

MEDICAL FITNESS AT 300 FSW

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Introduction

The American Academy of Underwater Sciences currently allows diving to 190 feet of seawater (fsw) (58.2 meters of seawater (msw)) and would like to extend that operating depth to 300 fsw (91.9 msw) for bounce (*i.e.*, non-saturation) dives. This paper discusses additional medical requirements to allow divers to work down to depths of 300 fsw and will not discuss saturation diving medical standards. It is beyond the scope of this paper to compare general diving medical standards for different organizations. Rather, this paper will describe the additional medical requirements of selected organizations that allow divers to dive deeper than the current AAUS compressed-air scuba limit of 190 fsw.

Throughout the world, organizations using divers almost universally require that those divers meet some sort of minimum medical standards for diving. Generally, the medical standards are based on the underwater environment, hazards of the job itself (irrespective of the underwater component), and the degree of litigative promiscuity of the society in which the organization operates. The diver will undergo periodic medical examinations by a physician with some degree of knowledge in diving medicine who will use the organization's medical standards, along with the physician's knowledge/experience to determine the fitness of the diver to perform his/her duties underwater. Generally, the physician has great leeway in making a determination about the diver's medical fitness to dive.

Organizations Considered

Several organizations that allow diving deeper than 190 fsw were identified in the commercial, military, and other governmental sectors. The selection of specific organizations was based on the author's familiarity with the organizations and the ready access of information by web searches, e-mail, or telephone calls. There are other good organizations, but the author felt that the organizations finally selected would provide sufficient representation of the sectors from which they were drawn to provide an adequate view of diving medical standards in general.

These included (in alphabetical order within each sector):

Commercial

- Association of Diving Contractors International (ADCI)
- The International Marine Contractors Association (IMCA)

Military

- Canada
- North Atlantic Treaty Organization (NATO)
- United Kingdom (UK)
- United States of America (USA)

Other Government Agencies

- Health Safety Executive (HSE)
- National Oceanographic and Atmospheric Administration (NOAA)

In addition, the American Academy of Underwater Sciences (AAUS) medical standards were also considered since the AAUS is standard-setting body for scientific diving.

Findings

The medical requirements for diving were examined for all of the organizations mentioned earlier by examining pertinent printed documentation and web pages along with personal communication with knowledgeable individuals.

AAUS

The AAUS¹ medical standards require age-based periodic examinations by a physician of the diver's choice. The physician does not have to be trained in diving medicine, although it is preferred that a physician be selected who is so trained. Specific laboratory tests are required, and the physician may order additional tests as deemed necessary. Divers must pass the diving medical examination and be certified by the physician as medically fit to participate in scuba diving.

The AAUS standards allow diving deeper than 190 fsw using mixed gas. There are no additional medical requirements mentioned in the AAUS standards for such diving. It is interesting to note that the AAUS standards restrict surface-supplied diving to a maximum depth of 190 fsw. Therefore, under the current AAUS standards, any mixed gas diving deeper than 190 fsw must be performed on open-circuit scuba or rebreathers.

Military

Canada

Currently Canadian Defence forces do not have additional medical requirements for bounce dives deeper than 190 fsw². However, Canadian Forces medical instructions are under review and a major change to the medical requirements is being recommended to

the senior medical policy makers and is expected to be approved this year³. Under the new instructions, divers will be divided into two groups -- shallow water (dive depths less than 15 msw (49 fsw)), and deep water divers (may dive deeper than 15 msw). Deep water divers will include Clearance Divers. Deep water diving candidates will be required to undergo a workup for patent foramen ovale (PFO). Candidates with a PFO larger than 9 mm diameter will be disqualified from deep water diving, but may continue as a shallow water diver. As a grandfather clause, all current Clearance Divers will be offered the PFO workup and corrective surgery if the results would be disqualifying. The workup is voluntary unless the diver has an episode of severe decompression sickness.

NATO

The NATO fitness to dive standards (ADivP-2)⁴ do not mention any medical requirements based on depth. However, ADivP-2 is an early attempt to document a consensus about diving medical standards among physicians from multiple countries. Therefore, although ADivP-2 contains general acceptance/rejection guidance for diving, it often defers to the diver's national standards for specifics. For example, ADivP-2 mentions neither the periodicity of the diving medical evaluations nor the specific laboratory tests required as part of the examination.

UK

The Royal Navy has diving medical requirements⁵ for three types of diving: Service Occupational Diver, Acquaint Diver, and Military Recreational Diver. Since only the Service Occupational Diver performs occupational work underwater, its diving medical standards will be examined in this paper.

