

Diabetes and diving: What we all need to know

Over the last 20 years or so, the attitude of diving doctors in the UK towards people wishing to dive with diabetes has altered dramatically from being a categorical “No, you can’t dive” to “You may be able to dive safely, provided your diabetes is well-managed and you have none of the long-term complications of the disease”. This change has been adopted world-wide with many countries now acknowledging that a blanket ban on diving with diabetes cannot be sustained in the light of current evidence and experience. British divers with diabetes, in a unique partnership with the UK diving medical doctors have been fundamental to this change. The partnership has involved collecting diving and medical data from

Diabetes is a disease affecting a growing number of people, and has serious implications for divers. Report by Doctors **Chris Edge, Mark Glover and Phil Bryson**

both new and established divers with diabetes, which has allowed doctors to see what sort of diving activities diabetic divers are participating in, and how diving may have affected the diabetic condition. Thus safety issues around diving with diabetes can start to be addressed.

This article salutes all those divers who have made this possible, and tries to explain

to anyone with diabetes who dives or who is thinking of learning to dive what the potential challenges to safe diving might be.

What is diabetes mellitus?

Type 1 diabetes

Diabetes mellitus was first described by the ancient Egyptian and Indian physicians who noted that a diabetic person’s urine was



➤ Above: Testing blood glucose as part of a diabetes management system

PHOTO: FREEIMAGES.COM



➤ Above: Diving with diabetes requires both pre and post-dive planning

PHOTO: SIMON ROGERSON

sweet and would attract ants. Undoubtedly these patients had what is now known as type 1 diabetes (and used to be known as insulin dependent diabetes mellitus or IDDM). Type 1 diabetes usually manifests itself during childhood or early adulthood and comes about as the islets of Langerhans in the pancreas cease to produce the hormone **insulin**, thus necessitating replacement with insulin injections. Insulin is part of the regulation mechanism for glucose and fat in the body. It allows glucose (one of the main fuels in the body) to be absorbed by skeletal muscle cells and fat tissue. Unless the levels of insulin are carefully regulated then one of two conditions may be the result: a) high blood sugar (hyperglycaemia) in which there is too much glucose in the blood (caused by insufficient insulin) resulting in the excess glucose acting like a toxin to the bodily tissues, or b) low blood sugar (hypoglycaemia) in which there is too little glucose in the blood (caused by too much insulin resulting in excessive absorption of glucose into the cells and tissues). The brain, which uses glucose as fuel, is thereby starved of glucose leading ultimately to fits, unconsciousness, and death unless treated rapidly by administration of glucose orally or

intravenously. Another treatment for hypoglycaemia is to use the hormone **glucagon** which is injected, like insulin, into the subcutaneous tissues. Glucagon causes the rapid release of stored glucose from the liver into the blood stream. Additionally, diabetes (both type 1 and type 2 – see below) may lead to other conditions such as high blood pressure, coronary heart disease and stroke. A person with diabetes may therefore be on medication for the treatment or prevention of such conditions.

Type 2 diabetes

Type 2 diabetes (which used to be known as non-insulin dependent diabetes mellitus or NIDDM) occurs either when the body can still make some insulin, but insufficient to control the amount of glucose in the blood, or when the body becomes resistant to the effects of insulin (insulin resistance). This form of diabetes usually occurs in people over the age of 40 but recently (and very worryingly) is being increasingly seen in children. The vast majority of cases of type 2 diabetes are linked with being overweight. The diabetes is treated in a variety of ways ranging from diet-control alone, through drugs such as **metformin** (used alone or in combination with other drugs such as



➤ Above: Metformin is the drug most commonly prescribed to help control type 2 diabetes in the UK

glitazide, rosiglitazone, or sitagliptin to name but a few) to insulin injections, either alone or in combination with the aforementioned drugs. It’s important to recognise that all the treatment methods for type 2 diabetes with the exception of diet-control alone and diet plus metformin alone have the potential to cause low blood sugar with the same consequences as for type 1 diabetes namely unconsciousness and death if not treated promptly.

A third type of diabetes, **diabetes insipidus**, may be confused with diabetes mellitus. It is caused by the lack of antidiuretic hormone (ADH) or its failure to act on cells in the kidney. It is much rarer in the population than diabetes mellitus and is not covered further in this article.



