SCUBA DIVING - THE MEDICAL EXAMINATION OF DIVERS AND PHYSIOLOGY OF UNDERWATER SWIMMING

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MEDICAL EXAMINATION

Within the last few decades skin diving has become an increasingly popular sport. This growing interest has prompted the formation of numerous diving and spear-fishing clubs, many of which provide courses on the physiology of diving and the use of diving equipment. In the interest of safety, many demand that before training begins, prospective divers undergo a thorough medical examination.

This article is an attempt to outline the form which such an examination might take and attempts, by giving a synopsis of underwater physiology, to provide a rational basis for such an examination.

History and Physical Examination:

1. Have you ever dived before?
2. Do you participate in active sports? (To assess exercise tolerance)
3. Have you ever been rejected for service or employment for medical reasons? (A history of chronic or acute illness with a sequel of functional impediment be it sensory, motor, cardiovascular or respiratory, should be a reason for rejection)
4. Check if you suffer from, or have ever had, any of the following:
   - (a) Hayfever or sinus trouble
   - (b) Trouble breathing through nose
   - (c) Discharge from ears, mastoid trouble or broken ear drum
   - (d) Asthma or shortness of breath after moderate exercise
   - (e) Chest pain or persistent cough
   - (f) Peptic ulcer or frequent upset stomach
   - (g) Frequent diarrhea or blood in stool
   - (h) Kidney or bladder disease
   - (i) Syphilis or gonorrhea
   - (j) Rheumatism or arthritis
   - (k) Severe or frequent headaches
   - (l) Nervous breakdown
   - (m) Claustrophobia
   - (n) Travel sickness
   - (o) Alcoholism or any drug or narcotic habit
   - (p) Jaundice or hepatitis
   - (q) Anemia
   - (r) Tuberculosis
   - (s) Diabetes
   - (t) Rheumatic Fever
   - (u) Any serious accident or illness not mentioned above

Age: (Men over 40 should have yearly check-ups)

Weight: (Should be within 15% of normal)

Eyes: Vision correctable to 20/40 in the better eye. Recognition and avoidance are extremely important.

Ears: External canals must be clear. No perforation or severe scarring of ear-drum must be present. Otitis media must disqualify. Eustachian tubes must be clear.

Nose, Throat and Sinuses: No obstruction to breathing, no rhinitis.

Teeth: Dentures acceptable if they do not interfere with gripping of the mouth-piece.

Respiratory System: Lungs must be normal to physical examination and X-ray.

Cardiovascular System: Blood pressure not to exceed 140/90. No varicose veins or haemorrhoids. No anemia or bleeding tendency.

Gastrointestinal System: No significant gastrointestinal disease. Rule out peptic ulcer.

Genitourinary System: No significant genitourinary abnormality. No active venereal disease. Urinalysis should be negative.

Extremities: No gross defects should be present. Most diving fatalities occur on the surface due to physical exhaustion after a dive.

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The Medical Society of Nova Scotia

The Nova Scotia Division

of the

Canadian Medical Association

Founded in 1854 and incorporated in 1861, the Medical Society has thirteen Branch Societies throughout the Province. There are thirteen sections within the Society representing groups with particular interests in various areas of Medicine.

Thirty-five committees and fifteen representatives to other organizations are responsible for projecting the policies of the Society. The governing body is a Council of approximately one hundred and twenty members which reports to the Annual Meeting. The Executive Committee is responsible for the business of the Society between Annual Meetings.

Group Disability Insurance, Overhead Office Expense Insurance, and Life Insurance are available to members in good standing. The Society publishes The Nova Scotia Medical Bulletin monthly. Membership in the Canadian Medical Association provides the Canadian Medical Association Journal weekly and eligibility for participation in the Canadian Medical Retirement Savings Plan and the Canadian Medical Equity Fund.

Conjoint membership in The Medical Society of Nova Scotia and the Canadian Medical Association is available to any physician licensed to practice in Nova Scotia.

Further information may be obtained from:

C. J. W. BECKWITH, M.D., D.P.H.
Executive Secretary

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Skin: There should be no active acute or chronic skin disease.

Central Nervous System: Claustrophobia, attacks of unconsciousness or epilepsy, history of head injury with sequelae, neuropsychiatric disorders, organic diseases of the nervous system, drug addiction or alcoholism must disqualify. The possibility of coma should bar diabetics from diving.

Whereas some absolute contraindications have been mentioned, the final judgment must be left to the discretion of the examining physician.

PHYSIOLOGY AND HAZARDS OF UNDERWATER SWIMMING

Pressures Exerted Upon the Diver:

While on the surface, the diver is subjected to an air pressure of one atmosphere (15 lb/sq. in. or 760 mm Hg.). This is caused by the weight of the blanket of air which envelops the earth. In diving, however, the weight of water above him exerts an additional pressure on the diver at a rate of about 1 lb/sq. in. for every 2 feet that he descends. Thus at 30 feet of depth, he is subjected to 30 lb/sq. in. (2 atmospheres). At 60 feet of depth he experiences 3 atmospheres, at 90 ft., 4 atmospheres and so on.

Problems in Descent

On the surface, air filled cavities within the diver, including the thorax, the sinuses and the middle ear, are connected to the atmosphere and are consequently filled with air at atmospheric pressure. In diving, external pressure rises and the walls of these cavities are subjected to this additional pressure and it is necessary to increase the internal pressure accordingly.

Thorax: If the diver is wearing SCUBA equipment, air is automatically supplied to his lungs at the correct pressure. If, however, he is diving with no external air supply, his thorax is subjected to increasing pressure as he descends, and becomes predictably smaller. This seldom becomes a problem until he exceeds a depth of 60 ft. whereupon his buoyancy may be seriously reduced. Since few free divers ever achieve such depths, this problem is somewhat academic. It may be of interest to note in passing that the foam neoprene "wet-suit" is subjected to the same pressures and may also lose valuable buoyancy at depth.

