In: Godfrey JM, Pollock NW, eds. Diving for Science 2006.Proceeding of the American Academy of Underwater Sciences 25th Symposium.Dauphin Island, AL: AAUS; 2007.

Evolving Standards for Diabetes and Diving: Implications for Scientific Diving

Neal W. Pollock, Ph.D.

Center for Hyperbaric Medicine and Environmental Physiology
Duke University Medical Center
Durham, NC 27710
neal.pollock@duke.edu

Abstract

Persons with diabetes were banned from diving in the United Kingdom (UK) after a serious case of decompression sickness was misdiagnosed in 1975 as a hypoglycemic event. Formal bans were subsequently established in many countries, including the United States (US). The UK ban was reversed in 1991, marked by a national database to monitor the diving activity of persons with diabetes. The database accumulated summary records of 14,000 dives by 447 persons with diabetes from 1991 through 2004, with minimal problems reported. Persons with diabetes are now cleared to dive for both recreational and professional purposes in UK. A 1993 US survey indicated that persons with diabetes were diving regardless of the prohibition still in place in this country. In 1995, the YMCA was the first American organization to develop a dive certification program specific to persons with diabetes. A respectable body of literature has documented safe diving by persons with diabetes from several countries since the mid-1990s. An international workshop, jointly sponsored by the Undersea and Hyperbaric Medical Society and Divers Alert Network in 2005, was used to develop consensus guidelines for recreational diving by persons with diabetes. The scientific diving community will be affected by a shift in the acceptance of diabetes in divers. The 2005 diabetes and recreational diving guidelines offer a starting point from which to consider new rules for scientific diving.

Keywords: health guidelines, hyperglycemia, hypoglycemia, insulin, safety, underwater

Introduction

Insulin-requiring diabetes mellitus (IRDM) has traditionally been considered an absolute contraindication to diving. Persons with IRDM who chose to dive despite the public ban generally did so by hiding their condition. However, there has been a growing shift away from the blanket prohibition position in recent years concomitant with the enactment of anti-discrimination laws and the growing body of literature demonstrating safe diving by individuals with diabetes. Persons with IRDM are now able to receive training and dive openly in several countries. It is likely that the permissive position regarding recreational diving will be strengthened in the future. It is timely for all sectors of diving to consider the available evidence and implications to their operations. The scientific diving community may be rapidly affected by changes in recreational diving policies since many scientific divers enter the discipline with recreational training backgrounds. This paper provides a brief history of diabetes and diving, reviews relevant literature, and discusses possible implications for and application to scientific diving regulation.

Research on Diabetes and Diving

The largest record of diving with diabetes comes from the United Kingdom (UK). Persons with diabetes were banned from diving in the UK in 1975 after a serious case of decompression sickness was misdiagnosed as a hypoglycemic event (Bryson *et al.*, 1994). Subsequently recognizing that persons with diabetes were continuing to dive, apparently with little problem, the UK ban was reversed in 1991. A national database was then established to monitor the diving activity of persons with diabetes. The

database accumulated reports of 14,000 dives by persons with diabetes from 1991 through 2004 with few adverse events (Edge *et al.*, 2005a&b). An experimental study completed in 1997 concluded that there was no direct effect of pressure on plasma glucose (Edge *et al.*, 1997).

Divers Alert Network (DAN) North America has also completed a series of studies of diving by persons with diabetes (Uguccioni and Pollock, 2005). A 1993 survey indicated that persons with diabetes were diving regardless of the fact that diabetes was classified as an absolute contraindication for participation. DAN then collected observational data on the blood glucose response to recreational diving in adult divers with IRDM from 1997-2000 (Dear *et al.*, 2004). A similar but smaller-scale study of teenage, novice divers with IRDM was completed in 2004 (Pollock *et al.*, 2006). Both the adult and teenage studies found a relatively low frequency of hypoglycemia associated with diving; the first concern for persons with diabetes.

Recognizing that a substantial body of literature had addressed diving by persons with diabetes, the Undersea and Hyperbaric Medical Society (UHMS) and DAN jointly sponsored an international workshop to consider the topic in June, 2005. The proceedings of the meeting (Pollock *et al.*, 2005a) included a series of papers reviewing the available data, discussion by the 50 workshop participants, and consensus guidelines resulting from the deliberations. A synopsis of the guidelines included in the executive summary (Pollock *et al.*, 2005b) appears in Table 1. While the workshop discussion, and subsequently the guidelines, were by design limited to recreational diving by persons with diabetes, it is likely that a regulatory evolution will affect all diving sectors. This shift will be supported by anti-discrimination legislation.