➤ Above: A hypoglycemic attack could be brought on by a diver with unmanaged diabetes having to work hard underwater

PHOTO: SIMON ROGERSON

Consequences for scuba diving

In 1991, the collection of data from divers with diabetes started. Figure 1 shows the percentage of divers with diabetes who have the two types of diabetes for the years 2001 and 2013. The rise in the numbers of divers with type 2 diabetes is reflected in the national statistics of the numbers of people with diabetes in the UK population where 90 per cent of diabetic persons are classified as having type 2 diabetes; before 1960 the number of people in the UK population with type 2 diabetes was in single figures. In 2008 in the general UK population it was estimated that three people were being diagnosed with diabetes every 10 minutes, and this figure is increasing.

What might be the consequences of diving with type 1 or type 2 diabetes, and does the changing proportion of type 1 to type 2 make any difference? Broadly, the answers can be divided into two main categories: short-term and long-term.

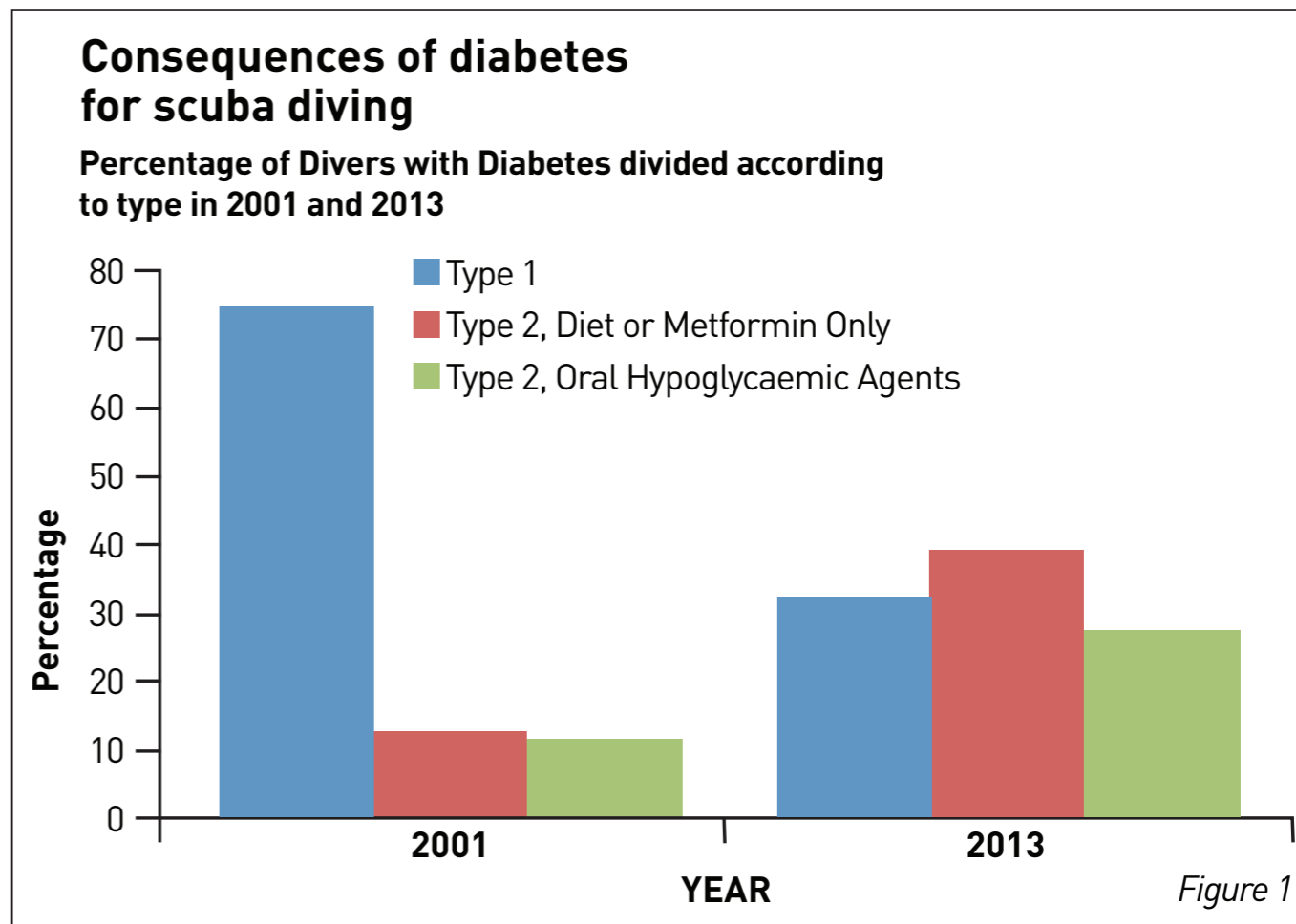
Any drug capable of causing a 'hypo' (low blood sugar) that is taken to control diabetes could cause the diver to have a fit underwater (as a result of the neurons in the brain having insufficient glucose to function properly), or to lose control of the regulator, with disastrous consequences.

