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Medical assessment of fitness to dive. Part II

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ABSTRACT

Good physical and mental health is a prerequisite for anyone planning to scuba dive. A certificate of fitness to dive for those willing to enter a scuba diving course as well as for active divers, either amateur or occupational, can only be issued if there are no medical contraindications to dive. It is usually within the competence of a diving instructor, a manager of underwater work or a physician to assess a person's mental and physical health and grant them permission to stay under hyperbaric conditions. The legal requirements for issuing a certificate of fitness to dive are different for recreational and occupational divers. The part II of this article discusses the issues concerning medical assessment of fitness to dive for professionals, and divers in uniformed services. It also discusses contraindications to scuba diving and guidelines for medical assessment of fitness to dive in divers with a history of a diving-related condition.

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Key words: diving, health assessment, medical contraindications

MEDICAL ASSESSMENT OF FITNESS TO DIVE FOR OCCUPATIONAL DIVERS

Because of the difficult working conditions and exposure to increased hydrostatic pressure, a candidate for a professional diver has to be in perfect health, both physically and mentally. Occupational divers are required to undergo a regular health assessment to check their fitness to work underwater. Divers themselves should be interested in maintaining full physical fitness in order to be able to cope with the physical and emotional strain of their job and their work environment. Taking good care of their own physical and mental health will allow them to stay professionally active for a longer time, and will help reduce the negative health effects of the job.

In 2003, the European Diving Technology Committee (EDTC), in cooperation with experts, set new standards for medical assessment of occupational divers [1]. The EDTC guidelines include standard record forms for medical assessment of working divers; they discuss all diagnostic tests which must be performed, and list all contraindications to scuba diving, grouped by organs and systems. In compliance with the European Union legislation, the guidelines have been adopted in Poland and have been outlined in the Regulation of the Minister of Health of 2007 [2]. Under the Regulation, all candidates for divers are obliged to undergo a preliminary health assessment, while professional divers must undergo a periodic medical examination. Medical assessment of fitness to dive can be carried out at the University Center for Maritime and Tropical Medicine in Gdynia, regional healthcare providers run by the port authorities and other medical facilities designated for this purpose. Medical assessment of fitness to dive can be also carried out by physicians certified by the Polish Hyperbaric Medicine and Technology Society and the National Center for Hyperbaric Medicine.

After the initial medical check-up, candidates for commercial divers are issued a certificate of fitness (or lack of fitness) to work as a diver. Professionally active divers, on the other hand, receive a certificate confirming a lack of contraindications to work as a commercial diver or a certificate

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of temporary or permanent disability to work underwater. After a fitness to dive assessment is complete, occupational divers are issued with one of the following documents:

— a certificate confirming a lack of contraindications to continue work as a commercial diver;
— a certificate limiting the maximum diving depth to 18 m;
— a certificate of temporary disability to work as a commercial diver;
— a certificate of permanent disability to work as a commercial diver.

A preliminary health assessment for prospective divers includes: a general medical examination, ear, nose and throat examination including an audiometric and a balance test, a neurological examination, an eye test, as well as multiple diagnostic tests such as: a chest X-ray, electrocardiogram (ECG), a blood test, urinalysis, a test for syphilis. If there are no medical contraindications to work as a commercial diver, candidates are referred for pressure tolerance test in order to assess their response to changes in the atmospheric pressure of no less than 0.3 MPa (an equivalent of 30 m of water column). Routine medical re-assessment of commercial divers is performed every 12 months, if their maximum depth limit is 18 m, or every 6 months, if they their allowable depth limit is more than 18 m. A special diving health re-assessment is carried out after a break from diving lasting longer than 3 months, a diving-related illness or injury, or right before a dive session if a diver reports of any health problems. Although the risk of diving-related illnesses or injuries is similar for all types of scuba-diving (occupational, sports, recreational), it may differ depending on the technology and equipment used by individual divers. Proper training, practice and modern equipment reduce the risk of diving-related illnesses and injuries. The basic criteria for determining fitness to dive in commercial divers are as follows:

— the absence of medical contraindications to work as a commercial diver (i.e. having good swimming skills and communications skills, being responsible and mentally competent);
— the absence of illnesses or disorders which could potentially put a diver or any member of a dive team at risk (e.g. a history of syncope, disorientation, a tendency to panic);
— the absence of conditions which might result in deterioration of a person's health condition (i.e. conditions which increase the potential for a barotrauma);
— the absence of conditions which increase the risk of diving-related illnesses, e.g. patent foramen ovale (PFO), a history of a diving-related accident (since the risk of developing a decompression sickness [DCS] is low in divers with PFO, diagnostic tests for this condition are generally not recommended in recreational divers; however, because occupational and military divers may be exposed to a much higher decompression stress, candidates should, in our opinion, be tested for PFO).

