the lesions associated with the humerus must not be overlooked. It is interesting to compare the sites of bone necrosis among 238 cases of decompression sickness as opposed to 77 cases of steroid induced bone necrosis (Figure 4). As can be seen in the decompression sickness induced cases 52% occurred in the shoulders, whereas in the steroid-induced number, 80% occurred within the hip joints. This is very suggestive that it occurs in the dominant joint, dominant weight-bearing or active joint that may be involved. This significance of the active joint, of course, will apply, not to professional divers but equally to sports divers.

DIAGNOSIS

In the asymptomatic diver the only means of diagnosis are radiological and nuclear (Figure 5). Where a diver has reached the stage of joint disintegration, then clinical means of diagnosis enter the picture. The radiological techniques involve not only straight x-rays but as previously mentioned, polytomography also. The difficulty with nuclear medical isotopes uptake lies in the interpretation of the results[13]. The radiological classification and interpretation has been known for many years. where as it is only recently that nuclear medicine has been applied to avascular necrosis of bone in
Divers (Cox 1973), so for some while to come more emphasis will be laid upon the radiological diagnosis than upon the nuclear diagnosis.

MANAGEMENT

In the non-articular (the B classification), the recommended management of patients with bone disease is modifications to their diving technique. The individual is to restrict his diving to within the limiting line of the Royal Navy Table. This allows a maximum, for example, of 20 minutes at 180 feet. The hazardous decompression of experimental and oxyhelium diving would no longer be permitted. In articular asymptomatic lesions the individual if a professional should cease diving but there is no certainty that the disease even at this stage will regress. It is equally not known for certain whether continuing to dive will aggravate the histopathology, but it may be presumed that an area of disorganised bone vasculature mat invite further gaseous embolisation and degeneration.

Active measures in asymptomatic articular disease may involve drilling through the fibrous layers and inserting pegs or bony chips to improve the blood supply of the area and therefore reossification. These however, have not proved particularly successful. The management of symptomatic severe juxta articular lesions with pain and degeneration of the joint will involve well recognized orthopaedic procedures such as osteotomy or arthrodesis.

Elevation of the indented articular cartilage and bolstering with ships inserted beneath the articular cartilage have also been tried but with only limited success. When all other orthopaedic attempts have failed to improve the joint, then total hip replacement remains. The problem with total hip replacement is that in a young diver aged 25 to 30 and a hip replacement with an anticipated life of 10 to 15 years then one may anticipate perhaps two or three joint changes prior to that diver’s demise and this is a particularly daunting thought. The surgery of established dysbaric osteonecrosis has up to this point in time, proved rather unsatisfactory. The predicament that we are in, is that an apparent unavoidable risk of diving is dysbaric osteonecrosis and that the only precaution is to avoid diving and not to expose the human body to changes in ambient pressure. But this not only involves considerable financial loss to professional divers but also involves giving up a sport that very many people not only enjoy at present but are likely to take up and enjoy in the future. We have therefore a potentially crippling condition about which we are not sure of its aetiology, the management of which is as yet unsatisfactory but of one thing we can be certain, that is of its existence - a most unfortunate situation and one to be resolved as soon as possible in the future.

REFERENCES

1. Bornstein, A *Fortschr. Geb. Rientgonstr. Nuklear Med.* 1912; 18: 197.

2. Grutzmacher, K Th. *Roentgenprax.* 1941; 13: 216-218.

3. Editorial. *Lancet.* 1974; 2: 263-264.

4. James, CCM. *Lancet.* 1945; 2: 6.

5. Fisher, DE and Brickel WH. *J Bone Lt Surg.* 1971; 53A: 859-873.

6. Spencer M et al. *Proc V Int Hyperbaric Congress.* Vancouver, 1973; pp 589-599.

7. McCallum RI et al. *J Bone Lt Surg.* 1966; 488: 207-235.

8. Elliott DH and Harrison JAB. *Jnl R Nav Med Serv.* 1970; 56: 140-161.

9. Davidson J. *J Clin Pathol.* 1972; 25: 1005.

10. Kawashima M. *Proc V Int Hyperbaric Congress.* Vancouver, 1973; pp 855-862.

11. Adams GH and Parker GW. *Undersea Biomed Res.* 1973; 1: A20.

12. Williams B and Unsworth I. *Australasian Biology.* 1976.

13. Cox PT. *J Roy Coll Surg (Edin).* 1973; 18: 290-293.

TABLE 1

AVASCULAR NECROSIS OF BONE

AETIOLOGY

Endogenous Hypercortisonism
Corticosteroid Immuno-Suppression (renal transplation)
Trauma - fractures, dislocations
Polyarteritis Nodose
Chronic Alcoholism and Pancreatitis
Sickle Cell Anaemia
Alcaptonuria
Syphilis
Gaucher’s Disease
Schandler’s Disease
Decompression Sickness (dysbaric osteonecrosis)

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TABLE 2

HYPERBARIC FACTORS

Pressures > 17 psig (4 atm)
Frequent exposures
Long history of exposure
35+ years of age
Experimental diving
Inadequate decompression
Inadequate treatment of decompression sickness

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TABLE 3

DIVING FACTORS

Lowest pressure known - 38 feet sea water

Shortest time known - 2 exposures on different days (2.5 hours, 4.5 hours) in 79 feet sea water.

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TABLE 4

MECHANISMS

Vasculitis
Coagulation Defects
Fat Embolism
Gas Embolism

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TABLE 5

INCIDENCE

	No. Divers	% Lesions
Elliott and Harrison (1970)	350	<5
MRC D/C S reg (1972)	1694	19.7
Kawashima (1973)	450	59
USN (1973)	303	32
Williams and Unsworth (1976)	110	24

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FIGURE 1

SHAFT PATHOLOGY

ISCHAEMIA
Ø
OSTEOGENIC TISSUE SUBJECTED TO
Ø pH and pCO^2 ≠
Ø
THICKENED TRABECULAE AND INCREASED CALIFICATION

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FIGURE 2

HEAD PATHOLOGY

NECROSIS and OSTEOCYTE DEATH

↓

BONE RESORPTION

↓

PARTIAL REVASCULARIZATION

↓

THICKENED TRABECULAE

↓

ZONE OF COLLAGEN

↓

TRABECULAR BREAKDOWN

and

JUXTA-ARTICULAR COLLAPSE

* * * * * * * *

FIGURE 3

DIAGNOSIS

DIVERS AND COMPRESSION WORKERS

110

84 (75%) CLEAR

26 (24%) LESIONS

7% JUXTA ARTICULAR

17% HEAD, NECK, SHAFT

Williams and Unsworth (1976)

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FIGURE 4

SITES

Decompression	(238 cases)		Steroids	(77 cases)
Shoulders	249	(52%)	11	(7%)
Hips	94	(20%)	127	(80%)
Other	181		4	

Steroids — Collagen/Vascular disorders
Steroids — Skin

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FIGURE 5

DIAGNOSIS

Clinical	-	Orthopaedic
Radiology	-	Tomography
Nuclear	-	Skeltec

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A “red” Monster?

Soviet Oceanographic Society member A Pechersky told a reporter of the Komsomolskaya Pravda that he and his son saw a giant snakelike creature in Lak Kok-Kol in southern Kazakhstan. Water fowl fled the water in alarm as the monster reached the surface and ploughed through the water. Several sightings of a huge creature have been reported in the lake. Scottish scientific circles have refused to comment on the possibility that “Nessie” has defected.

The Australian, 31 January 1977

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The kiss of Mildred’s Life

Mildred the goldfish is alive and kicking today ... saved by the kiss of life. She had been found floating apparently lifeless in her tank by Rodney Griffiths, 8, at his home in Stevenage, Hertfordshire, England. his uncle, Michael Reed, lifted the fish from the water and blew into it’s mouth. “I was amazed,” said Mr Reed, “the fish responded immediately and looks fine now.”

6 April 1977

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A DECOMPRESSION CHAMBER FOR FISHES

Phil S Lobel and Jane B Culp

In recent years, the demand for live specimens of deep-water fishes for use in both scientific studies and aquariums has increased. One problem, however, is that, regardless of the collecting technique used, most fishes should be decompressed if captured at depths greater than 30 feet.

Many marine fishes possess a gas-filled swim bladder, which expands as they are brought toward the surface. It is used by fishes to maintain a stable position in midwater and often to produce and detect sound.

Fishes are capable of absorbing excess gases from the swim bladder, as well as secreting gases into it. In most coral-reef species, the absorption of the gases is a slow process. They are absorbed by the blood in a capillary network known as the oval gland and then secreted back into the water through the gills. Only a few bottom-dwelling fishes such as hawkfishes (Cirrhitidae) and blennies (Blenniidae) do not need to be decompressed, since they lack gas-filled bladders.

An angelfish captured at a depth of 100 feet may require more than three hours to be safely brought up to the surface. If brought up too rapidly (ie. the normal ascent rate for a scuba diver), its swim bladder will probably burst. Even if the fish is brought up slowly with occasional stops to prevent exploding, its swim bladder may still expand enough to damage nearby vital organs such as the kidney, which lies directly above the swim bladder. In either case, the fish will slowly die, perhaps lingering as long as a week or two. A fish whose swim bladder is overexpanded is termed hyperbuoyant; the fish needs to be equalized in order to remain stable in the water column.

UN-IDEAL COLLECTING METHODS

Unfortunately, most divers merely talk about fishes requiring decompression time. There are, however, several adequate methods for bringing them to the surface in slow stages. Commonly, it is most practical to take a few hours and relax in the boat while periodically raising the fishes in a holder attached to a line. The disadvantages of this method are that it may be time consuming and, if the seas are rough, extremely unpleasant. It also takes considerable experience to learn the proper rates at which to raise the different species.

While ascending with the fishes, a diver can watch to see when their abdomens swell. At this point, they are unable to maintain a steady position in the water. They should be raised just enough so that they are slightly hyperbuoyant but still able to swim down. If done properly, the fishes will maintain a head-down posture but will not appear to be overly distressed. They should be kept at this depth until they are swimming normally again. Then they can be raised a little more.

One method used by some collectors is to bring a fish near the surface and insert a hypodermic needle (about 23 gauge) carefully under the scales and directly into the swollen swim bladder. Then, with slight pressure on the fish, the collector can bleed out the excess gases. This method is useful but requires a certain amount of experience in learning the exact location of the swim bladder in various species.