This may occur rapidly after taking the drug, as for example with too much insulin, or rather more slowly, as in the case of the *sulphonylurea* class of drugs, which include gliclazide and glibenclamide. This 'hypo' state may be brought on more rapidly if the diver is exercising hard, such as finning against a current, or even breathing rapidly as a result of anxiety. Cold, too, may exacerbate the problem. It is therefore essential that a diver who dives with diabetes has the condition under good control and is able to recognise signs of an impending 'hypo', even in an environment which may have many distractions. Such a 'hypo' can then be avoided underwater by taking glucose in the form of a tube of paste which can be inserted into the corner of the mouth without removing the regulator, or on the surface in the form of sugary snacks. Whatever the form of sugar, the diver must practise taking it underwater and using it, so that a 'hypo' does not become an emergency situation. Even on the surface, a diver may have difficulty in safely ingesting the sugar as a result of the swell and spray; again, practise under controlled conditions will help to prevent the problem getting out-of-hand.

Long-term consequences

Diabetes, whether type 1 or type 2, must be kept under good, long-term control. Control can be maintained by measuring the blood sugar concentration on at least a daily basis (and more often if insulin is being used) and by having a blood test for glycosylated haemoglobin (HbA1c) on at least an annual basis (again, this should be performed more frequently, depending on the control of the diabetic condition). Poor control is more likely to lead to long-term complications of diabetes, with implications for diving. These complications can arise in many organs, including the eye, heart, blood vessels, kidney, nervous system, and skin. They appear to arise from a common cause, namely the blockage of the small and medium-sized arteries in the body. Here are a few of the more important complications and their consequences for divers:

Heart: Diabetes can accelerate the blockage of the coronary vessels, leading to early heart attack and other serious problems. Sudden exercise such as finning against a current, particularly in people who don't normally take much exercise, is particularly prone to cause such problems (see box). Cardiac pain (angina) on exercise, which may be a



warning sign of an impending heart attack is often absent in people with diabetes.

Another problem with the heart in diabetes is not recognised widely. Diabetes can affect the nerves in the autonomic nervous system that controls the heart rate. If this happens, then the heart rate does not vary appropriately in response to, for example, exercise, a Valsalva manoeuvre (pinching the nose whilst puffing out the cheeks) or stress and, as Wang Shuhe recognised as early as the third Century AD, this too can lead to sudden death.

Nerves: Diabetes can cause problems such as numbness, tingling, hypersensitivity, and pain. These symptoms tend to occur in the arms and the legs and feet. Numbness in the feet (in a so-called 'stocking' distribution) can then lead to ulceration of the feet. Should a diver with diabetes experience any of these problems, there is a risk that the symptoms can be confused with decompression illness. The symptoms may appear or disappear rapidly and it may be difficult for the doctor in the hyperbaric chamber to come to the correct diagnosis.

Kidneys: One of the tasks of the kidneys is to filter blood to remove unwanted

products but keeping the vital blood proteins and salts that are important for maintaining the body's internal physiology. Diabetes can disrupt the filtration process, leading first to a loss of protein and then to a more general loss of function, resulting in long-term kidney failure. This in turn will affect the functioning of many of the other organs in the body. Although dialysis may help, the logistics of diving when having regular dialysis are overwhelming in all but a very few cases.

Diving with diabetes

As diving is one of the very few activities in which a person is completely immersed in a non-breathable environment, there are some limits placed on both divers and potential divers with diabetes. These are:

- No would-be diver under the age of 18 with diabetes is allowed to dive in open water, and may only dive in the pool with close supervision. The reason for this is that during adolescence, insulin requirements may vary within short periods of time due to the glucose demands of the body. Such changes are difficult to take into account when diving and the risks of hypoglycaemia in the

water are high. By the age of 18, most growth has occurred and the doses of insulin required are more stable.