Sinuses: Sinuses normally open into the nasal cavity through ostia and thus adopt the same pressure as the surrounding water. If for any reason, the ostia are blocked the sinuses are unable to equalize the pressure, intense sinus pain is experienced, discouraging further descent.

Middle-Ear: The middle-ear is connected to the nasopharynx by the Eustachian tube. As external pressure increases, the Eustachian tube tends to flatten and occlude, preventing air from flowing into the middle ear. The diver can usually prevent this by swallowing or by performing a modified Valsalva technique. In swallowing, the opening of the Eustachian tube is pulled down, allowing air to flow through it. In the modified Valsalva technique, which can be accomplished by attempting to exhale whilst holding the nose, air is forced through the Eustachian tube into the middle ear. If the Eustachian tube cannot be opened, intense pain will be felt in the eardrum as water pressure forces the drum inwards. If the diver disregards this warning the drum may begin to haemorrhage or suddenly rupture. If the latter occurs, cold water pours into the middle ear cavity causing vertigo, nausea, nystagmus, disorientation and panic. Should the diver survive this agonizing experience, he is a candidate for otitis media and temporary or permanent deafness in the effected ear.

Problems at Depth

Upon reaching the desired depth, the diver equilibrates to the surrounding pressure and is no longer subjected to changing pressures, although several new hazards await him.

Oxygen Poisoning:

Pure oxygen is seldom used as an air supply for sport divers. The oxygen equipment is, however, available and should be mentioned. High pressure oxygen is toxic to everyone, although individuals differ in their sensitivity to it. Usually symptoms do not appear unless the diver has remained deeper than 30 ft. for longer than half an hour. If he exceeds these limits he is in danger of experiencing oxygen poisoning manifested by convulsions. and unconsciousness as seen in grand-mal, and drowning is inevitable.

With the standard SCUBA equipment the poisoning does not occur unless the diver exceeds 300 feet. This depth is difficult and dangerous to achieve and even the exceptional diver is seldom tempted to descend more than

120 feet, the depth limit usually recommended by SCUBA manufacturers.

Nitrogen Narcosis:

SCUBA tanks are filled with compressed air and contain about 80% nitrogen. On the surface, a minimal amount of nitrogen dissolves in the blood but, in descent, air is delivered to the diver at increasing pressures. More nitrogen is then dissolved in the blood, which has a narcotic effect upon the diver. The effect is similar to that of alcoholic intoxication and it has been estimated that the diver experiences the effect of one Martini for every 50 feet that he descends. At 200 feet he would experience the effect of four Martinis, at 250 ft., five Martinis. A drunken diver at 250 feet of depth is in terrible danger unless he is aware of his state and is able to "hold his nitrogen". As he ascends the effect of the nitrogen disappears and there is no hangover. Deep dives therefore require an intelligent, rational approach.

Carbon Monoxide Poisoning:

Just as the pressure of nitrogen increases, so does that of carbon monoxide. Often diving tanks are filled from a gasoline-driven pump, and carbon-monoxide in the exhaust has been known to enter the tanks. If dives are short and shallow the carbon monoxide probably passes unnoticed, but if the dives are long and deep, the carbon monoxide at high pressure is fatal.

Problems in Ascent

Assuming that the diver has survived the descent and spent some time at depth without drowning, he is now ready to return to the surface. Several more hazards await him.

Air Embolism:

In ascent, the water pressure decreases and the dissolved gases in the blood stream come out of solution and form bubbles. Provided his ascent is slow, no great harm befalls the diver, as the bubbles are small. But if he ascends too quickly, larger bubbles form which may circulate to the brain and cause fatal air embolism. A useful trick adopted by many divers is to blow out a lungful of bubbles and follow them to the surface, which regulates their ascent to a safe speed.

Air embolism may also be caused by failure to exhale whilst returning to the surface. In such a case, the decreasing water pressures allows the lungs to expand and the delicate alveoli may rupture, allowing air to enter the blood stream.

The Bends:

In long deep dives, nitrogen slowly accumulates in the blood. The amount accumulated depends upon the depth of the dive and the amount of time spent at that depth. As the ascent begins, because of the decreasing pressure, the nitrogen comes out of solution and forms bubbles. If the bubbles are small, as is the case when the nitrogen accumulation is minimal, no effects are felt. If, however, larger bubbles form and lodge in the joints, the diver experiences ischemic pain due to occlusion of the blood supply to the area, resulting in the condition known as "the bends".

Should an embolism form in the C.N.S., convulsions, paralysis or death may be caused.

Symptoms are usually apparent soon after the dive but may develop at any time in the 24 hour post-dive period.

The only known treatment of the bends is immediate recompression in order to redissolve the bubbles. This may be affected in a recompression chamber where the external pressure may be increased until the symptoms disappear. The diver is then returned to atmospheric pressure by stages. Unfortunately, these chambers are in short supply, the only ones in the Maritimes being at the Royal Canadian Diving Establishment (East) in Dartmouth, Nova Scotia.

Although it is re-assuring that divers may remain at 40 feet indefinitely without requiring decompression, those wishing to descend to greater depths must plan their dives beforehand to insure adequate decompression stops on ascending.

The foregoing article was written to acquaint the physician with some of the hazards of diving and to provide a plan for the medical examination of a prospective diver.

The great and the humble have the same misfortunes, the same griefs, the same passions, but the one is at the top of the wheel, and the other near the centre, and so less disturbed by the same revolutions.

–Pascal