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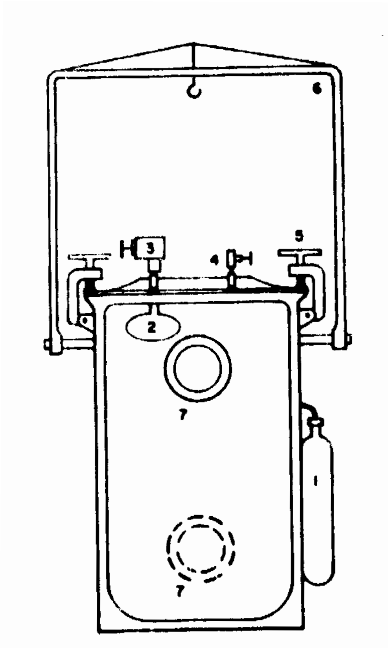
The disadvantages of this method are two-fold. If not properly inserted, the needle may cause considerable damage to other organs.

Also, by allowing the swim bladder to become overexpanded, a rupture in the swim bladder may occur due to the excess pressure on nearby organs. This may partially be avoided by inserting the needle in the fishes at the depth at which they are caught. The fishes also should be treated with antibiotics in order to prevent infection of the wound.



THE DREAM MACHINE

A few years ago a group of scientists and divers began discussing the ideal situation in which some sort of container could be used to maintain pressure on fishes as they are brought to the surface. Thus, once they were there, the pressure could be slowly decreased.

After some testing, Edwin Baughman has made this dream machine available. Known as the “decom tank” the little decompression chamber is made from a high-pressure cylinder and is modified with valves, viewing ports, and filters. It is epoxy coated and holds approximately 18 gallons of seawater. It is lowered from the boat to the desired depth on a 1/8-inch stainless-steel cable.

After capture, fishes are placed in a “keep”, which is then placed inside the decom tank. The lid is fastened by six cover clamps, and air is admitted at ambient pressure from a pony bottle via a regulator into a purge control valve. The air is contained in a rubber bladder inside the chamber. All valves are then closed. The decom tank is winched up to the boat, and a reverse pressure regulator is attached. The pressure inside the decom tank is then equal to the pressure at the depth at which the fishes were placed in it. Once on the surface, the pressure can also be increased, equilibrating pressure to a deeper depth if needed. The fishes can now be slowly decompressed and carefully watched through the viewing ports.

UNNECESSARY DEATHS PREVENTED

Originally, the decom tank was rigged so that fresh air could be continually pumped through the water that was under pressure. It was found, however, that since the fishes were then breathing compressed air, they were subject to decompression sickness, or the bends. It is physically impossible to provide air at 1 atmosphere of pressure and still keep the animals in water at the pressure at which they were captured. The lack of oxygen does not affect the fishes as long as they are not crowded.

The decom tank has enabled Hawaiian researchers to collect many rare fishes from deep water. Usually, only one dive to depths between 150 and 200 feet is now necessary to collect fishes such as tinker’s butterflyfish *Chaetodon tinkeri,* bandit angelfish, *Molacanthus arcuatus,* and the fancy bass, *Pseudanthias thompsoni.*

In our resource-conscious world, the decom tank should become generally used by collectors of deep-water fishes, since it saves many rare and beautiful species from unnecessary death.

DRUGS AND DIVERS - CASE REPORT AND COMMENTS
Professor Martin J Nemiroff

We here at Ann Arbor, Michigan, are particularly suited to comment on this matter as our fair city has been dubbed the "Dope Capital of the Midwest: at least since the decriminalisation of marijuana and the institution of a $5 mail-in fine for possession. I will not address the moral or ethical issues but will describe diving and drugs from the physician's point of view, the treatment and prevention of scuba accidents.

CASE

A 21 year old uncertified diver was brought to the Emergency Department at 7.15 pm with the following history. He was in prior good health until 3 pm when he had approximately 2-4 ozs of alcohol and "snorted" an unknown amount of "THC" (tetrahydrocanabinol, the active ingredient in marijuana). He put on a scuba tank and dived alone in a 30 foot maximum depth lake for an unknown period of time. His entry and exit points were on opposite sides of the lake. He climbed from the water, then fell backwards off the dock into the water again. He was recovered and brought to the Hospital.

On admission he was combative, inappropriate and disoriented, with widely dilated unresponsive pupils. He had a blood pressure of 150/90, pulse rate 80, respirations of 24. His skin colour was normal and the skin felt warm. He had marked coarse nystagmus to the left. There was marked hyperreflexia throughout. Sensory testing was inaccurate.

An attempt was made to pressurize in the University of Michigan Sea Grant (NOAA) chamber to 165 fsw utilising US Navy table 5A. This was accomplished with incredible difficulty due to a rage reaction and marked disorientation. With the aid of his fiancee, a certified scuba diver, he was persuaded with "verbal anaesthesia" to co-operate and consent to closing the pressure seals, although he could not be persuaded to wear a pressurized 02 mask at the prescribed 60 foot level. At depth he gradually resumed his normal behaviour pattern and became oriented to time, place, and person. The neurologic abnormalities resolved to normal at this time and the pressurisation was terminated after 2 hours.

Subsequent investigation revealed the drug inhaled was actually "PCP", a horse tranquilliser (phencyclidine) and popular street drug-hallucinogen. The patient was returned to the neuropsychiatric Institute, where it was felt he had a mild residual organic brain syndrome probably secondary to drug intake. He removed himself from the hospital one hour later, against medical advice. Our final impression was Organic Brain Syndrome, secondary to PCP usage, with a secondary diagnosis of possible air embolism secondary to scuba diving. Research into the effects of PCP indicates that hyperreflexia, nystagmus and reflex asymmetry are common signs of intoxication. One factor leading to suspicion of the initial history was that THC is usually ingested or inhaled rather than "snorted". We believe that this is a unique case of response to the drug-intoxicated diver simulating air embolism.

DISCUSSION

A diver may seek to heighten the positive aspects of diving by utilising drugs. I include alcohol since this is the commonest agent abused and studied in this instance. The level of consciousness is depressed and measurements in our laboratory have confirmed the additive, and even synergistic, effects of alcohol intake with that of nitrogen narcosis. Forty six subjects were tested for eye-hand co-ordination with a maze test before and during a simulated bounce air dive. Depths ranged from 132 to 228 fsw. In paired divers (one alcohol impaired, the other not) the decrement in performance increased with depth, with the greatest change in an extreme risk in the sea, especially if impairment of judgement is synergised by the effects of narcosis.

hallucinogens have been widely denounced in the diving medicine literature. The disorientation, the long latency of onset and peak action, and the depersonalization of some (as noted in this case) make this point quite clearly. The underwater environment with its impaired visual stimuli, unknown animal risks and subtle dangers, intensifies hallucinogenic effects. A reaction as occurred in our hyperbaric chamber could lead to a fatal lack of judgement in a hostile sea environment.

A recent article in The Physician and Sports Medicine (Groner-Strauss and Michael Strauss; Aug 1976) lists pharmacological agents and contraindications to diving. I agree with their list:

ABSOLUTE	RELATIVE	NONE
Alcohol	Analgesics	Antacids
Antiasthmatics	Antibiotics	Birth control pills
Anticonvulsants	Antidiarrhoeal agents	External agents (eg. lotions, oils, salves
Cardiovascular medications	Antiemetics	Laxatives
Depressants (eg. barbiturates)	Antihistamines	Mouthwashes
LSD	Antitussives	Vitamins
Marijuana	Cigarette smoking	Wheat germ
Narcotics	Aspirin	
Steroids	Relaxants	
Stimulants	Thyroid medication	
	Vasoconstrictors	
	Insulin	

As physicians we are asked to certify the health of divers prior to diving in the USA. I believe we are the first line of defence to a sport that is endangered because of its unique hazards. To certify a diver taking anticonvulsants or using insulin has to be done without any concrete statistical background of safety. My own analysis of the last 45 consecutive near-drowning cases I have treated reveals 7 had a history of seizure disorders, all supposedly under control. I seriously question the advisability of certification of a diver with a history of chronic usage of drugs listed in the first two groups above.

A Fin way to ensure cleared water!

Terry Hendrickson of the La Jolla Scripps School of Oceanography has been credited with a novel way of clearing others away from where he wants to dive. He is said to have constructed a large dorsel fin and wired it for remote control. When solitude is required he comes ashore and suddently the fin appears weaving in a sinister fashion along the top of the water. It is to be hoped that he also leaves the water is the fin fails to respond to the control instructions ....

Manly Daily, 16 February 1977

REPORT OF A SCUBA DIVING TRAINING COURSE FOR PARAPLEGICS AND DOUBLE LEG AMPUTEES WITH AN ASSESSMENT OF PHYSIOLOGICAL AND REHABILITATION FACTORS

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ABSTRACT

Six severely disabled men were selected for their swimming ability and physiological suitability for diving. Four paraplegics - T4, T6, T12, and L3, and two double leg amputees, one with both legs amputated above the knee, one with one above and one below. The three high lesion paraplegics and the more severe double amputee were normally mobile only in wheelchairs. Medical history and present physical status is presented for all trainees. A daily report is given of a five-day acquaintance diving course during which the trainees completed all the normal scuba pool training schedule as required by the Confederation Mondiale des Activites Subaquatiques and the British Sub Aqua Club. The course concluded with trainees diving in the open sea. It is concluded that self-contained diving training is an excellent rehabilitatory activity for disabled people with the following limitations: no paraplegic should dive in the sea with a lesion above T5; no paraplegic whose injury was caused by bends should dive at all; no disabled diver should undertake decompression dives. Certain general limitations should be applied to weather conditions, etc. Recommendations are made for further training courses, and for supervision of disabled people in diving schools and clubs.

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DIVING TRAINING FOR THE SERIOUSLY DISABLED

INTRODUCTION

Since the 1940s it has been recognised that sports offer to disabled people a unique opportunity to improve their health, enjoy themselves, and achieve social participation and acceptance. Since the inception of the Stoke Mandeville games by Sir Ludwig Guttman in 1948 this aspect of rehabilitation has received public recognition all over the world.