- No person with diabetes who has any of the long-term complications of diabetes (with the exception of mild background retinopathy) is allowed to dive. The reason for this is that once long-term complications of diabetes are present, then neuropathies and kidney problems are more likely to develop. These can cause serious problems with diagnosis of possible decompression illness and with exercise tolerance.

A pack containing the medical forms for diving with diabetes is obtainable from the BSAC website. A diving medical **must** be undertaken **annually** by a diving medical referee. A list of such referees is available again on the BSAC website or at www.uksdmc.co.uk

The reason for this is that many doctors do not have specialist knowledge of diving medicine which a diving medical referee will have. The annual requirement is necessary, as diabetes may evolve over time, necessitating medication changes which may have an effect on diving.

» Diving with diabetes involves both pre and post-dive planning

Pre-dive: The diver with diabetes should be as fit and mentally prepared to dive as his/her non-diabetic buddy. The diver with diabetes should be especially careful with regard to being adequately (but not over) hydrated as there is some evidence that the level of hydration affects the chances of experiencing decompression illness. The Dive Manager must be aware that the diver is diabetic and should also be informed of the profile of the dive ('plan the dive, dive the plan'). The diabetic diver's buddy should be a person who is either:

- A regular diving partner and who is familiar with the diabetic person and the problems he/she is likely to experience
- A trained medic, nurse, or paramedic who is familiar with the problems of diabetes

A diver with type 1 diabetes or type 2 diabetes taking any medication that could cause hypoglycaemia may be unable to help him / herself. In order that appropriate and timely assistance can be given, the diver should carry the following in his / her dive kit:

- Oral glucose tablets or a tube of glucose paste
- Emergency intramuscular injection of glucagon;
- Glucose measurement sticks together with the necessary glucometer kit and CLEAR instructions for use of such a kit.

It is essential that there is at least one person in the dive party who is able to use and administer the glucose tablets and intramuscular injection of glucagon.

If a diver with type 2 diabetes is controlled **only** on diet or diet plus metformin then it is not necessary to have emergency supplies of glucose in the dive kit, as the diver will not become hypoglycaemic during the course of the dive.

A diver with diabetes should probably dive no deeper than 30 metres until considerable experience is gained of how diabetic control is affected by diving. The reason for this is that dives to greater depth are more likely to require compulsory decompression stops, with a greater risk for the development of decompression illness if hypoglycaemia forces the diver to surface early and stops are not carried out correctly. Therefore, he/she should remain well within the tables or have no less than two minutes

Heart attack in Belize

Roberta was diving off the coast of Belize, when she experienced shortness of breath. A 60-year-old diabetic with a history of coronary problems, she didn't waste time in proceeding to the local hospital, where she was diagnosed with a mild heart attack... She was provided with private ground and air ambulance transport with full medical teams to take her to Miami, FL where she received appropriate medical intervention and was stabilised.

From a diving magazine advertisement

no-stop time left on a dive computer.

- He/she must not dive with a buddy who has diabetes
- Safety equipment must be carried, for example – marker buoy, flag, flares
- Long-term build-up of nitrogen in the tissues must be avoided by ensuring that no more than three consecutive days' diving are undertaken, with no more than two dives to be done each day.

It would seem sensible for the diver with diabetes to ensure that he/she has a slightly high blood sugar level before the dive by consuming glucose in whatever form takes their preference.

Post-dive: On arrival back at the boat (or on shore if a shore-dive) the diver with diabetes should check their glucose level and, if necessary, correct it in the appropriate manner. Any adverse symptoms or signs should immediately be reported either to their diving buddy or to the Dive Manager and should not be passed off as merely 'part of diving'.

Does diving have any effect on diabetes?

The short-term effect of exercise on diabetes generally is to lower the blood sugar level which may result in a 'hypo'. Many divers can recognise this as mentioned above and take suitable steps to avoid serious consequences. In the long-term, exercise undertaken by divers with well-controlled diabetes is thought to be beneficial, as it is with most other forms of exercise. A few trials conducted in hyperbaric chambers have found that hyperbaric oxygen can lower blood sugar levels quite rapidly, but these trials have been conducted in people with long-term consequences of diabetes

while breathing 100 per cent oxygen. Such people are not permitted to dive.

How can the diver with diabetes stay healthy?