The task of a dive doctor performing a diving health assessment is to disqualify each person who has medical contraindications to scuba diving, using their own experience and the recommended medical guidelines for assessing a person's fitness to dive. A preliminary health assessment for commercial divers must be very careful. Disqualification from scuba diving before the training starts will be less stressful for a candidate than disqualification shortly after the completion of training or at the beginning of a career. The primary purpose of each diving health assessment is to improve diving safety as much as it is possible. A thorough preliminary evaluation of candidates will reduce the risk of major injuries as well as the risk of death from pre-existing conditions which might occur during a dive session. Manifestation of an underlying condition under water is dangerous for a diver himself as well as for his buddy and other members of a dive team. The aim of periodic re-examination is not only to determine a person's fitness to continue work as a commercial diver but also to detect any conditions or abnormalities which might have resulted from exposure to hyperbaric conditions in order to minimize the negative health effects of scuba diving which may affect a diver later in his life. When a diver retires, his complete medical records might be used to determine the extent of work-related personal injury for the purposes of an insurance claim. A reliable medical assessment of fitness to dive requires close cooperation between a patient and a doctor, which is based on mutual trust. During an interview, a diver must provide the physician with accurate and complete information about their health condition and inform the physician of any illnesses or injuries which had occurred in between successive re-examinations that resulted in a temporary disability to scuba dive. The fitness to dive examination and assessment form should be completed in the presence of a patient. A physician must make sure the patient fully understands the questions concerning their past and present medical history. An interview is an excellent opportunity to observe patient's behavior and assess their mental condition and communication skills. Before a dive doctor issues a certificate of medical fitness to dive, he or she will have to analyze the results of the diagnostic tests and get acquainted with the opinion of other specialists. The medical examination form must be signed by both the doctor conducting the examination and the diver. The medical records should be available for review by any other physician if necessary. If possible, it is highly recommended that all subsequent fitness to dive re-examinations should be carried out by the same physician. This way, it will be easier to identify even the slightest changes to a diver's health.

A certificate of fitness to dive should include the following information: the type of scuba diving a person is cleared to engage in, the maximum depth limit and the term of its validity. If an individual is declared 'unfit to dive' or 'fit to dive with restrictions', the reasons for such a decision must be clarified to the diver. If a diver is not cleared to scuba dive, he should have the right to appeal against the decision to a superior institution.

European Diving Technology Committee recommends to distinguish between: a preliminary diving health assessment of candidates for occupational divers (during which a maximum depth limit is established), periodical medical assessment and special medical re-assessment to resume diving after a diving-related illness or injury, including DCS. According to the EDTC guidelines, a periodical health re-assessment does not require such comprehensive tests and procedures as the initial examination. However, it is recommended that a diver is interviewed by a dive physician on a yearly basis. If the information obtained during the interview suggests any abnormalities, a diver should be referred for diagnostic tests. EDTC recommends that an in-depth health re-assessment is to be performed every 5 years. Divers who have suffered a diving-related condition or injury or those who have recently had a surgical procedure will require a special medical re-assessment including the analysis of the existing health problem and its consequences for continuation of occupational diving. This type of examination needs understanding and knowledge of the job as well as its physical demands and hazards in order to be able identify potential restrictions [3].

MEDICAL ASSESSMENT OF FITNESS TO DIVE FOR UNIFORMED SERVICES

In Poland, the most stringent regulations concerning medical assessment of fitness to dive apply to the military personnel. This can be explained by the fact that soldiers must at all times be ready to work under extremely dangerous conditions, often in operational settings, and might be involved in exceptionally challenging missions and tasks, such as offshore rescue operations (including submarine rescue operations), planting explosives, sabotage or subversion missions. To accomplish such difficult tasks, military divers may be required to dive using highly specialized equipment, e.g. a semi-closed or closed circuit breathing apparatus as well as an oxygen or mixed breathing apparatus [3].