Because of the institutional background of hospital life, and the need to supervise many subjects with few instructors, it is natural that emphasis has usually been on team games and competitive games. These games have also, in western culture, been granted great respect, so that disabled people acquired social integration by playing such games, and particularly by winning. Less attention has been paid to the more solitary sports, characterised in the extreme by the rugged individualist climbing Mount Everest. This class of sports included skiing, canoeing, sailing, mountain climbing, diving, pony trekking, camping, camping, caving or pot-holing, parachuting, flying, hang-gliding, gliding, etc. They are sometimes described as ‘adventure’ sports or ‘risk’ sports.

In view of the risk entailed in most of these activities, and the outdoor mobile nature which makes supervision difficult, it may seem perverse to encourage people to take part who have already suffered severe injury or disability at least once. However, there is a good case to be made, and this will be put forward fully at the end of this paper. At this point it is sufficient to say that there is a psychological difference between team competitive games and adventure sports, and that people who are attracted to one are often not attracted to the other. Thus, granted that sports have rehabilitative value, adventure sports reach a new section of the disabled population. The risk element is no higher than with able-bodied people since the essential art of learning these activities is to learn how to maintain the risk within acceptable limits by modifying the techniques and restricting the task attempted.

DEFINITION OF THE PROBLEM

Swimming has long been recognised as a sport of enormous value, though usually restricted to a pool, and we only know of a few examples of seriously disabled people who attempt long distance swims in the open sea.

Several individuals have taught themselves SCUBA diving, but there has been little formal attempt to define standards of diving instruction and diving qualifications so that disabled people may acquire safe diving training.

The United States army has run several courses in Hawaii for soldiers with single and double leg amputations, and we have been informed by an instructor in Guam of a diver who learnt to dive although he had one arm amputated at the shoulder, and the other at the wrist.

At this point we should define what we mean by a seriously disabled person, and what degree of self-sufficiency is aimed at in training. In the context of diving, the amputation of one leg is not serious, because many people can swim well with one leg. There are problems in walking about wearing the equipment, but they are not medical or physiological problems, nor peculiar to diving. The absence of a hand or arm is more serious, since a diver frequently has to adjust his equipment while underwater. However, the problem is one which can be solved by careful supervision and instruction by a good diving instructor, who must judge the safety of the pupil. There is no special medical problem.

The class of disability which we are considering is typified by double leg amputation or paraplegic spinal lesion. The precise limitations of safe diving will be discussed below, but it is obvious that any injury which affects the subject’s respiration, sinus, heart, etc. immediately debars him from open water diving.

It is important also to define the competence in diving which we intend the subject to acquire. In 1966 Mr Pritchard in Kenya showed that diving was possible even for a cervical lesion. He dived accompanied by two friends who lifted him into the water, fitted his aqualung, and towed him about underwater. This has enormous psychological value for the individual who enjoys the underwater world, but does not constitute safe diving at an independent level. In the late 60s and early 70s several individual paraplegics found that it was possible to dive, particularly R Head of London, England, who was an active diver for many years with a partial T10 lesion.

The level of competence which we are seeking to achieve is as follows:- the subject is passed as medically fit to dive so that his companions do not have to worry about him. He drives himself to the dive site, looks after his own diving equipment, but may need assistance getting into a boat, and getting his scuba gear fitted in the water. Once dressed he can swim unaided, dive, adjust his equipment, perform all the normal safety exercises, swim in the company of a buddy diver, monitor the progress of the dive, control his ascent, and swim to the boat on the surface. At the boat he will probably require further assistance to remove his equipment and to get back on board. In the event of becoming separated from the boat he could inflate his life-jacket and survive for many hours. This level of independence ensures a high degree of safety, and permits the disabled person to join in diving groups of able-bodied people, to enjoy underwater observation, photography, natural history, or underwater science and research.

MEDICAL AND PHYSIOLOGICAL REQUIREMENTS FOR SUBJECTS

In July 1974 six disabled men were selected from the Israel Defence Forces wounded soldiers rehabilitation programme. The criteria of the medical examination used were the same as those demanded for any person who is to join a diving course. (References: Bennett and Elliott, Miles, CMAS, NAUI, MAC, etc). In addition each case was examined separately taking into consideration the causes of the injury, and the results of the criterion for uninjured people necessitates a completely normal physiological system, central nervous system, ear nose and throat, and sinuses. In short, the potential diver should be very fit.

The examination included a precise medical history (anamnesia) plus a description of the present physical status, as well as the character of the applicant as far as it could possibly be judged. With regard to disabled divers, all the factors mentioned above were taken into consideration, plus the eight following special points:

1. The respiratory system should be completely normal. All the respiratory muscles should be under control, and the spinal lesion not above T5, preferably not above T8.
2. It is of extreme importance that the skin condition of a paraplegic is proper without any injury, kobitus (pressure sores). For amputees, the scars should be completely healed or perfect, meaning at least three months after amputations.
3. The paraplegic should not have any urinary tract infection, and should have full control of urine and bowel movements, with or without artificial aids.
4. Fullest consideration should be given to the personality of the disabled person: he should show self-discipline, with a full knowledge of his own abilities and disabilities. He should be of steady character with the capability of withstanding anxiety and withstanding anxiety and panic. He should also be of a co-operative nature, accepting orders from his superiors without resentment.
5. He should be an excellent swimmer, participating regularly in intensive swimming, including sea swimming.
6. He should pass physical tests and exercises concerned in preparation for the course, and if necessary undergo special physio-therapeutical training.
7. If he is a paraplegic, his disability should not have been caused by a spinal bend (discussion below), nor by arterio-vascular malformation, nor by transverse myelitis.
8. It should be pointed out to persons with partial spinal lesions, from whatever cause, that there is a possibility that diving might make the lesion complete. There is no record of this ever having happened other than with bends cases, but it is a possibility. There are several cases of people with partial traumatological lesions diving with no ill effects.

Description OF COURSE CANDIDATES

CASE A

Date of birth: 1947
Date of injury: 28 February 1969
Injury: Gun-shot wound penetrating the right upper thorax, lung, and lamina of the fourth thoracic vertebra, with laceration of nerve roots on the right side and contusion of the spinal cord.

Status after treatment:
State after decompression lamenectomy at level T4-5 (27 February 1969). The bullet during penetration caused intra parenchimal haemorrhage in the upper apex of the right lung and haemopneumothorax, and was operated. A week after operation all X-rays were within normal limits. The patient remained a paraplegic T4.

Medical history:
Before the injury there is nothing to say, and Case A was always healthy.

Present physical status:
Except for the result of the injury is without pathological finding. Lung and heart within normal limits.

Note: As a result of the high injury it was decided that this person was not fit for sea diving, but he was allowed to participate in the exercises in the swimming pool with full guidance. This was in order to define more precisely the realistic limits for disabled divers. Case A performed most of the exercises correctly, but it was clear that short bursts of intense exercise caused a difficulty in breathing. This was because he was breathing only with the diaphragm.

CASE B

Date of birth: 4 September 1945
Date of injury: 21 July 1970
Type of injury: Gun-shot wound of the chest. Bilateral haemopneumothorax with fracture of sixth rib and scapular. Paraplegia T6.
Treatment: The penetrating wound back left shoulder, and exit wound in the right shoulder. Suction applied twice and after 4 days of tracheotomy, his condition was improved. He was left paraplegic with sensory level of T.6. X-ray of chest and heart within normal limits.

Medical history:
According to the check sheet the anamnesia excluded any illness past or present.

Present physical status:
Blood pressure 70/110. 60 seconds later - 70.
Ears, eustachian tubes, sinus and pharynx, within normal limits.
Chest, good expansion, good alveolar breathing on both lungs.
Heart - rate 70, regular sinus rhythm, within normal limits.
Chest x-ray - normal. State of fractured rib 6th right, slight thickening of pleura in that region.
Paraplegic with sensory level at T6.
Skin on legs healthy without any pressure sores. Good blood supply to the extremities.

Conclusion: Case B passed the acquaintance course successfully performing all the exercises to the satisfaction of the instructors, including one dive to 7 metres in the open sea.

CASE C

Date of birth: 1947
Date of injury: 27 August 1970
Type of injury: Gun-shot wound entered right side of the back vertebra T12, passed through the spleen and came out through the left side of the body.

Treatment: Had a splenectomy.
Status after treatment:
Paraplegic with sensory level L2. Has had several urinary tract infections, but left the hospital in a good condition.
Medical History:
According to the check-up sheet the artamnesia excludes any illness in the past. After the injury always healthy, only occasional urinary tract infection.
Present Physical Status:
Blood pressure - 110/70 Pulse - 60, 80, 70, 60.
Ears, eustachian tube, ear drum, pharynx, within normal limits.
Chest - good expansion, alveolar breathing with both lungs.
Heart - regular sinus rhythm within normal limits.
Neurological - paraplegia with sensory level L2. No sense of position, no sense of vibration, no reflexes in leg, stomach reflex within normal limits, lower epigastrium reflex absent, no feeling in the genital area, no feeling in the sphincters.
Chest X-ray - without pathological findings.

Conclusions: Case C passed the acquaintance course successfully, performing all the exercises to the satisfaction of the instructors, including one dive to a depth of metres in the open sea.

<u>CASE D</u>

Date of birth: 2 November 1947
Date of injury: 10 June 1967
Type of injury: Compression of cauda equina at level III, IV.
Treatment: Decompression laminectomy.
Status after treatment:
Lesion L3-5. State post haemothorax right side, state after rupture of liver (laparotomy).
Medical history:
According to the medical sheet there was no illness before the injury. After the injury there was paralysis below the knees.
Present physical status:
Blood pressure - 130/8. Pulse - 80, 100, 80.
Ears, sinus, nose, eustachian tube, pharynx, without pathological finds.
Chest - good expansion, alveolar breathing in both lungs.
Heart - Sinus rhythm regular 80. Within normal limits.
Chest X-ray - without pathological finding, lung and heart.
Neurological - paralysis below the knees. With control of sphincters.

Conclusions: Case D passed the acquaintance course successfully and performed all the exercises to the satisfaction of the instructors, including one dive to a depth of 7 metres in the open sea.