There are no additional diving medical standards for the Service Occupational Diver based on depths with the exception of screening for dysbaric osteonecrosis. All Clearance Divers are required to have a full long bone radiological survey upon completion of initial training and on leaving the Service. In addition, divers who dive to depths deeper than 50 msw at least ten times per year should have additional full surveys performed no more frequently than every five years.

USN

The U.S. Navy does not have any additional medical requirements for bounce diving to 300 fsw vice 190 fsw. Change 126 of the Manual of the Medical Department⁶ did separate Naval Special Warfare (NSW) and other Special Operations (SO) medical standards (Article 15-105) from the "regular" Navy diver standards (Article 15-102). However, that change was made to allow consideration of the additional hazards (such as parachuting) other than diving that the NSW and SO personnel face.

Other Government

HSE

The HSE and local government are the enforcing authorities for the Health and Safety Commission which is responsible for health and safety regulation in Great Britain⁷. HSE's Diving Group exists to reduce fatalities and major accidents across all sectors of

the diving industry, not just offshore diving^{8,9}. The HSE Diving Group responsibility covers all types of commercial diving including, but not limited to, scuba, mixed-gas, and saturation diving.

The HSE does not currently (as of May 2005) have additional medical requirements for divers performing bounce dives deeper than 190 fsw¹⁰. However, wording in the document referenced generally "recommends", not "requires" specific standards. In addition, the HSE relies heavily on the recommendation of an Approved Medical Examiner of Divers (AMED), who must examine the diver and has great latitude in the diver's evaluation. Based on the results of the medical evaluation, the AMED may place restrictions on the type of diving in which a diver may function.

NOAA

NOAA is a U.S. federal agency that focuses on the condition of the seas and atmosphere. It is administered by the U.S. Department of Commerce¹¹. The diving related functions of NOAA involve diving that include scuba with air or nitrox, mixed-gas, and saturation diving.

NOAA does not have additional medical requirements for diving deeper than 190 fsw¹². However, they do perform cardiac stress testing on any diver who conducts decompression stop diving¹³.

Commercial

ADCI

The ADCI was founded in 1968 to promote standardization of commercial diving practices. Currently the organization has over 500 members in 41 countries, although most companies are US-based¹⁴. Diving performed by ADCI members includes, but is not limited to, scuba, mixed-gas, and saturation diving.

The ADCI does not have additional medical requirements for diving deeper than 190 fsw¹⁵. However, the examining physician will make recommendations based on diver's examination and review of the essential job functions that the examined diver will perform. The ADCI recommends, but does not require, that the examining physician be trained or experienced in diving medicine for commercial divers. If the examining physician lacks diving medicine knowledge/training, then the examining physician should consult with another physician who is qualified, but that step is also not required.

IMCA

IMCA is also an international trade association of commercial companies with a focus on standardizing commercial diving practices. It was formed in 1995 with the merger of two other organizations, the AODC (originally founded in 1972), and DPVOA (founded in 1990). IMCA had over 250 organizations in early 2004¹⁶. The membership is worldwide, but most companies are northern European-based. Diving performed by IMCA members includes, but is not limited to, scuba, mixed-gas, and saturation diving.

IMCA International Code of Practice for Offshore Diving (IMCA D 014) requires each diver to obtain a certificate of medical fitness to dive from a physician trained in diving medicine. Until 2001, IMCA relied on the HSE to provide a list of suitable trained physicians. Afterwards, IMCA released an information note (IMCA D 20/01)¹⁷ to help members identify appropriated qualified physicians, and also gave key elements in the medical examination, based on the HSE requirements. Today, IMCA recognizes physicians trained in accordance with "Approval of Diving Medicine Courses"¹⁸, a publication produced in January 2006 by an alliance between the Diving Medical Advisory Committee (DMAC) and the Medical Subcommittee of the European Diving Technology Committee (EDTC).

The author, a non-member, had no ready access to IMCA D 20/01. However, since IMCA has a close relationship with EDTC and sells the printed version of EDTC's publication "Fitness to Dive Standards", the author used the EDTC publication as IMCA's diving medical standards guidance. A freely downloadable, electronic version of the document is available at the EDTC web site¹⁹.

The EDTC publication stresses the importance of having a qualified physician perform the diving medical evaluation, rather than the use of pass-fail checklists. Such a qualified physician is necessary to judge medical fitness by taking into account the diver's job description and the worksite's environment conditions.