Anti-Discrimination Legislation

The traditional authority determining medical fitness to participate in a range of activities is the physician. Justification for medical decisions has been based on varying degrees of research evidence, expert opinion, and personal judgment. Recent legislation favoring individual freedom has made it more difficult to rely on anything but evidence-based decisions.

The Americans with Disabilitities Act (Public Law 101-336; 104 Stat. 327; 1990), signed into US Federal law 26 January 1990, was designed to remove barriers to access to normal elements of society for persons with disabilities. The act had five titles: employment, public services, public accommodations, telecommunications, and miscellaneous. The legislation quickly demonstrated wide-ranging effects. It allowed any exclusionary policy to be more easily challenged, thus requiring clear and compelling evidence to justify such decisions. The legislation has substantial weight in cases where prohibitions are primarily based on theoretical risk and the wisdom of the medical community. The need for evidence-based decisions is increasingly apparent as challenges to conventional wisdom gain strength and number. The heart of the legislation is that reasonable accommodations must be made for persons with disabilities.

The American Diabetes Association assists in cases where discrimination may be unfairly influencing the individual freedoms of persons with diabetes. Some of these cases have involved professional diving (Lorber, 2005). It is expected that pressure will increase for flexible case-by-case evaluations to replace blanket prohibition against either recreational or professional diving, mirroring the movement seen in the UK.

Table 1: Guidelines for Recreational Diving with Diabetes - Summary Form (Pollock *et al.*, 2005b)

Selection and Surveillance
▪ Age ≥18 years (≥16 years if in special training program) ▪ Delay diving after start/change in medication o 3 months with oral hypoglycemic agents (OHA) o 1 year after initiation of insulin therapy ▪ No episodes of hypoglycemia or hyperglycemia requiring intervention from a third party for at least one year ▪ No history of hypoglycemia unawareness ▪ HbA_{1c} ≤9% no more than one month prior to initial assessment and at each annual review o values >9% indicate the need for further evaluation and possible modification of therapy ▪ No significant secondary complications from diabetes ▪ Physician/Diabetologist should carry out annual review and determine that diver has good understanding of disease and effect of exercise o in consultation with an expert in diving medicine, as required ▪ Evaluation for silent ischemia for candidates >40 years of age o after initial evaluation, periodic surveillance for silent ischemia can be in accordance with accepted local/national guidelines for the evaluation of diabetics ▪ Candidate documents intent to follow protocol for divers with diabetes and to cease diving and seek medical review for any adverse events during diving possibly related to diabetes

Scope of Diving
▪ Diving should be planned to avoid o depths >100 fsw (30 msw) o durations >60 min o compulsory decompression stops o overhead environments (*e.g.*, cave, wreck penetration) o situations that may exacerbate hypoglycemia (*e.g.*, prolonged cold and arduous dives) ▪ Dive buddy/leader informed of diver's condition and steps to follow in case of problem ▪ Dive buddy should not have diabetes

Glucose Management on the Day of Diving

- General self-assessment of fitness to dive
- Blood glucose (BG) ≥150 mg·dL^{-1} (8.3 mmol·L^{-1}), stable or rising, before entering the water
  - complete a minimum of three pre-dive BG tests to evaluate trends
    - 60 min, 30 min and immediately prior to diving
  - alterations in dosage of OHA or insulin on evening prior or day of diving may help
- Delay dive if BG
  - <150 mg·dL^{-1} (8.3 mmol·L^{-1})
  - >300 mg·dL^{-1} (16.7 mmol·L^{-1})
- Rescue medications
  - carry readily accessible oral glucose during all dives
  - have parenteral glucagon available at the surface
- If hypoglycemia noticed underwater, the diver should surface (with buddy), establish positive buoyancy, ingest glucose and leave the water
- Check blood sugar frequently for 12-15 hours after diving
- Ensure adequate hydration on days of diving
- Log all dives (include BG test results and all information pertinent to diabetes management)

Organizational Support of Diabetes and Diving in North America

The majority of recreational diving agencies in North America have taken cautious or passive positions regarding diving and diabetes. In marked contrast, the YMCA developed a dive certification program specific to persons with diabetes in 1995 (Scott, 2000; 2005). The YMCA program standards were later adopted by Scuba Schools International. It remains to be seen if the recent guidelines will encourage other training agencies to openly accommodate persons with diabetes wanting to learn to dive. The accumulated data and the growing support of the medical community suggest that this direction is likely.