<u>CASE E</u>

Date of birth: 20 October 1945
Date of injury: August 1969
Type of injury and treatment:
Amputation above knee right. Rupture and fracture of right hand. Amputation of left foot.
Medical history:
Medical record sheet shows always healthy.

Present physical status:

Blood pressure - 110/70.
Pulse - 60, 80, 60.
Ears, nose, eustachian tube, sinus, pharynx, without pathological finding.
Chest - without pathological finding.
Chest x-ray - Lungs and heart without pathological finding. A small metal fragment 0.5 cms x 0.5 cms below rib 10 on left side. All scars have healed perfectly and are dry.

Conclusions: Case E passed the acquaintance course successfully performing all the exercises to the satisfaction of the instructors, and made one dive to a depth of 7 metres at sea.

CASE F

Date of birth: 1947
Date of injury: October 1973
Injury and treatment:
Both legs amputated above the knee.
Medical History and Present physical status:
Healthy.
Conclusions: Case F passed the acquaintance course successfully performing all the exercises to the satisfaction of the instructors, including one dive to a depth of 7 metres in the sea.

PHYSIOTHERAPY AND PHYSICAL TRAINING

Medical examination shows whether people have disabling conditions which would prevent them from diving, but even if they are medically suitable they may not be fit in the sportsman's sense of being in training. Diving does require quick reflexes and physical exertion, and fitness is therefore essential. Subjects for a diving course should be able to pull down with 1/8 -1/5 their body weight on each hand at full arm extension sideways. They should swim regularly, and lead an active life, involving frequent transfers in and out of wheel chairs, or walking on crutches.

If the normal level of physical activity of the subject, and his present physical condition, do not satisfy a physiotherapist or physical training instructor that he is fit to dive, then a course of exercises should be attended for several weeks prior to commencing diving training. This course would involve at least an hour of swimming daily, with bar exercises, walking on callipers, and exercises with weights, punchbags, etc.

DESCRIPTION OF THE DIVING COURSE, JULY 1974

The six subjects mentioned above were selected by the Israel War Veterans Disabled Rehabilitation organisation, and the medical examinations carried out by Yehuda Melamed and Dan Harel. The course ran from July 11-16th, based at Tivon, a small town near Haifa, Israel. A staff of diving instructors, swimming instructors, and physiotherapists was assembled. The essential point is that every disabled subject was accompanied by a diving instructor when in the water in the training pool, and by two instructors, when in the sea. The visibility in the pool was about 3.0 metres, and there was no attempt to run an underwater class, with one instructor supervising several pupils.

Pre-course training

The subjects gathered at the Tivon swimming pool a week before the course and were tested for swimming ability. They purchased masks and snorkels, and practised swimming with them in the pool.

Course routine

It was originally planned that the course should be full-time during the day, allowing a total of 6 hours for lectures and pool sessions each day. Some of the course pupils had to continue studies and exams in the mornings, and thus the timetable was rescheduled to run from 1500 to 1900 or later each day. The pupils thus had a very heavy day's work. Four days of pool exercises and theoretical lectures were followed by one day for diving in the open sea at Akko. Pupils drove themselves to and from the pool and lecture areas, changed into swimming trunks themselves, and in most cases could get in and out of the pool without assistance.

Course syllabus

The course syllabus was based on the British Sub-Aqua Club 3rd and 2nd Class standards, and the training methods of the Israel Underwater Federation.

DAY 1 - Demonstration by disabled instructor (NCF) of the following exercises in the pool:

(a) Fitting mask and snorkel on pool side and entering water
(b) Fitting mask and snorkel while swimming
(c) Duck-dive to 3 metre depth
(d) Swim 20 metres underwater
(e) 3 rolls forward underwater on one breath
(f) 3 rolls backwards underwater on one breath
(g) Breathing through snorkel without mask, face down in the water
(h) Fitting scuba set while hanging on side of pool
(i) Adjusting buoyancy with air-inflatable life-jacket (ABLJ)
(j) Removing and replacing mask and scuba mouthpiece underwater
(k) Removing weight belt, mask, and scuba underwater, and free ascent

The pupils then swam 180 metres each on the surface, at a steady pace. The T4 Case A was considerably slower than the others, though the swim was not timed.

The pupils then demonstrated breath-holding and confidence in the water by lying face down floating on the surface for as long as possible. Times, without hyperventilation, were as follows:

Case A - 35 secs	Case B - 1 min 42 secs	Case C - 1 min 35 secs;
Case D - 1 min 20 secs;	Case E - no test;	Case F - 28 secs.

Pupils hung on the side of the pool and breathed through snorkel without wearing a mask for one minute. All adapted successfully with the exception of Case A, who had to continue practising. All pupils then swam 20-30 metres submerged on a single breath, with times varying from 20-40 seconds.

Pupils then demonstrated forward and backward rolls underwater equipped only with mask and snorkel. All pupils achieved 3 rolls on one breath, with the exception of Case A who could only do two. It was clear that, although very competent and self-possessed in the water, this exercise required greater breath control and inhalation than could be achieved using the diaphragm alone.

Pupils then practised fitting mask and snorkel while swimming or floating in the pool. For a paraplegic, or double amputee without fins, this is much more difficult than it sounds, since the act of raising the hands out of the water causes the body and the head to sink. The most effective technique was as follows: the pupil duck-dived to 3 metres and picked up the mask and snorkel from the bottom. The snorkel was then tucked into the side of the swimming trunks while the mask was fitted. Since the head and the mouth sank into the water during mask fitting, breath-holding was required, and the mask was inevitably full of water. As soon as the mask was sealed the pupil breathed through his mouth, swimming with one hand, while he recovered his snorkel. The snorkel was fitted while breathholding again, and then the mask could be cleared of water by inhaling through the snorkel and exhaling into the mask. Most pupils made several attempts before succeeding in this test, and Case A found it very difficult because of his difficulty in preventing inhalation through the nose.

During this pool session pupils were in the water for nearly two hours, most of that time being actively devoted to exercises, and part of it hanging on the side. Because of the effort involved getting in and out of the pool, pupils tended to keep this to a minimum. Several pupils scratched or grazed their legs, in spite of frequent warnings. In subsequent sessions all paraplegic pupils wore elastic athletic bandages around their knees, and a canvas pad was arranged on the side of the pool in the corner.

Lectures before and after the pool session included the following topics: Mobility for the disabled diver; physics of diving; liquid laws (Boyle’s Law, Charles’ Law, Dalton’s Law, Henry’s Law); outline of the physiology of diving; respiratory system; dangers of hyperventilation and incorrect breathing.

<u>DAY 2</u>: The pupils spent 25 minutes in the pool repeating the exercises learnt on Day 1. To test confidence and sense of direction, all pupils then swam one length on the surface with the mask completely blacked out.

This was followed by a 45 minute lecture at the pool-side on the following subjects, with demonstrations: adjustment of ABLJ, filling and fitting ABLJ cylinder, buoyancy adjustment while diving, breath control, principle of breathing regulator, fitting regulator to tank, testing tank pressure, importance of exhaling during ascent, hand signals.

The pupils all filled their own ABLJ cylinders from their scuba tanks, and entered the water for their first exercises with scuba equipment. In each case the pupil entered the pool at the corner wearing mask, snorkel, and ABLJ. The scuba set was lowered beside the pupil as he hung on the rail, and the instructor helped the pupil to fit the set and adjust the harness. With an inflated ABLJ the pupil could fit the scuba gear without help. Two or three pupils were in the pool at a time, each with an instructor. The pupils dived to rehearse hand signals, and then performed the following tests: two lengths of the 30 metre pool submerged on scuba; rolls and loops to demonstrate attitude control; buoyancy control by breathing; clearing the mask of water.

Performance was very variable. Case A was good on swimming and hand signals, but could not clear mask; Case B was so confident that he took off his mask completely several times and exchanged masks with his instructor while submerged; Cases C, C and E performed well; Case F was confident and successful, but had difficulty in maintaining a balanced attitude in the water.

Each pupil was submerged for 20-30 minutes on scuba. Although they wore ABLJs they were not permitted to adjust buoyancy themselves for the first day, to avoid the danger of over-inflation and rapid ascent. The instructor adjusted the buoyancy as needed.

There were no lectures on this day.

DAY 3: In the pool training all pupils dived first to rehearse the lesson of the previous day. After assembling and donning their ABLJ and scuba gear they performed the following tests: rolls forward and backwards; remove and replace regulator mouthpiece; remove and replace mask underwater. Pupil A was submerged for 16 minutes but could not succeed in mask clearing; the other pupils completed the tests in times as follows: B - 16 minutes, C - 9 minutes, D 9 minutes and E - 14 minutes. Pupil F had extreme difficulty in getting his attitude trim balanced, and worked closely with an instructor attaching weights on various positions on the torso until stability was gained. This was achieved by fitting weights to the ABLJ at the upper chest level. Pupil F was submerged for 18 minutes.

A pool-side lecture and demonstration was then given on the following topics: operation of the ABLJ, control of ascents, effect of wearing a diving suit, effect of pressure on buoyancy of suit and ABLJ, effects of work, cold, and depth on rate of air consumption, variations in breathing resistance with depth and tank pressure. There was a demonstration of the correct order of donning equipment.

All pupils then dived with their instructors in the pool and carried out the following exercises: submerge and share the scuba mouthpiece breathing alternately with the instructor for several minutes; swim one length submerged, surface, change to snorkel, and swim one length on the surface; swim one length underwater with a blacked-out face mask. All pupils completed these tests successfully.

In the evening there was a lecture on the following topics: physiology under pressure; effects of the various gas laws as they apply to the gas spaces of the body; Dalton’s Law and the various kinds of gas poisoning, oxygen, nitrogen narcosis, carbon monoxide, carbon dioxide, and hydrocarbon gases.

This was followed by a lecture on mobility for disabled people on diving expeditions, including methods of crossing rough ground, negotiating steps, camping, and living rough.

DAY 4: The course gathered at the pool to practise the advanced exercises of fitting and removing complete scuba gear while submerged, and life-saving. It was explained that removing scuba gear underwater was possibly useful in certain kinds of emergency, and that donning equipment underwater was relevant to changing sets for prolonged decompression, etc. However, it was made clear that the principle reasons for these tests was to show complete control of the equipment by the pupil, and complete confidence underwater.

