

DIVING WITH DIABETES - A REVIEW OF RECOMMENDATIONS

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ABSTRACT

Recreational diving is becoming an increasingly popular physical activity around the world. The vast majority of people who practice scuba diving are amateurs, often being treated for a number of chronic diseases and having cardiovascular burdens. Due to the high prevalence of diabetes mellitus in the world population and the potential for dangerous complications during diving, there is a need for unified recommendations for safe diving with this condition. Current guidelines from international diving associations are not entirely consistent. This review presents the positions of international diving associations concerning the requirements for diving with diabetes, the scope of diving and recommended management of life-threatening conditions during the dive.

Keywords: diving diabetes mellitus, hypoglycemia, hyperglycemia.

ARTICLE INFO

PolHypRes 2021 Vol. 74 Issue 1 pp. 35 – 42

ISSN: 1734-7009 **eISSN:** 2084-0535

DOI: 10.2478/phr-2021-0006

Pages: 8, figures: 0, tables: 0

page www of the periodical: www.phr.net.pl

Publisher

Polish Hyperbaric Medicine and Technology Society

Review article

Submission date: 24.11.2020 r.

Acceptance for print: 12.12.2020 r.



INTRODUCTION

Regular physical activity is particularly recommended to people being treated for diabetes and is an adjunctive therapy for primary treatment. Patients with type 2 diabetes, often associated with obesity and overweight, benefit through improved glycemic control, body fat reduction, cardiovascular risk factors, and delayed onset of diabetic complications. There are also definite benefits for patients with type 1 diabetes, in whom physical activity increases insulin sensitivity and overall cardiovascular fitness. According to the ADA, physical exercise should be advised for all patients with diabetes and should be adjusted to the type of diabetes and the individual needs and abilities of the patient [1,2,3].

The increasing popularity of recreational diving has led to a demand for recommendations on which people with diabetes can dive more safely. People with diabetes are at particular risk of diving accidents [4,5]. Hypoglycemia is one of the most severe conditions that can occur in a person with diabetes while diving [6]. During the exercise, there is an increased metabolism of glucose, glycogen, fatty acids and muscle triglycerides, as well as increased insulin sensitivity of the muscles and increased glucose utilization by them. In case of people with type 1 diabetes, physiological mechanisms of homeostasis are impaired due to defective endogenous regulation of insulin. The above changes may also occur in type 2 but with lesser intensity [7,8]. The exceptions are patients requiring treatment with insulin or sulphonylurea derivatives, in whom the risk of hypoglycemia is high [9,10]. The central nervous system is sensitive to low glucose concentrations, resulting in symptoms of weakness and impaired motor coordination or even severely impaired consciousness. It should also be noted that the symptoms of hypoglycemia are similar to those observed in decompression sickness [11]. The occurrence of hypoglycemia during diving is not only a threat to the life and health of the diabetic patient but also the accompanying divers. Another potentially dangerous condition associated with diabetes is hyperglycemia. This is much more common in people with poorly controlled diseases. Individuals who dive with high glycemia are at risk of dehydration and the development of ketoacidosis during exertion [12].

Nowadays, diabetes is not an absolute contraindication to recreational diving. This change in approach has come as a result of an increasing number of scientific reports, experimental studies and the experiences of divers and diving associations. Worth mentioning is a study conducted in a hyperbaric chamber by Edge et al. in 1997, in which individuals with type 1 diabetes were subjected to the conditions that prevailed during diving. No significant changes in blood glucose were observed during the simulation [27]. Based on new scientific findings, international diving associations have made guidelines regarding the safety and management of hypoglycemia in people with diabetes mellitus. However, there are no uniform guidelines on this issue and the current recommendations of the international diving associations are not consistent.

DAN AND UHMS RECOMMENDATIONS

Until the late 1990s, the American diving association DAN considered type 1 diabetes an absolute contraindication to diving but permitted people with well-controlled type 2 diabetes [14]. The DAN, in a published report in 1996, reported about 177 actively diving people with diabetes, despite the existing recommendations [15]. In 1994, UHMS and DAN formed a committee to create the first criteria to allow people with diabetes to dive. These criteria were supported by a DAN survey of its members, of whom 110 divers had diabetes, 79 were being treated with insulin and made 48,633 dives. Of all the dives, only one case of DCI was reported and 15% of the divers experienced hypoglycaemic symptoms without any adverse effects [16,17]. In 2005, the DAN/UHMS guidelines for people with diabetes and recreational diving were established. These guidelines detailed three key aspects that should be fulfilled: selection and surveillance, the scope of diving and glucose management on the day of the dive [18].