One of the main concerns with type 2 diabetes is early recognition of the condition. Tiredness, frequency of passing urine, multiple skin infections, and blurred vision are some of the symptoms and signs that may occur. In older studies, people presenting with type 2 diabetes had had the disease for 4-7 years, which is ample time for long-term complications to be present. Diving doctors are becoming increasingly concerned about these complications and the effect that they may have, if unrecognised, in the diver. In more recent studies, 25 per cent had eye disease, nine per cent nervous disease, and 8 per cent kidney disease at the time of diagnosis. It is important to have regular, annual medical check-ups for diabetes if there is a history of diabetes in the family, or you have a BMI (Body Mass Index) of over 30 (calculated as the weight in kilogrammes divided by height in metres squared).

Some divers who have been diagnosed with diabetes, especially type 2 diabetes in which the condition can be controlled only by diet, fail to recognise the potential seriousness of the condition. It is important, given the exercise-limiting potential of cardiac autonomic neuropathy (CAN) that regular testing for the condition is carried out. Five simple clinical tests (see box) that can be carried out in the GP's surgery can, together with a careful history, help this condition to be diagnosed. Once diagnosed, then treatment can be given to reduce the impact of this condition on the diver with diabetes. It is also important that any change in medication, especially addition of new medication, is discussed with a diving medical doctor as this medication may have consequences for fitness to dive. Failure to do so can invalidate any diving medical insurance that the diver may have.

If diabetes is already present, then the diver can stay healthy by regular exercise, eating healthy foods, regularly measuring blood sugar levels, taking any medication as prescribed, and attending annual diabetic clinics. If, in the case of type 2 diabetes the BMI is greater than 35 and attempts at weight-loss have been unsuccessful, then there is the option of bariatric surgery, which is recommended by the National Institute of health and Care Excellence – NICE. This may take the

» form of either a banding of the stomach, or a re-plumbing of the stomach and intestine (called a Roux-en-Y procedure). Both methods result in weight reduction and fewer medications being required to control the diabetes, but in the case of the Roux-en-Y procedure it can in some cases lead to disappearance of the type 2 diabetes altogether. Consultation with a general practitioner is recommended to discuss these options, which must not be taken lightly. Provided there are no long-

term complications from the procedure, diving should not be affected, but clearance from a diving doctor will be required before diving is restarted after the operation.

Can diving instructors dive with diabetes?

Given the increasing numbers of divers diving with diabetes, the question of instructing with the disease was bound to arise. When considering this problem, the over-riding concern must be the duty of care

to the diver under instruction. This must apply whether the instructor is being remunerated for instruction or not. It would be unacceptable for a trainee diver to have to deal with a medical condition, such as a hypoglycaemic attack, that has occurred in the instructor. Therefore, the instructor must be in control of his/her diabetic condition at all times when diving.

Most diving doctors would want to see that any person with diabetes has been able to control their disease both on land and underwater, diving under different conditions, for a period of at least one year. This means keeping records of blood sugar measurements every day, particularly before and after any dive. Long-term control must also be good and there must be no long-term complications of diabetes present. Once the instructor with diabetes has been passed as fit to instruct then, as with all diving instruction, a gradual programme should be undertaken of graded instruction. Competent divers wishing to learn new skills in shallow water might be a useful starting point, with progression up to novice divers undertaking their first dive in open water. It would be unacceptable for the dive to have an instructor with diabetes teaching another diver with the same condition in the water. ●



PHOTO: MORGUEFILE.COM

ⓘ ⚠ Above and below: A balanced diet with careful carb and fat control is the key to both avoidance and management of type 2 diabetes. Ration those burgers!



PHOTO: MORGUEFILE.COM

Five tests for CAN

- 1 Heart rate variability during inspiration and expiration
- 2 Heart rate variability during and after a Valsalva manoeuvre
- 3 Heart rate variability between lying down and standing
- 4 Blood pressure change between lying down and standing up
- 5 Blood pressure difference before and during a sustained handgrip measured using a dynamometer

Summary

Despite opposition from many groups over the years, it is now largely accepted that divers with well-controlled diabetes and none of the long-term complications can safely dive recreationally. This is radically different situation from that which existed 20 years ago, where people with diabetes were banned from diving altogether. Although divers with diabetes may be reticent to undergo an annual diving medical, regular check-ups can enable the complications of diabetes to be avoided or postponed, and this in turn means that diving can continue for a longer time period, which has to be a good thing! Divers in the UK with diabetes and the UK diving medical doctors have been largely responsible for this worldwide change in the attitude to diving with diabetes and it is something for which the diving community as a whole in this country can be proud.