For removing equipment the pupils were instructed to proceed as follows: sit on the bottom, remove weight belt and place it across the legs, unfasten scuba harness and slip off one shoulder strap, swing tank round and slip off the other shoulder strap, pull tank down beside diver and lay it on the bottom so that the regulator is close to the diver, remove mask and snorkel and place them on the bottom, start to turn off the tank pillar-valve, take one large breath and close the tank completely, ascend slowly exhaling all the time.

For fitting equipment underwater all the gear was thrown into 2-3 metre depth with the tank pillar-valve turned on, and the regulator mouthpiece tucked under the weight belt to prevent free venting. The pupils were instructed to proceed as follows: swim down, pick up mouthpiece and start breathing, take weight belt off tank and place across legs while sitting on the bottom, pick up mask, fit and clear it, pick up tank, slip one arm through harness, swing tank round behind back or over the head, put other arm through harness, faster waist buckle, fit weight belt, swim one length submerged, surface slowly.

It was explained that the second exercise was much more difficult than the first. Pupils must compete the first exercise to qualify for a sea dive, but would not be disqualified if they failed to complete the second. For paraplegics with no control of their waist muscles it should be appreciated that both exercises require an extremely acute sense of balance, and continuous slight hand movements to prevent the diver falling over. NCF then gave a demonstration of fitting the equipment underwater using the technique as instructed.

The pupils then carried out exercises as follows:

A - Had not achieved sufficient control to attempt these tests. Was given intensive instruction in breath control, balance, and mask clearing. Improved rapidly.
B - Removed equipment swiftly and calmly. Had trouble with balance during fitting equipment, and instructor held legs down to improve stability. Completed both tests.
C - as for B, but could have completed exercise without help
D - as for B
E - both exercises completed quickly and calmly without any help
F - both exercises completed quickly and calmly without any help

Pupils B - F were very enthusiastic about these tests, and carried them out several times in order to improve their efficiency. The instructors then demonstrated life-saving with each pupil in turn, bringing them to the surface and towing them one length of the pool. The pupils were shown that they could assist a diver in difficulty by releasing his weight belt and/or inflating his ABLJ, but these exercises were not practised.

In the evening there was a lecture on the following topics: structure and function of the sinus, ear, eustachian tube, ear-drum; circulation and respiration, function of alveoli, risks of embolism and blocked alveoli, dangers of heat loss and exhaustion; dive planning.

This was followed by a lecture on methods suitable for disabled people getting from the shore onto diving boats, in and out of the sea from various kinds of beach and foreshore, and from boats into the sea and out again.

DAY 5: The class and instructors met at the quay-side in the harbour of Akko at 0715. The early hour was chosen to try and avoid the wind which gets up during the day. After careful consultation and discussion YM and NCF had decided that it was not safe for A’ to dive in the sea with scuba tanks. While he undoubtedly had excellent mental and emotional adaptation to diving, the height of the lesion at T4 made diving dangerous anywhere except in a pool under supervision. At 0750 the first pair of pupils, B and F boarded the 8 metre diving boat, accompanied by diving instructors, a doctor (YM) and physiotherapists and observers. In a water depth of 8 metres the boat was anchored, the pupils lowered themselves over the side, and the instructors helped them to fit scuba gear in the water. Each pupil dived in the company of two instructors, and the visibility was less than 3 metres. They were submerged for 20 minutes, and then returned to the boat. F was able to get from the boat into the water and out again unassisted, but B required assistance.

The boat returned to shore, and the personnel were exchanged so that the other four course members could put to sea. Pupils C and E carried out the same dive as the first pair, in a slight wind with a half metre swell. Pupil D dived last, by which time, nearly 1000, there was a strong breeze and waves of about 1.0 metre. Pupil A snorkelled safely for about half an hour, but did not dive.

On July 22nd 1974 pupils A, C, D and E gave a demonstration of diving at Beith Halochem Sports Centre for the Disabled, near Tel Aviv. The pool was 50 metres long with excellent clear water, and the demonstration was documented with underwater photographs and underwater television. An audience of several hundred watched the demonstration at the pool, and the participants were presented with certificates recording their achievements.

DISCUSSION

Effectiveness of the course

The course described above was designed as an acquaintance course to demonstrate that seriously disabled people could master the techniques of scuba diving in safety, and to establish the best methods of diving and instruction. The progress of the course has been presented in detail since authorities wishing to follow or improve upon this example will naturally be very cautious, not to say sceptical, and it is therefore important to provide exact evidence of the progress of a group pupils. The question of further training will be discussed below.

Maximum degree of injury permissible

This problem has already been discussed in the section on medical criteria, but is considered here from the point of view of safety on a dive in the open sea, rather than from a purely physiological standpoint. It has been demonstrated clearly that T4 paraplegic lesion prevents diving in the open sea. Whilst pupil A showed the greatest courage, self-control, and competence in the water, the loss of respiratory muscles was critical. In contrast, pupil B with a T6 lesion was completely safe. This confirms the theoretical prediction that T5 is the highest lesion which can be permitted diving in the present definition. Any pupil with a lesion above T8 should be scrutinised especially carefully.

The most serious problems of safety related to attitude control in the water, and the restrictions resulting from the hands being required both for propulsion and adjustment of equipment. The paraplegics had good attitude control when swimming, though the feet tended to float up a bit, but had some problems with the advanced pool tests because of the lack of waist muscle control. Conversely, the double amputee with both legs off above the knee had difficulty in controlling the attitude when swimming with scuba, but had no difficulty when swimming with scuba, but had no difficulty when sitting on the floor of the pool. Pupil F found it necessary to attach weights at waist level to attain a good swimming attitude with tanks.

A special danger for paraplegics is that they do not know the position of their legs unless they look at them. This is quite difficult while wearing mask and scuba, and so there is the risk that their feet or knees will collide with rocks, coral, or wreckage. If complete suit covering is worn there is no risk of abrasion or cuts, but in the absence of a suit, extreme care must be maintained.

Special consideration has been given to the situation of paraplegic lesions, or other types of paralysis, arising from bends. The conclusion quite simply is that *a person who acquired a paralysing disability as a result of bends should not dive again,* and this applies to a spinal or cerebral bend even if a cure is achieved through recompression treatment.

Discussion with Dr HV Hempleman and Dr HL Frankel produced the following evidence. A spinal bend damages the spinal card as a result of interrupted or reduced blood supply. Recompression treatment, or the restoration of blood flow. However, there is no means of knowing whether the capillaries have truly been restored to their normal efficiency. Neurological tests of reflexes etc. will confirm that the spinal cord is functioning adequately at normal atmospheric pleasure, but there is no means of discovering whether the blood supply would remain adequate under extreme stress, pressure, or unusual respiratory conditions, other than by exposing the subject to risk in those conditions.

The recent cases can be quoted to illustrate the risk. Subject X was diving in the Channel Islands, acquired a bend, and was brought to Stoke Mandeville Hospital paralysed after recompression treatment which failed to bring any improvement. After ten weeks of complete rest and care X began to recover sensation and muscle control in the lower part of his body, and eventually walked out of hospital completely fit. A few months later X was swimming in a pool, and attempted to swim a length underwater whilst holding his breath. He was paralysed again and was returned to hospital. After a further few weeks he recovered sufficient strength in his legs to walk with the aid of a stick, but four years later he still walked with a serious limp, and required a stick for support.

Subject Y was diving daily to 35 metres in the North Sea, and acquired a bend which paralysed him from the waist down. He was treated immediately with recompression, and apparently recovered completely. Several weeks later he returned to diving with scuba, and two months later was diving at 25 metres on a no-stop dive. After ascent he was paralysed again, from the lower chest down. Recompression treatment failed to produce complete alleviation of symptoms, and for several months he experienced numbness in the legs, headaches, and abnormal reflexes a year later there were still slight residual symptoms.

These cases demonstrate that inadequate decompression causing spinal damage can result in a condition which is undetectable by neurological examination, but which is extremely dangerous. Quite apart from the fact that a person who has suffered one Type II bend may be prone to such bends, the first exposure, whether partially or totally cured or not, may have left damage at a higher spinal level with no neurological symptoms. Upon a second exposure the subject may be very seriously injured.

Optimum Training Schedule

The course at Tivon/Akko was designed as an intensive acquaintance course. It was successful because the pupils had been selected as having exceptional aptitude, in spite of their disabilities, and there was a large team of skilled instructors. There were doubts on the first day as to whether the course members could stand the pace of two hours in the water and two hours lectures as the second half of a working day. In practice the pupils showed increasing enthusiasm and no adverse effects. However, the course was excessively intensive, and people with less innate aptitude are capable of becoming competent divers. In general an introductory course should be more gradual and less intensive.

An optimum introductory course, with a view to subsequent continuous diving training, might consist of 5-10 trainees, supervised by a doctor, 2-3 physiotherapist/swimming instructors, and 3-5 diving instructors.

The course would last 3-5 full days, including 2 hours of lectures, demonstrations, films, technical displays, etc for each hour actually spent in the pool. There should be ample opportunity for reading and studying, discussion with the instructors, and trainees to form a single social group. Each disabled trainee has special difficulties and problems arising from his injury, and the instructors will be learning how to cope with this, as much as is the trainee. This requires the instructors to understand and identify themselves with the trainees to a very high degree.

Optimum follow-up and progressive training

When the standards of training for disabled divers have become well established it may be possible, and preferable, for trainees to join diving clubs or diving schools immediately after their medical selection, and receive training from qualified diving instructors in the usual way. In the mean time it is preferable that severely disabled people in the categories considered here should receive initial training at special short courses supervised by doctors and physiotherapists. Such courses could be established in many countries by co-operation of national sports diving organisations such as NAUI, BSAC, FFSSEM, and the veterans administration, and disabled sports organisations.

Disabled divers should not dive with each other. After receiving initial training, the trainee should join an active diving club or diving school. Training in these organisations is usually carried out on a part-time basis over many weeks or a few months, and this is ideal for the disabled person. By diving regularly with members of the club or school the disabled diver will acquire a group of friends and fellow divers who know his capabilities and limitations when diving at sea, and this will provide maximum safety.