Selection and surveillance:

- Age over 18 (over 16 after special training).
- Withdrawal from diving after initiation/change of treatment:
 - Three months for oral hypoglycaemic drugs.
 - One year after initiating treatment with insulin.
 - No episodes of hypoglycemia or hyperglycemia requiring the intervention of another person within the last year.
 - No history of impaired consciousness due to hypoglycemia.
 - HbA1c \leq 9.0 % one month before initial assessment and at each annual examination.
 - No significant secondary complications from diabetes.
 - Annual diabetes consultation allows the patient to dive.
 - Evaluation for silent ischemic heart disease for candidates > 40 years of age

Scope of diving:

- The assisting diver should be non-diabetic and be aware of the sick diver's medical condition.
- Divers should avoid:
 - diving to depths > 30 m,
 - dives > 60 minutes,
 - dangerous areas from which it is difficult to resurface,
 - situations that may cause hypoglycemia,
 - Compulsory decompression stops,
 - Glucose management of the day of diving:
- Glycemia \geq 150 mg/dl, stable or rising, before entering the water,
- Measure blood glucose at 60 minutes, 30 minutes and immediately before diving.
- Abandon diving if glycaemia < 150 mg/dl or > 300 mg/dl.
- Equip with glucose preparation and glucagon injection at the Surface.
- If symptoms of hypoglycemia occur underwater, surface immediately, take a glucose preparation and withdraw from diving
- Assess blood glucose 12-15 hours after diving

- Ensure adequate hydration on the day of diving.
- Keep a record of blood glucose measurements.

SWEDISH RECOMMENDATION

In Sweden, recreational diving was permitted for people with type 1 and type 2 diabetes in 1998. The requirement for this was well-controlled disease management. In 2012, Swedish guidelines included conditions under which people treated for diabetes with insulin and oral hypoglycaemic medication were allowed to dive. The current Swedish recommendations updated in 2020 require a person treated for diabetes [6,19,26] to present:

- HbA1c < 7.9% .
- No history of chronic complications of diabetes (mild diabetic retinopathy is allowed).
- No episodes of hypoglycemia in the last year and related loss of consciousness anytime in the candidate's medical history.
- Continuous glycaemic monitoring is recommended prior to immersion for risk evaluation.
- Regular glycaemic monitoring should be performed 4-8 times a day for two weeks prior to diving - aim for stable glucose concentrations.
- Regular annual health assessment by a diabetologist or doctor specializing in diving medicine.
- Glucose assessment should be done 90, 60, 30 and 10 minutes before and 10 minutes after the dive.
- 1.5 to 2 hours before the dive, a meal should be taken and the last dose of insulin reduced to achieve a glycemia of 7-12 mmol/l. An additional carbohydrate intake of 15-30 g per kilogram of body weight may be considered depending on glycaemic values.
- If symptoms of hypoglycemia occur, the person with diabetes should immediately take a glucose preparation (gel) and then inform a companion. Then the diver's course of action depends on the depth of the dive: immediate ascent or ascent with decompression.

BRITISH UKDMC RECOMMENDATION

Until the mid-1970s, the British Sub-Aqua Club (BS-AC) allowed people with diabetes to dive, provided they presented good disease control and no hypoglycaemic episodes in the last year. The situation changed after an accident in 1975, based on which diving was banned for people with diabetes [24, 25]. Present recommendations allow people being treated for diabetes to practice recreational diving, provided the following criteria are followed [20]:

- No history of any hypoglycaemic episode in the last year.
- No hospital admissions due to diabetes-related events in the last year.
- A positive opinion of the attending physician on the patient's ability to practice recreational diving safely.

- No presence of microalbuminuria, retinopathy (any degree), neuropathy (any type) and micro- and macrovascular complications of diabetes.
- BMI preferably < 29.9 and should not be higher than 34.9.
- Medical assessment of the patient's health and fitness to dive, as well as an assessment of the patient's knowledge of the dangers of immersion.
- Persons under 18 years of age may not dive in open water except under controlled conditions in a swimming pool.
- Anyone with diabetes requires an annual health check by the diving committee.