The EDTC recommends no specific additional diving medical standards based on depths with the exception of screening for dysbaric osteonecrosis. The document states that radiological screening is needed for divers who dive deeper than 30 msw or spend more than 20 hours per week underwater. Two paragraphs later the publication recommends that all new graduates should be considered for initial screening. Periodic screening is then recommended for those who routinely dive deeper than 30 msw with a total dive time of over four hours. This would include deep air and mixed gas diving in addition to saturation diving. Screening in the past was performed by x-ray evaluation of the long bones, but Magnetic Resonance Imaging (MRI) is expected to be the standard method used in the future.

Discussion

Generally, diving organizations did not require additional medical standards based on diving depth. (Two exceptions will be discussed later.) It is the author's impression that the additional medical fitness required of a diver who dives deeper than 190 fsw is much less than the initial medical fitness required to dive to 190 fsw.

In addition, organizations typically rely on the examining physician to determine if a particular diver is medically fit to perform a particular type of job in a particular working environment. In Europe, much emphasis is placed on the qualifications of the examining physician, while in the US, practically no such emphasis is made.

Physical fitness was not discussed because there were no specific additional requirements for deep diving in any of the organizations reviewed. In addition, physical fitness at the time of diving medical examination may be greatly different from that at the time of the dive. It is up to the Dive Supervisor (or equivalent) to determine if the diver is sufficiently physically fit to perform the dive based on the work required and the work environment.

One exception that gives an additional depth-based medical requirement is the Canadian Forces proposed PFO workup and repair policy. In the author's opinion, the concept of using a scale other than a simple presence-or-absence of PFO to restrict diving is a step in the right direction. On the other hand, the use of an interventional cardiac procedure to implant hardware in an otherwise normally-operating heart, where that hardware will remain for the rest of the diver's life, is concerning. However, the author is woefully ignorant of such hardware, and instead is influenced by his experiences at the Navy Experimental Diving Unit where occasionally a manufacturer's claim of a device's reliability differed significantly from reality.

Since the Canadian Forces policy would apply to all dives deeper than 49 fsw, AAUS adherence to the policy would affect general AAUS diving, and not just deep diving. Thus the paper is able to defer this contentious issue to the general AAUS diving medical standards policymakers, assuming that diving deeper than 190 fsw will create venous bubble loads no greater than those encountered in AAUS diving less than 190 fsw.

The other additional medical requirements exception deals with dysbaric osteonecrosis, a recognized problem, but one that hasn't had the glamour or investigative funding for quite a few years. Both the Royal Navy and EDTC require initial and periodic radiological surveys for dysbaric osteonecrosis. The current HSE guidance states that routine x-rays are not required before undertaking saturation diving unless osteonecrosis is suspected. However, this policy may simply reflect great concerns about the risk of radiation exposure.

When queried by the author about dysbaric necrosis, David Elliott responded with an informative letter²⁰ that provided an overview of screening divers for dysbaric osteonecrosis. In the letter, he states:

"Bone necrosis is a particularly complex clinical subject and is in an already difficult area of employee health but *there seems no doubt that the scientific divers will be at increased risk when compared with those diving within the safer envelope of conventional and shallower procedures.* Those divers do need some form of specific health surveillance."

He then provides his reasoning why the preferred method of monitoring divers is through periodic x-ray surveillance, although he recognizes that it is becoming an unacceptable procedure due to the hazards of radiation exposure. At present, MRI is felt unsuitable for diver screening because it is too sensitive in the early asymptomatic phase of dysbaric osteonecrosis, and the lack of appropriate epidemiological studies. An

additional factor is the much higher cost of MRI compared with x-ray procedures. In a follow-up document²¹, he offers a possible pathway for evaluating dysbaric osteonecrosis and other avascular necroses.

Conclusions/Recommendations

In general, AAUS scientific diving standards appear adequate for diving to 300 fsw.

If AAUS is satisfied with the performance of the physicians who currently examine AAUS divers, then continue to use them.

For AAUS divers who will work deep, or spend multiple hours at a time underwater, consider developing a screening program for dysbaric osteonecrosis using David Elliott's recommendations as a starting point.

There is no need to consider an additional PFO policy for deep diving unless it is known that the deep diving decompression schedules will give divers significantly higher venous bubble loads.

Issues related to dysbaric osteonecrosis and PFO are not unique to the deeper diving discussed in this meeting and could therefore affect currently accepted diving practices at SI and in the scientific diving community in general. A consensus on the proper methods to screen divers for dysbaric osteonecrosis and PFO may take significant time. In the author's opinion, it is unnecessary to delay diving to 300 fsw while awaiting a consensus, since the probability of an adverse event is low with either condition, based on current diving practices at AAUS and in the US in general.

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