Disabled divers should as far as possible complete all the established training exercises as laid down by the Confederation Mondiale des Activites Subaquatique, and be granted the appropriate certificates. The CMAS standards of training should only be reduced or modified to allow for restricted depth and sea conditions, as discussed below, and in respect of life-saving, since the disabled diver can give very little assistance to others. The disabled diver who acquires sufficient sea experience to become qualified should receive a certificate or log book endorsement stating clearly the limiting conditions within which he may dive safely. He should receive an annual medical check to ensure that it is safe to continue diving.

Performance limitations and dive planning

It is hoped that the present article will be used by diving clubs and disabled sports organisations to help them assess the suitability of disabled diving trainees, and to plan diving trips including disabled people. It is important therefore to try and visualise the full performance envelope of a disabled diver, showing the weak points, and the means of compensation.

Table 1 is a very subjective attempt to estimate the relative level of competence which may be shown by a disabled diver compared with an average trained sports diver. The figure of 100 is taken to represent the normal competence, safety level, etc for the average sports diver.

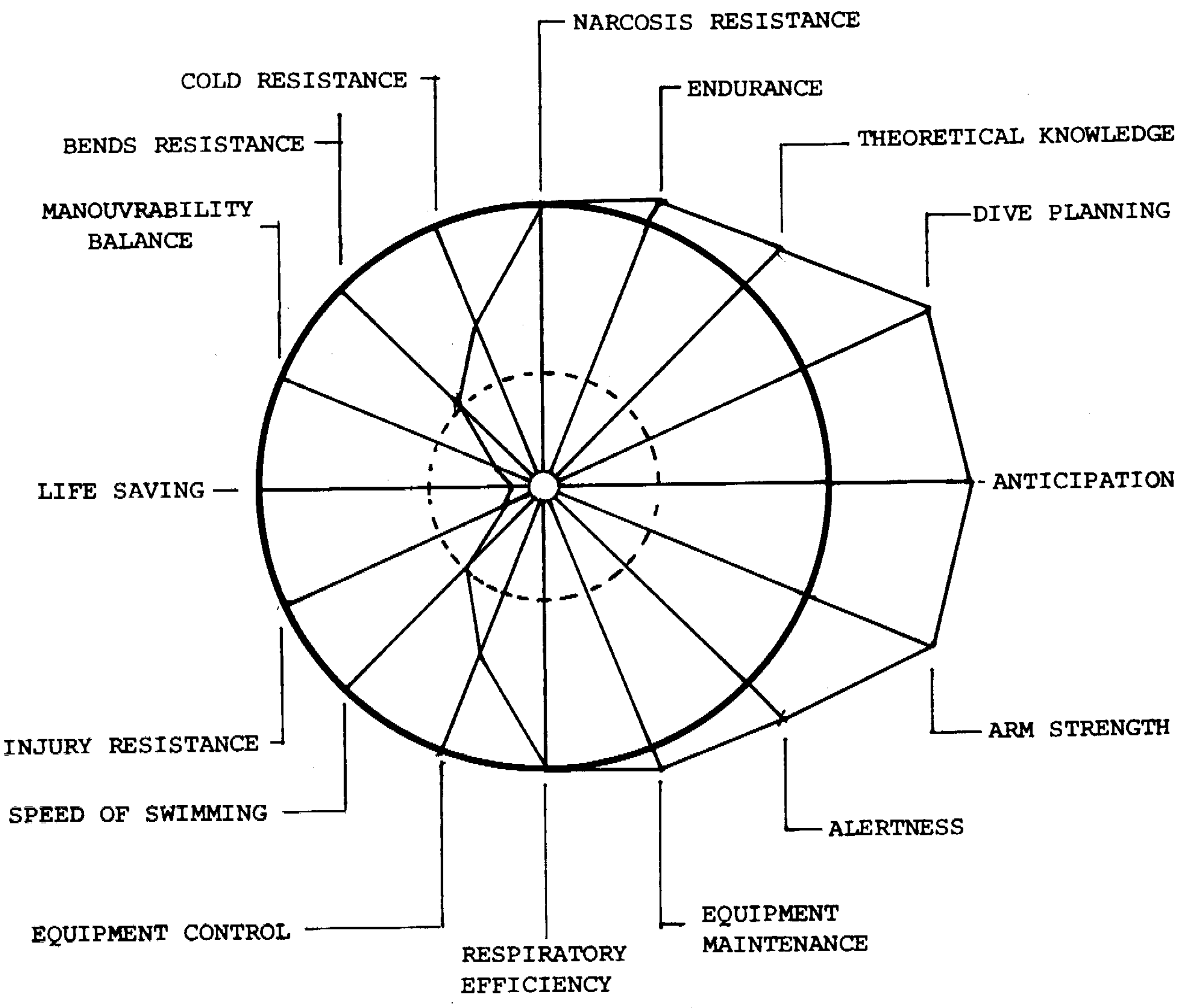
Paraplegics may tend to get cold more quickly than able-bodied divers, and should wear additional protection. This will vary between individuals very much. If a paraplegic becomes very cold during diving, do not try to warm him up with a very hot bath, as this may cause burns. The hottest bath that is safe is about 40°C.

TABLE ONE

AVERAGE SPORTS DIVER = 100

Performance losses		Performance improvements	
Life saving	10	Dive planning	140
Manoeuvrability/balance	30	Anticipation	140
Injury resistance	40	Arm strength	130
Speed in water	50	Alertness	120
Bends resistance	50	Equipment maintenance	120
Cold resistance	70	Theory knowledge	120
Equipment control	70	Endurance	110
Narcosis resitance	100	Respiratory efficiency	100

FIGURE 1



BASIC RULES FOR SEA DIVING BY DISABLED PEOPLE

The following rules are based on six years of disabled diving experience by one of the authors (NCF) and the conclusions from the course in Israel.

1. Obey all usual diving regulations and medical regulations concerning diving.

2. Your safety factor is always lower than for an able-bodied diver.

3. The dive begins when you leave home and ends when you get back home safely.

4. NEVER DIVE ALONE.

5. ALWAYS DIVE WITH TWO ABLE-BODIED EXPERIENCED DIVERS CLOSE TO YOU IN THE WATER; THAT IS WITHIN 5 METRES OR VISIBILITY RANGE WHICHEVER IS THE SMALLER. THERE MUST BE AT LEAST ONE DIVER IN THE COVER BOAT AND A BOATMAN.

6. Always plan and survey your entry into and exit from the water with the people who will be helping you.

7. Make sure that your diving companions know your limitations in terms of diving safety, and general medical care.

8. You cannot use your hands to adjust your equipment or carry out work while you are swimming. Avoid situations which require both at once.

9. Never dive in a current stronger than you can swim against for a long time.

10. Avoid abrasions and cuts from reefs and rocks. Do not touch corals.

11. Do not make dives requiring decompressions stops.

12. Never go under overhangs.

13. Never go inside caves or wrecks.

14. Never dive at night.

15. Never dive in visibility less than 3 metres. It is impossible for your companions to stay sufficiently close to you to give rapid help in these conditions.

16. Never dive in waves of more than 2 m (?) or a strong wind.

17. Plan all diving operations with multiple redundant safety measures and fail-safe procedures.

VALUE OF DIVING FOR DISABLED PEOPLE

It has long been recognised that swimming is an ideal sport for disabled people, since it enables them to discard all artificial aids to mobility and to obtain a maximum level of exercise enjoyably. While swimming gives the disabled person free mobility in two dimensions, diving gives the third dimension. The disabled diver can swim, rise, or descend, roll and turn in any attitude, with no special equipment other than conventional diving gear.

As pointed out at the beginning of this article, risk sports, or adventure sports, appeal to a different mental and emotional character than do team competitive sports. Team competitive sports require superlative performance within the limits of arbitrary man-made rules; the goal is competitive victory over the opponent. It is most unlikely that the disabled person will be able to compete with able-bodied people because he would always be beaten. Adventure sports are not competitive, although they can be made so in some cases, and the goal is to use skill, judgement, and strength to live with and overcome a natural environmental situation: the air, the sea, a sheer cliff, a glacier.

Quite apart from the satisfaction of mastering a difficult technique, a dangerous environment, and obtaining enjoyable physical exercise, diving - in common with some other adventure sports - requires intense group cohesion, loyalty, and mutual trust. A solitary diver is always unsafe, whether disabled or not, and divers learn to depend on each others' skill and ability for their physical safety. This applies to planning, equipment maintenance, and training, as much as to actual co-operation during buddy dives. Involvement in the overall planning and preparation for dives means that the disabled person should become completely integrated into the team. Even in cases where a person is so severely disabled that it is not safe to dive at sea, it is possible

the sufficient enjoyment and exercise may be obtained in a pool to justify the effort.

ACKNOWLEDGMENTS

The paper on the Israeli paraplegic divers was first presented at the Diving Officers Conference of the British Sub-Aqua Club in 1974. The paper by Culp and Lobel first appeared in Sea Frontier, the bi-monthly magazine of the International Oceanographic Foundation. Our thanks are due to these organisations for help in allowing

republication.

APPENDIX A

BRITISH SUB-AQUA CLUB   DIVING OFFICERS CONFERENCE
Guidance for Branch Diving Officers on the Possibility of Diving Training for Disabled People
6 November 1974

INTRODUCTION

Early in 1974 there was a meeting between the Minister for Sport and the Minister for the Disabled, as a result of which the Sports Council has set up a number of liaison groups between sporting bodies and various groups representing disabled people. The aim of this scheme is to permit disabled people to join normal sports clubs, and to participate in outdoor activities. Reg Vallintine represented the BS-AC at the first few meetings until, about midsummer 1974, I was appointed the official BS-AC representative on the Sports Council Committee for Water Sports for the Disabled.

In spite of the strict necessity for medical fitness in diving, it has long been apparent that a person with quite a serious injury, say one leg amputated above the knee, could become quite a competent diver, other things being equal. Several more seriously injured people have taught themselves to dive, and in about 1968 Bob Head, a paraplegic with both legs almost completely paralysed, joined London Branch. Keith Nicholson was then Diving Officer, and he decided to accept Bob for training, using his experience of diving safety to judge what could and could not be safely attempted by a person with this disability. Bob became a competent and keen diver, with many sea dives to his credit, though he has recently cut back on his diving in order to take up flying aircraft!