AUSTRALIAN RECOMMENDATIONS

In 1994, the Australian Diabetes Association stated diving by people with diabetes. According to the statement, people treated with insulin were not allowed to recreational dive [21]. In 2015, the ADS formed a committee that changed its position and made recommendations covering safe recreational diving for people with type 1 and type 2 diabetes [22]. The Australian guidelines are divided into three sections:

1. Admission requirements for diving:
 - Age over 18 years,
 - No diving after initiation/change in treatment:
 - 3 months if a significant change in diabetes therapy.
 - > 1 year after starting insulin treatment
 - Ability to use blood glucose monitoring equipment correctly.
 - HbA1c ≤ 9.0 %.
 - Knowledge of the effects of carbohydrates, insulin and exercise on blood glucose levels and the ability to administer appropriate insulin doses.
 - No history of hypoglycemia-related disorders of consciousness or severe hypoglycemia in the last year.
 - Diagnosis for asymptomatic coronary artery disease in people > 40 years of age.
 - Regular annual and initial assessment by a general practitioner and a diabetologist or endocrinologist who is appropriately licensed to screen divers.
2. Scope of diving:
 - At least one-hour surface break before the next dive. It is recommended to extend the break time after the second dive of the day.
 - Diving with a non-diabetic companion who has knowledge of the diver's condition and has the skills to respond to hypoglycemia.
 - Avoiding diving into areas without the possibility of rapid ascent and at depths greater than 30 m which require a decompression protocol.
 - Avoid long dives of more than one hour and in favorable conditions for the development of hypoglycemia (cold water, high physical exertion).
 - Having oral, readily available glucose preparations during the dive and on the surface and injectable glucagon on the surface.

- Glucose control on the day of diving:
- Glycaemic control at 60 minutes, 30 minutes and immediately before the dive.
 - Recommended blood glucose values immediately before diving 8.3 - 16.7 mmol/L - stable or rising.
 - With blood glucose 6.6 - 8.3 mmol/L oral intake of 15g carbohydrate before diving.
 - With blood glucose <6.6 mmol/L: oral intake of 30 g of carbohydrate; if blood glucose >8.3 mmol/L after reassessment, then dive.
 - With glycemia >16.7 mmol/L dive should be postponed and ketone level checked; if >1.0 mmol/L dive should be abandoned the following day.
 - Blood glucose should be controlled after each dive.
 - Each subsequent dive should follow the above pattern.

SUMMARY OF THE GUIDELINES

People with diabetes interested in recreational diving should be physically prepared and have sufficient knowledge of their disease to avoid potentially hazardous situations during the immersion. The primary importance of safe diving with this condition is an adequate medical screening to determine if a person is fit to dive. A common recommendation of diving associations is a cardiovascular assessment for all people with diabetes, performed by an experienced specialist in diving medicine at least once a year. When diving, the cardiovascular system is stressed by many

mechanisms (ambient pressure, temperature, physical exertion, stress) [28]. This screening enables the selection of divers with serious cardiovascular burden and chronic complications of diabetes (nephropathy, retinopathy, neuropathy, diabetic foot), which pose a serious risk during diving [26]. The DAN and the ADS specifically point out the need to exclude the presence of silent ischemic heart disease for candidates > 40 years of age. The second common recommendation is to assess carbohydrate metabolism and the degree of diabetes control. The glycemia of a person with diabetes should be well controlled. The patient should not have a history of severe hypoglycemia or hypoglycemia with loss of consciousness. A blood glucose measurement should be taken before and after the dive and indicate stable values. Only the US guidelines refer to the need for glycaemic monitoring 12-15 hours after diving, which is done to avoid the occurrence of delayed hypoglycemia. Differences are outlined in the admission criteria based on Hb1Ac, an indicator of carbohydrate balance in people with diabetes. Another recommendation highlighted by all associations is to dive only with an accompanying diver who is properly trained, knowledgeable about the diver's condition and able to intervene in case of hypoglycemia in a sick diver. Significant differences in the management of symptoms suggest low blood glucose - the Swedish guidelines recommend immediate ascent according to decompression protocol, whereas the Australian and US guidelines do not recommend diving to depths that would preclude immediate ascent [18,19,20,22].

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