Implications for the Scientific Diving Community

A shift in recreational fitness to dive standards would affect the scientific diving community. The growing record of safe diving will be used to support calls for inclusion in all diving sectors. The UK has already expanded medical clearance for persons with diabetes from solely recreational activities to include occupational purposes (Edge *et al.*, 2005). Questions regarding fitness-to-dive and diabetes and demands for inclusion are expected to rise rapidly given the recent attention given the issues.

Resistance to a change in standards will undoubtedly be expressed by some factions. Defense of this position, however, is becoming less tenable. The rate of documented problems is simply too small to justify blanket prohibition. This does not imply that a diver with diabetes has the same risk as the diver who does not have diabetes, just that the risks can be effectively managed by at least some motivated and thoughtful individuals. Awareness of the risks, complications and management strategies is most effective when shared by all members of a diving group. A fully informed team is expected to be better prepared to manage acute events than a team for which the health status of one or more members may be hidden.

In the past, an individual might choose to hide his or her health status from everyone for fear of losing privilege. A new problem can be anticipated within the current climate of confidentiality. The sole documentation provided to a program diving officer regarding an individual's medical fitness to dive will now often be limited to a simple signed statement by the approving physician. It is possible that special considerations for an individual might not be communicated to the program authority if guidelines are not in place to address the matter.

Application to Scientific Diving

The scientific diving community will benefit from efforts to review standards, protocols and training to consider the needs of divers with diabetes. Thorough documentation of the demands of different operations would be helpful to facilitate the most appropriate case-by-case evaluations, identifying good candidates for participation and, equally important, individuals who reasonably should not participate. Acceptance of a case-by-case approach is already established in the current American Academy of Underwater Sciences (AAUS) standards, which provide a list of "conditions which may disqualify candidates from diving" instead of absolute disqualifying factors (Section 6.10; Standards, 2005). Diabetes mellitus appears on the list.

The structure of scientific diving regulation also lends itself to the incorporation of rules representing both reasonable accommodation for and protection of persons with diabetes wanting to dive. The 2005 consensus guidelines for recreational diving could provide a sound foundation.

The selection and surveillance section of the consensus guidelines could be easily integrated into the current medical and fitness evaluations and record-keeping sections of the AAUS standards (Section 6.10 and 2.70, respectively; Standards, 2005). The glucose management on the day of diving section could be established as a separate subsection for operations involving personnel that would make them relevant. Additional requirements could be added, for example, to address required training for buddies of persons with diabetes. Such a subsection would be similar for that established to address rebreather diving in the current standards (Section 12.40; Standards, 2005).

The scope of diving section of the consensus guidelines likely has the greatest potential for future evolution. As maximum exposure limits, the relative conservatism was intentional, given limited data and as least theoretical concerns associated with more severe exposures. Divers should still approach the limits cautiously, however. The progressive certification structure built into scientific diving regulations provides an excellent framework to allow individuals to gain experience in more conservative setting before expanding their range. The depth certification steps required for all scientific divers (Section 5.40; Standards, 2005) can easily be adapted to accommodate issues for persons with diabetes. While persons with diabetes who are good candidates for diving will have effective management techniques, it will take additional experience for them to learn to prepare for the variable demands of operational diving. Adjustments can be made to the insulin preparation (commonly a combination of long-acting and short-acting insulins) on the preceding evening and on the day of diving, to the magnitude of the pre-dive insulin bolus and to pre-dive feeding practices (Cersosimo, 2005). The nature of the surface and underwater conditions, physical activity level, emotional stress and thermal status all influence the efficacy of such changes. Documenting the ability to maintain effective management under a range of conditions would be required to advance through certification levels. Dive logs should include information on insulin therapy, plasma glucose measures and any other diabetes-related events or actions that would be useful to optimize practices. To ensure adequate preparedness, the number of successful dives needed at each step might reasonably be greater than the four required under current AAUS rules to progress through depth certification levels beyond 60 fsw (18 msw).

Dive duration, for example, is a key element to warrant progressive steps, probably further delineated to consider different degrees of thermal stress and physical activity.

The continuation of certificate section of the current AAUS standards (Section 5.50; Standards, 2005) is another strength of the current scientific diving regulations in terms of this discussion. Both minimum activity and satisfactory, regular medical evaluation are important to ensure the continued qualification of persons with diabetes. An increase in potential risk posed by the development of secondary complications of diabetes is a chief concern.