In 1969 I became paralysed from the waist down as a result of a car accident, a condition known medically as paraplegia. From 1970-73 I worked slowly and steadily at exploring the full possibilities for disabled diving, sticking as closely as possible to the full BS-AC training schedule and tests. In 1974, as a result of negotiations by BS-AC Vice President Alex Flinder, I compiled a diving training course for seriously disabled men. The attached report is a preliminary version of a paper which I have written together with Dr Yehuda Melamed, which we hope will be published soon in the journal Undersea Biomedical Research.

The policy of the BS-AC is to encourage branches to accept disabled members for diving training wherever possible, entirely at the discretion of the Branch Diving Officer. The attached report should demonstrate that disabled people can be safe divers, and active branch members, provided that the proper medical precautions and checks are made first. If a seriously disabled person comes to you and wants to learn to dive, give him a copy of this paper, and ask him to take it to his GP, and your branch diving doctor, so that the doctor can establish the basic feasibility of the person taking up diving. Once that has been done it is up to you, the DO, to decide if the candidate is suitable. To put it in its most direct terms, if a man is going to make a safe diver in a disabled condition, he would have been a very good diver when he was completely fit.

There is no reason why a disabled diver should be a passenger in the branch, and you can always clobber him for equipment maintenance, treasurer, social organisation, fund raising, editor of the Branch newsletter, etc.

If half the branches of the BS-AC enrolled one disabled person each and taught him or her to dive, that would be a fantastic achievement. Please write to me if you have any questions.

NC Fleming

NSW Branch Scientific Meeting - 5 March 1977

The members who attended this meeting were treated to an interesting and varied program, the result is large part of the determined efforts of Dr Chris Lowry. The setting was the Old Stone Building lecture room at the Prince of Wales Hospital. This choice of venue loses nothing from its proximity to a pleasant and historic hostelry and is commended for future meetings.

The first speaker was Dr Doug Walker, who tried to persuade the audience that a fresh look was needed in the realm of Medical Standards. He instanced the cases of applicants with histories of asthma, diabetes, spinal Bends or even traumatic paraplegia. Individual consideration rather than inflexible rules were advocated. The fallibility of the resting ECG in predicting future coronary thrombosis was noted, quoting aviation medicals in Australia over a recent 10 year period. The overwhelming importance of good training and correct diving routine as the most important safety factor was stressed. Next Dr Bart McKenzie spoke on sinus barotrauma, mentioning that 25% of cases were associated with ascent and warning that facial numbness could result from antral reaction effecting the nerve directly and need not indicate a CNS lesion. The diagnosis naturally considerably effects therapy!

We were privileged to hear Dr Yeo describe the recent work at the RNSH Spinal Unit, using sheep, concerning the use of HPO to reduce the damage after spinal injury. The results justify further work and in fact some patients have received treatment. It was suggested that possible repeated treatments would be even better than a single one, the mode of the initial sheep experiments. The supposed reason for benefit from HPO was by helping tissues near to the primary damage retain viability despite the bruising and reduced circulation. That HPO can itself produce toxic effects was mentioned by one member. It was noted that in the elderly a central cord lesion could very easily follow a minor fall. It was suggested that any casualty where cord damage was suspected should be given mask oxygen therapy from the earliest time seen and transported with continued oxygen.

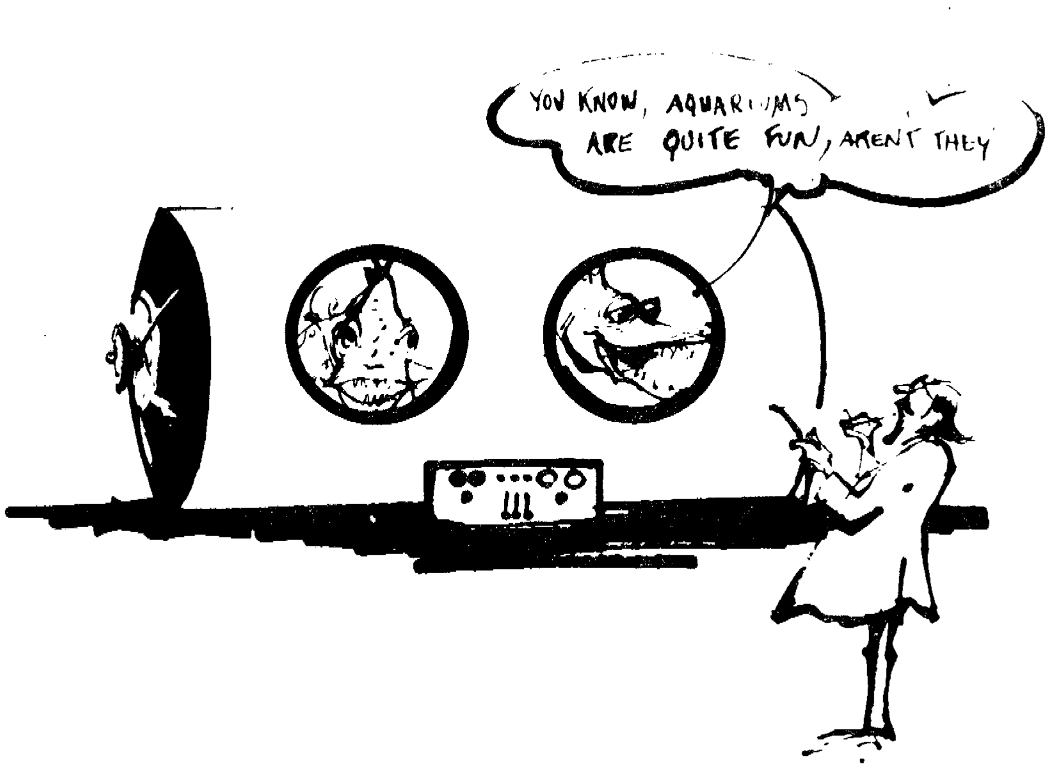
Professor Colebatch was our second “special”. He described his recent work on divers who had suffered pulmonary barotrauma not due to apparent failure of ascent techniques. He related the damage to the abnormal elastic forces in the lungs of such people, an abnormality not effecting routine tests of respiratory function. Both Professor Colebatch and a member of the audience described the occurrence of pulmonary barotrauma in people attempting too vigorously to excel at ventilatory tests! The damage occurs, logically but possible unexpectedly, on the INSPIRATORY effort phase. Cases where the barotrauma occurred associated with ascent technique failure have been shown to have normal elastic forces in their lungs.

Mr John Pennyfather gently but firmly let us see that the problems of diving at altitude were complex: we could see why those in need of advice came to him. In answer to a query about flying after diving he gave two instances worth serious consideration. The first concerned a saturation diver in the USA who suffered Decompression Sickness five days after surfacing, due to taking a plane trip. In the other instance, five RAN divers went on a bus tour in the Canary isles, to an altitude of 7,000 feet, after diving that day and the one previously: they suffered “bends” also. As he said, there appeared to be little basis for the accepted rule of 12 hour delay between a dive and flying. One possibility is that ascent from sea level merely makes apparent the subclinical decompression problem in such people. Once more we must accept the limited safety given by our present level of understanding of decompression problems.

Dr John Knight brought us back from the clouds to the practical dangers of entering cold water. In one instance in Victoria an experienced diver only survived his entry because his demand valve was already in his mouth; the sudden cold-reflex inhibition of control of respiration made it quite impossible for him to take voluntary action. Had he needed to surface in order to take a breath he would inevitably have drowned. Dr Knight also reminded the audience that body core temperature continued to fall for perhaps half an hour after removal from the water, and full return to a normal core temperature could require two hours or more. Heat loss in water is delayed in onset but not changed in ultimate extent by normal wet suits, heat loss being greater in the active than the static: the fact that 71% of the human body is within 2.5 cms of the skin surface makes the peripheral vasoconstriction important in heat conservation.

The final talk was by our President, Dr Ian Unsworth. Two case histories were presented to indicate that HPO therapy can be beneficial even after a delay of several hours from the incident of cerebral air embolism. Neither of these cases were initially recognised as being examples of this condition, and in neither case was the necessity for HPO as a primary mode of treatment recognised immediately. The first case was associated with an anaesthetic incident, the second with a childhood misadventure. Despite a delay in initiating HPO of 20 hours, the recovery was ultimately complete in the first case. Naturally diagnosis is easier in retrospect than under clinical stress but the existence of a hyperbaric facility makes diagnosis important.

The meeting was a success. The report is full so that the many who almost came will gain some benefit also.



continued from page 3

to the details. Only the Medical Profession can offer a reasonable case to act as both custodian and evaluator, and then only with a cast iron guarantee that such records could never be made available to others without the permission of the report's originator. It is common medical practice to write usefully yet to maintain confidentiality, so such guarantees would not hamstring any investigation. If such a scheme should be initiated there would be a need to obtain "finance without strings", but that would be another story!

When Lobel and Culp wrote their article it was directed to helping those who catch fishes for aquaria reduce the wasteful mortality associated with previous methods of dealing with the expanding swim bladder resulting from the reduced ambient pressure. Their approach can teach much to those who wish to keep their divers fit. First they recognised that there was indeed a problem and identified it. They studied the results of the conventional procedures and decided that they were inefficient and wasteful of both resources (the fish) and of money. They reinvented the DDC approach to decompressing saturation divers and calibrated their schedule by clinical criteria, the observation of a minor but acceptable dysequilibrium. They recognised the possibility of inducing complications if they rashly added to the gas dissolved in the water. In view of the complex nature of Gas Bubble disease in fishes they were wise to avoid this complication. Just as we are exhorted to consider the Lilies of the Field, so may we profitably consider the Fishes from the Sea. And may the Authors forgive my interpretation of their article.

We are pleased to have the interesting article from Professor Nemiroff, a very welcome new member of our Society. It is surely only a matter of time before some fool tries drugs and diving here, fatally. Only one case of alcoholic diving death has been recognised in Australia but alcohol is a frequent factor in drownings in general.

All the matters raised by the EUBS subcommittees are worth discussion by members. The problems of training medical and other personnel in Diving Medicine are considerable. The apparent rarity of cases requiring treatment reduces the provision of facilities for such treatment, so there appears to be no need to train operators ... However, as noted by many writers, the majority of diving incidents are related to inadequate diver training and/or techniques rather than ill health per se, a matter both Employers and Unions would find profit in considering.