The latest provisions regulating medical assessment of fitness to dive in military personnel were specified in the Regulation of the Minister of National Defense of 2015 [4], the provisions form the basis for qualifying or disqualifying prospective and active divers from occupational diving. According to the eligibility criteria, the age of a candidate should range from 18 to 30 years. In compliance with the provisions, a candidate for a military diver must be in perfect health and should demonstrate a high level of physical fitness. In order to determine his health status and fitness level, a prospective diver is referred for an initial assessment of fitness to dive by a board of specialists. The preliminary evaluation of candidates includes a series of diagnostic tests (e.g. ECG, echocardiogram, radiography of the chest, paranasal sinuses and the epiphysis of the long bones, blood test, urinalysis) as well as multiple consultations with specialists: a psychologist, a neurologist (electroencephalography [EEG] test), an ophthalmologist (fundus examination), otolaryngologist (audiometric test), internal medicine specialist (a spirometry test), a surgeon, a dermatologist and a dentist. During the initial assessment of candidates, particular attention is paid to their body build. In doubtful cases, exercise ECG and spirometry test results are used to determine the physical fitness of candidates. Excessive body weight (obesity), underweight and asthenic body build are considered absolute contraindications to occupational scuba diving in the Polish Armed Forces. ECG and echocardiography (ECHO) tests are performed to exclude those candidates who suffer from a heart condition. During contrast ECHO a candidate for a diver performs the Valsalva maneuver. The ECHO test performed in this way makes it possible to detect the PFO in the interatrial septum. If such a condition is diagnosed, a candidate is declared unfit to become a military diver because of a high risk of developing a severe decompression sickness. Radiography of the chest and paranasal sinuses is performed in order to disqualify any candidates with respiratory system pathologies. Radiography of the long bones epiphysis is performed during the first 3 years of service, before a diver leaves the service as well as after each diving related accident. The aim of the preliminary radiography is to disqualify any candidates with aseptic osteonecrosis, while the tests which are performed after accidents or when a person leaves the service are aimed at identifying any possible long-term health effects associated with scuba diving or the extent of work-related personal injury. Because of the nature of the underwater environment, it is essential that military divers have excellent eyesight and good color vision. Also, they should present with no dental problems or conditions. The proportion of the missing teeth cannot exceed 45%; however, none of the front teeth can be missing, otherwise a candidate will not be able to hold the scuba mouthpiece. Also, a prospective military diver cannot have any chronic, allergic or purulent dermatoses. The assessment of the mental state of a prospective diver is a key element of the initial evaluation of fitness to dive. Psychological consultation is aimed to assess the emotional state of a person and their tolerance to stress. Psychological assessment of military divers is performed before they start service, shortly before they leave

the service as well as after each diving-related accident. All types of neuroses or phobias (e.g. claustrophobia) are considered an absolute contraindication to scuba diving in the military. However, the final decision whether or not a person may be medically cleared to become a military diver is taken after the analysis of the hyperbaric chamber test results. The hyperbaric pressure tolerance test and oxygen tolerance test are performed to determine a person's sensitivity to the effects of hyperbaric oxygen. A routine reassessment of military divers' fitness to dive is normally carried out every 12 months. A number of diagnostic procedures, including radiography of the long bones, EEG test, fundus examination and audiometric test are performed as part of the initial assessment of candidates. The same tests are routinely performed in all active military divers during periodic medical re-assessments at least every 3 years; the tests are performed in order to identify any negative health effects associated with scuba diving.

The following medical conditions disqualify a person from becoming a military diver or continuing service as a military diver: chronic infections of the upper respiratory tract, especially chronic or recurrent paranasal sinusitis, perforation of the tympanic membrane, chronic otitis media, a past history of the inner or middle ear surgery, inability to equalize middle ear pressure, chronic pulmonary illnesses, cardiac diseases, arterial hypertension, peptic ulcer, hernias (until surgically managed), epilepsy, a history of severe head trauma or craniocerebral surgery, disorders of the central nervous system, severe hearing or vision loss, obesity, diabetes, mental disorders, urinary tract abnormalities, alcohol or substance abuse.