Developing the scope of diving protocols to integrate the 2005 consensus standards with the current structure of the AAUS regulations would allow the scientific community to approach inclusion in a controlled manner that would instill confidence, minimize risk and provide valuable data applicable to both the scientific and the wider diving community. Participation by multiple institutional and individual members would provide a tremendous opportunity for relevant data to be rapidly accumulated.

Additional data are required because there are still many open questions regarding diabetes and diving. For example, it is still unclear how the interaction of cold, arduous, deep and/or decompression diving and different insulin regimens might affect blood glucose response or how off-nominal blood glucose levels might affect thermal status, inert gas narcosis, dehydration or decompression stress. The scientific diving sector could provide a valuable service by making data gathered through the collective experience available. Applicable data will facilitate informed review of guidelines or regulations to benefit all divers.

Conclusions

An arbitrary ban on diving for persons with IRDM is increasingly difficult to justify. The shift away from prohibition is expected to become more pronounced in the future. It is timely for all disciplines of diving to consider the available evidence and implications to their operations. The scientific diving community is well-positioned to collect data of value both for their own discipline and for the wider diving community.

References

Bryson P, Edge CJ, Lindsay D, Wilmshurst P. The case for diving diabetics. SPUMS. 1994; 24(1): 11-13.

Cersosimo E. Insulin therapy in the management of diabetes mellitus. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea and Hyperbaric Medical Society/Divers Alert Network June 19, 2005 Workshop. Durham, NC: Divers Alert Network; 2005: 19-34.

Dear GdeL, Pollock NW, Uguccioni DM, Dovenbarger J, Feinglos MN, Moon RE. Plasma glucose response to recreational diving in divers with insulin-requiring diabetes. Undersea Hyperb Med. 2004; 31(3): 291-301.

Edge CJ, Grieve AP, Gibbons N, O'Sullivan F, Bryson P. Control of blood glucose in a group of diabetic scuba divers. Undersea Hyperb Med. 1997; 24(3):201-207.

Edge CJ, St Ledger Dowse M. Diving with diabetes: the British data. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea and Hyperbaric Medical Society/Divers Alert Network June 19, 2005 Workshop. Durham, NC: Divers Alert Network; 2005: 35-43.

Edge CJ, St Ledger Dowse M, Bryson P. Scuba diving with diabetes mellitus - the UK experience 1991-2001. Undersea Hyperb Med. 2005; 32(1):27-37.

Lorber DL. Legal advocacy at the American Diabetes Association. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea and Hyperbaric Medical Society/Divers Alert Network June 19, 2005 Workshop. Durham, NC: Divers Alert Network; 2005: 44-49.

Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea Hyperbaric Medical Society/Divers Alert Network 2005 June 19 Workshop. Durham, NC: Divers Alert Network; 2005a.

Pollock NW, Uguccioni DM, Dear GdeL. 2005 diabetes and recreational diving workshop: executive summary. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea Hyperbaric Medical Society/Divers Alert Network 2005 June 19 Workshop. Durham, NC: Divers Alert Network; 2005b: 5-9.

Pollock NW, Uguccioni DM, Dear GdeL, Bates S, Albushies TM, Prosterman SA. Plasma glucose response to recreational diving in novice teenage divers with insulin-requiring diabetes. Undersea Hyperb Med; 2006; 33(2): 125-133.

Prosterman SA. Insights of a diving instructor teaching and managing diabetes. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea and Hyperbaric Medical Society/Divers Alert Network June 19, 2005 Workshop. Durham, NC: Divers Alert Network; 2005: 12-18.

Scott DH. A diving with diabetes program: the YMCA experience. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea Hyperbaric Medical Society/Divers Alert Network 2005 June 19 Workshop. Durham, NC: Divers Alert Network; 2005: 58-67.

Scott DH. YMCA SCUBA protocol for diabetic divers. YSCUBA Standards and procedures, Part III, 2000: 15-20.

Uguccioni DM, Pollock NW. Divers Alert Network (DAN) diabetes and diving: history and data. In: Pollock NW, Uguccioni DM, Dear GdeL, eds. Diabetes and recreational diving: guidelines for the future. Proceedings of the Undersea Hyperbaric Medical Society/Divers Alert Network 2005 June 19 Workshop. Durham, NC: Divers Alert Network; 2005: 50-57.

Standards for Scientific Diving. American Academy of Underwater Sciences: Nahant, MA. Revision October, 2005: 69 pp.