Possibly the fastest growing area of diving medicine is that of the Diving Medical Examination, aimed at increasing safety by assisting fitness to divers. Till now there has been a somewhat uncritical assumption that *'Only the Best is Good Enough'*, and that peacetime Naval Standards tell it all. In the real world of commercial diving where training is most frequently done by the *"learn by doing it method',* and *Diving Tables* are not allowed to make the job unprofitable, the Bone Necrosis problem is as well known now by repute as is the risk of Mongolism among pregnant ladies. It is hard, when requested to set a Standard, to settle for the adequate basic when there is more credit (and safety of reputation) through demanding perfect health. That the Blind can go diving is already known to readers but the existence of paraplegic divers will surprise the majority. The Israel initiative in this pioneer course has only been possible through the efforts of individual paraplegics who have, through sheer determination, sweet talked someone into both teaching and diving with them. A hard look at just what are the basic requirements for acceptance for diving instructions is easier if we consider such individuals. We are being asked to define in some degree our attitude to risk as a part of living. But it must always be remembered that there is a trade off of their disabilities against the much higher degree of care in training and in dive procedure. Healthy divers could learn much from such attitudes. There is also the extra ability and care demanded from their buddy divers. How much simpler to apply the Procrustian Bed of *"the regulations say"* than make decisions where the conscientious doctor's reputation would be forfeit to a diver's carelessness. *How think you??*

Once more we are in debt to our contributors, and not least to Peter Harrigan for his amusing and thought provoking Cartoons. And beware the diver who once had a little spinal bend.

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CORRESPONDENCE

To the Editor

I read with interest the article "Some observations on Hypothermia" by J Knight in the Jan-Mar 1976 Newsletter. The Author has failed to review the international literature. Neither is there any mention of the literature in the discussion or of the work so far carried out on hypothermia. It is for your kind information and better knowledge that I tell you that in Nazi Concentration camps human victims were forcibly immersed in iced water and all the physiological datas (sic) were recorded until they were dead. Annual Reviews of Physiology reported the findings in greater detail. Neither is there any comment available for the grounds of difference (between the Nazi findings and Dr Knight's paper). It is therefore in the fitness of things that a detailed account of the reasons of difference in the two findings be published in the next issue of the SPUMS Newsletter.

MV Khan (Dr) Kazipura, Rampura

Reply by Dr J Knight

I would reply to Dr Khan that the paper "Some observations on Hypothermia" was written to illustrate a case report. The patient was only mildly hypothermic and the paper discussed mild hypothermia and how it can creep up on a diver unaware. Page 25 of the Jan-March 1976 Newsletter is headed "further reading" and gives 11 references to the recent literature, all of which bear out the views expressed in the article, which was of necessity a potted precis.

I would be grateful to Dr Khan if he would be willing to write a similar length article, based on the sources he quotes, dealing with severe hypothermia.

It is encouraging to have informed comments from interested readers. The Newsletter is supposed to be the communication medium for the Society.

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EUBS Autumn Scientific Meeting - 22, 23 September 1976

This report on the papers given at this meeting, held at the University of Newcastle upon Tyne, is based on the preprinted information supplied by the speakers and naturally does not include contributions made by others who attended. The first day was devoted to the reports of the eight sub-committees set up previously to consider many of the areas of interest that are claimed as relevant to Diving Medicine (which covers a very wide range of matters!) They were presented by the distinguished chairmen of each investigation. The second day was devoted to a discussion of some aspects of aseptic bone necrosis, a term chosen in preference to dysbaric osteonecrosis. It is not clear whether there is any significance in this nomenclature. The range of the subjects and the renown of the EUBS members demonstrate the progress of Diving Medicine and the vigour of our European colleagues. We can gain from their initiatives and seek, necessarily on a modest scale, to emulate their curiosity in the matters of our subject ..... diving.

The first speaker was Dr Barnini, reporting Sub-committee 1 which had given consideration to Standardisation of Medical Examinations and criteria for diving suitability. It was suggested that different standards were permissible for those undertaking only shallow air dives from those diving deep on either air or gas mixtures. The long list of unsuitable disease conditions suggests that perhaps the halt, lame and generally “crook” have been trying to join in the North Sea fiscal plenty in which divers are said to bask. It could be best summarised as saying that one should look beyond merely the diving-medicine contraindications and note the general health, in fact the “fitness”, of all applicants. Perhaps the public now thinks diving is so scientific that physical exertion and agility and training are no longer necessary. Some of the North Sea fatalities suggest non-application of Medical Standards has been a factor effecting the outcome adversely.

Sub-committee 2, under Dr Madsen, had considered the medical training of divers and diving supervisors, pointing out that ALL divers should be trained in first aid and that where diving operations took place beyond the range of rapid medical attention of a competent kind at least one of the dive team should have received additional training. The suggested basic standard was a knowledge equivalent to that in the USN Diving Manual, or equivalent, plus medical knowledge to the WHO International Medical Guide for Ships level. The special training would ensure ability to give an accurate description of the victim’s condition, to follow medical advice, to put up a drip and use a catheter. Sub-committee 3 also considered the problems of Medical Emergency Procedures and the need for a 24 hour medical advice and aid facility for divers.

Surgeon Commander Smith-Silvertsen presented Committee 4’s report concerning the training requirements and qualifications of Diving Doctors. It was noted that apart from those trained during Naval service, or specifically trained by some of the large diving companies and thereafter employed by them, it was nearly impossible to arrange instruction for interested civilian doctors. Especially lacking were facilities for the vital supervised on-the-job-training after this basic training. This situation is mirrored here in Australia at the present time. It was recognised that this made the setting of international minimal training standards difficult, though it was of the utmost importance that the diving community be assured that there are physicians available from whom divers and diving operators can receive medical assistance, health control, treatment and advice. It was suggested that EUBS should establish standards, two categories being awarded.

Category A: Qualified to issue certificates of fitness to dive. Basic course in diving medicine and physics, at least one week (30 hours) duration, to approved syllabus.

Category B: Competent to treat all diving illnesses and emergencies.

Category A qualifications plus:

a. One year experience of practical field work in diving medicine (as main part of daily occupation) and/or research relating to physiological aspects of diving and involving human subjects
b. Advanced course in diving medicine to approved syllabus lasting not less than two weeks (60 hours)
c. Medical fitness and demonstrated ability to dive and/or enter a hyperbaric environment.

Waivers might be possible for candidates on some points, based on their documented experience and known merits. There was also a case for a third category reserved for the specialists of underwater medicine who are competent to advise diving organisations on the medical factors effecting operational matters and on research and development. This would require 4-5 years experience in the field plus an appropriate postgraduate qualification (eg PhD). An examination at the conclusion of the courses was “to ensure that the attendees have absorbed the material presented”. Such is life!

Sub-committee 5 listed the basic equipment to be kept in readiness, primarily for the treatment of Decompression Sickness. It was accepted that any doctor arriving at the site was likely to be without the necessary equipment. There would be equipment to allow catherterisation, intubation and the drainage of a pneumothorax. An aneroid sphygnomanometer must be used, NOT a mercury one and the thermometer a thermocouple one. A foot operated sucker was included, as also basic drugs.

The basic properties required of the breathing apparatus and gas supply to 91 persons and organisations thought likely to be interested. Nineteen questionaries were returned, plus the expressions of support for the idea from eight others. Prof Ornhagen can now speak with feeling to the proposition that divers are reluctant to recognise the need for their involvement in diving research even where it is clearly designed to improve their own safety!

Surgeon Commander Hanson dealt with the problems of thermal control of divers, cold being a limiting factor capable of causing the cancellation of some dives and the deaths of some divers. The following guidelines were offered:

a. Wet suits are unsuitable for all but very shallow dives (20m or less) and for exposures of under 60 minutes.
b. Insulation by means of a dry suit with suitable underwear and air inflation should be suitable for exposures 45-60 minutes.
c. The USN Minimum inspired gas temperatures should be used and diving should not exceed 150m without provision for heating the inspired gas

d. The amount of heat required to cover the heat loss from the surface of the body will depend upon the insulation but it should be such as to maintain a skin temperature of 34.5°C±0.5°C. For free. flooding hotwater suits the amount of heat required at the diver will be between 1.25-1.5 KW.

Perhaps the most important single subject given to any sub-committee for its consideration was that of organising the central reporting of diving information. The chairman, Professor Dennis Walder, started with the comment that the UK legislation should already ensure that all such information was being collected but that unofficially he thought the collection could be much improved. The MRC Decompression Sickness Central Registry, however, already operating an efficient scheme and could become the central point for such information from all areas of Europe.

All countries could have their own central registry, with sharing of information to widen experience. Better evaluation of diving tables could result, as also clues to the better understanding of bone necrosis: annual radiographic bone surveys of commercial divers would be considered and analysed centrally, with an immediate as well as long term benefit to divers themselves. Records of diving deaths, with the fullest possible details, were possible in England and Scotland through the co-operation of the Authorities involved. It was hoped that the rest of Europe would follow suit in this matter. Accidents involving divers should be reported to an agreed national centre, and the efficient keeping of personal log books would be very helpful. Surgeon Commander David Elliott spoke to this subject also, suggesting that there could be centres for different types of information and they need not all be in a single country, there being a single postal address for all reports from which they would be redirected to the appropriate centre. Subjects to be for special attention included, he proposed, coincidental trauma and loss of consciousness in the water as well as other noted matters. There would be problems resulting from the habit of divers of choosing different dive tables on different occasions (and varying these!) the likely fact that not all records would be conscientiously maintained, and the cost of such a scheme.

Papers on the second day discussed the differential diagnosis, information evaluation and storage (computer), and experimental creation of bone necrosis. Professor R I McCallum noted the worth of the MRC. “Exposure to risk” registry for tunnel, caisson and diver workers. There was a panel to give advice on difficult diagnostic problems. The Registry was receiving about 200 radiographs a month from divers alone in 1976. PJ Gregg described the role of the scanning with radioisotopes to detect early bone changes, using rabbits prepared by Mr Peter Cox using glass microspheres as emboli. Results show that scanning will detect regions of bone necrosis three weeks after operation: it takes three months and more for radiographic changes to be first noted.

We thank EUBS for this glimpse at the European diving medicine world.