A large number of tasks and missions which were previously carried out by military divers or members of the national scuba diving clubs have been taken over by the Polish National Police and the State Fire Service. The regulations on medical assessment of fitness to dive in police officers and firefighters have been specified in the Regulation of the Minister of Health of 2007 [2] and the Regulation of the Minister of Internal Affairs and Administration of 2014 [5]. Under these Regulations, candidates for divers recruited from among the ranks of the Polish Police or the State Fire Service must show perfect physical and mental health and a good level of fitness, as is the case with military divers. The tasks executed by members of the two services are usually carried out under difficult conditions and in dangerous waters. The task of a physician responsible for certification of medical fitness to dive is to determine each candidate's fitness to dive and disqualify all candidates with any underlying health conditions on the basis of the applicable guidelines as well as their own experience. The initial medical assessment of fitness to dive is extremely important and has to be very careful. The purpose of routine fitness to dive examinations, on the other hand, is not only to declare a person fit or unfit to dive, but also to identify any illnesses or conditions which might have resulted from exposure to hyperbaric conditions and which may potentially have a negative effect on a diver's health later in his life. After conducting all the recommended tests and procedures a medical board declares whether a given candidate is fit to become a diver. Prospective divers are selected on a voluntary basis. All amateur or professional divers should hold a current medical certificate confirming their fitness to dive and stating the date of their last fitness to dive assessment. In order to become a good diver, a candidate must enjoy the activity, feel safe underwater and be confident with the equipment he is using [3].

FITNESS HEALTH ASSESSMENT AFTER DIVING-RELATED ILLNESSES

Whether it will be possible to return to diving after having had a diving-related accident or a diving illness will much depend on the nature of the incident or the condition itself and the risk of deterioration or recurrence of symptoms. The criteria for medical assessment of fitness to dive in individuals with a history of a diving related-illness vary depending on the institution or types of services which employ the diver, in other words, they will be different for the military and for commercial companies. Each time a diver has suffered a diving-related injury or illness, they will be obliged to undergo a careful medical examination. The purpose of such an examination will be to assess a diver's general health condition and the extent of the injuries. Such an examination will also be necessary if an injured diver claims for compensation or a disability benefit. Before declaring a person fit to dive, a physician needs to consider whether this person will continue to dive occupationally (either for a commercial company or as a member of the uniformed services) or only for recreational purposes [3].

DECOMPRESSION SICKNESS

When a diver exhibits signs of a DCS, the role of a physician is to determine whether the condition has resulted from inadequate decompression or if it has been the result of individual risk factors which could increase the chance of DCS occurrence. The primary cause of a decompression sickness is shortening the decompression time. However, in some cases the disease may occur even if a diver has followed the recommended decompression procedures and adhered to the diving tables limits; in such cases, the decompression sickness is usually associated with cerebral or cutaneous manifestations. The incidence of DCS in divers is relatively low, ranging from 0.01% to 0.095% depending on the diving environment and the type of diving activity. A study involving a relatively small group of divers with

a known PFO has shown that the incidence of decompression sickness in such individuals ranges from 0.5% to 1.8% [6, 7]. During a longitudinal study of a group of recreational divers who had received recompression treatment for decompression sickness, study subjects received a variety of psychometric tests as well as the electronystagmography test (electronystagmography is a diagnostic test which records nystagmus in response to stimuli and helps diagnose the causes of vertigo). A total of 50% of the study group showed abnormal tests results after 1 week of completing the treatment, after 3 weeks of the treatment only 10% of the patients had abnormal tests results, which indicates that the neurological signs and symptoms of decompression illness persist for a minimum of 1 month. Therefore, divers are not recommended to return to scuba diving for at least 4 weeks after hyperbaric treatment [1, 8–11].

A mild form of a decompression sickness is relatively easy to manage. Some specialists even believe that if recompression treatment is effective and all signs and symptoms subside, a person can safely return to scuba diving after a minimum of 24 hours of the treatment. A lot of researchers, however, consider such an approach too risky. In compliance with the United States (US) Navy recommendations, a person who has suffered a mild form of a decompression sickness and met the criteria for recompression treatment specified in the US Navy Treatment Table 5, can safely return to diving after a week of hyperbaric treatment, provided that all signs and symptoms have subsided. Divers who meet the criteria listed in the US Navy Treatment Table 6 may be allowed to return to scuba diving after a week of successful hyperbaric treatment, whereas those with a severe form of a decompression sickness manifesting with neurological, pulmonary or circulatory signs and symptoms who have been treated in compliance with the criteria defined in the US Navy Treatment Tables 4 or 7, can only be allowed to return to scuba diving after they have had a medical assessment of fitness to dive by a specialist physician and no earlier than 3 months after completing recompression treatment. Individuals who have experienced a severe form of a decompression illness with residual neurological symptoms should not be allowed to return to occupational diving at all. A medical assessment of fitness to dive in individuals with a history of a decompression illness should include a complete neurological and psychological examination as well as a computed tomography or magnetic resonance imaging scan of the brain and the spinal cord as well as the evoked potential test [8, 9].

It is not uncommon that commercial or military divers conceal or dissimulate their symptoms for fear of losing their job. It is, therefore, important that a physician makes them realize that diving with any residual neurological symptoms increases the potential risk for further brain damage, which may eventually lead to a permanent neurological dysfunction. According to the general recommendations, divers may be medically cleared to return to diving 1–4 weeks after successful hyperbaric treatment. Not all diving specialists, however, agree with the proposed guidelines. The reason for this is the fact that the results of imaging tests performed in patients with a history of a severe form of a decompression illness have shown that the central nervous system damage was far more extensive than the presence (or absence) of residual symptoms. Some diving specialists believe that every single episode of a decompression illness manifesting with neurological symptoms should be considered an absolute contraindication to commercial or professional diving. In our opinion divers with a patent foramen ovale, atrial septal defect or intracardiac or intrapulmonary shunts should not be cleared to return to commercial scuba diving after they have experienced an episode of a decompression illness. In some cases, one might consider limiting professional activity to more conservative diving in order to reduce the risk of venous gas bubbles forming and passing through the PFO to the left part of the circulatory system. This can be achieved by: shortening the dive time to the limits of a no-D dive, limiting the diving depth to less than 15 m, performing only one dive per day, using nitrox, deliberately extending the safety stop or the duration of shallow decompression stops, avoiding any exercise or any unnecessary effort for at least 3 hours after diving. Percutaneous PFO closure may also be considered; performing the procedure eliminates the risk of DCS [12]. As for recreational divers, only those with the atrial septal defect and a history of a severe decompression illness manifesting with neurological symptoms should not be permitted to resume scuba diving. Divers with osteonecrosis revealed by a routine X-ray examination can be medically cleared to return to commercial or professional scuba diving [8–10].

PULMONARY BAROTRAUMA AND ARTERIAL GAS EMBOLISM

Medical assessment of fitness to dive in individuals who have suffered arterial gas embolism (AGE) resulting from a pulmonary barotrauma (PB) or those who have experienced a PB with or without accompanying neurological symptoms is a more complicated issue. Experts disagree as to whether such patients may be medically cleared to safely return to scuba diving. It is generally accepted that individuals who have had any of these conditions may be more prone to the recurrence of symptoms because once a lesion has occurred, lungs become more susceptible to injury. For this reason, before a patient with a history of AGE or PB might be declared fit to return to scuba diving, he will need to undergo a series of specialist pulmonary tests. When consulting a diver who has suffered a PB it is

important to establish whether the condition has been the result of a diver's mistake or whether it might have been caused by some underlying conditions or the presence of pathological lesions within the lungs which increase the potential for pulmonary parenchymal damage. If a diver has not had a quick and uncontrolled ascent and has not reported a respiratory arrest during a dive, the reasons for air-trapping must be looked for elsewhere. The common causes of a diving-related barotrauma might include: a recent respiratory infection, air bubbles trapped at lung apices or interstitial scarring. Because minor lesions may not be visible on a standard chest X-ray, in some cases it might be necessary to perform more accurate diagnostic tests (e.g. computed tomography scan). If the test reveals any abnormalities in the lungs, a patient cannot be medically cleared to return to scuba diving. In rare cases, divers who have received treatment for AGE may develop neurological residuals (although the symptoms are generally more common in patients with a PB). In such cases, divers with a history of AGE will have to undergo the same tests and procedures as those who have had a decompression illness. It will be necessary to perform tests to detect a patent foramen ovale or intracardiac or intrapulmonary shunting. According to the United Kingdom Diving Medical Advisory Committee, any person with symptoms of AGE (with or without the signs of pulmonary damage) as well as any person with signs of a lung injury should be declared as permanently unfit to scuba diving. In exceptional cases, and only if a patient shows a complete recovery from a PB or AGE, divers may be medically cleared to return to scuba diving after a minimum of 3 months [8–10, 13].

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