This column is adapted from a chapter in my book, *Scuba Physiological – Think you know all about Scuba Medicine? Think Again!* The chapters in this book were originally written by scientists in the field of decompression research as part of a three-year project called PHYPODE (Physiology of Decompression). My (self-appointed) task was to rewrite their sometimes-complex research in a form accessible to all divers.

One interesting aspect they addressed was the concept of preconditioning as it may apply to scuba diving safety. In other sports, preconditioning strategies such as warming up, passive heat maintenance and prior exercise are used to ensure that athletes perform as well as possible on game day.

Tiny gas bubbles in the bloodstream are thought to be the main cause of decompression sickness (DCS), so the PHYPODE researchers looked at six preconditioning strategies that divers might be able to deploy before a dive to reduce the quantity of tiny bubbles produced during the dive, thus reducing both decompression stress and the risk of DCS.

1. Pre-dive endurance exercise
An aerobically fit diver has a lower risk of developing DCS than an unfit diver and aerobically trained runners produce fewer bubbles on a dive than people who are mostly sedentary. Why this should be the case is not yet clear. In the past, it was thought that a bout of aerobic activity immediately before diving had exactly the opposite effect. Pre-dive exercise was seen as a factor that increased the risk of DCS, because it was thought that muscle contractions and tissue movement might produce gas nuclei leading to increased bubble formation. This theory has now been seriously challenged. In studies conducted in a hyperbaric chamber, divers produced fewer bubbles when they had performed a bout of aerobic exercise 24 hours before a dive. Another study tested the effect of cycling for 45 minutes, two hours before a dive in the ocean. The results confirmed the data obtained in the chamber and...
found that both moderate and strenuous exercise pre-dive reduced bubble production. A further study showed that running on a treadmill for 45 minutes, one hour before a dive, also significantly reduced the bubble count. Nobody knows yet what the optimal timescale is for doing pre-dive exercise, or even if anyone is doing it. Nor is it clear why pre-dive exercise should have this effect: but it seems clear that divers are best advised to make diving safer, but there are still glaring gaps in our knowledge. Scuba Physiological provides us with a good summary of what we know, a glimpse of where current science is taking us, and some good tips to make us all safer divers now.

The chapters in Scuba Physiological were originally written by scientists in the field of decompression research as part of a three-year project called PHYPODE (Physiology of Decompression). Simon Pridmore is not an expert on diving medicine but, when he came across the material, he knew that many people in scuba diving beyond the scientific community would be interested in it. So, he contacted the original authors and proposed an abridged, edited, simplified and re-formatted e-book, which would make the information more accessible to the general population of divers. They thought it was a great idea and Scuba Physiological is the result.

Scuba Physiological: Think you know all about Scuba Medicine? Think again! by Simon Pridmore is available on: Amazon.com.

3. Pre-dive oxygen breathing

Oxygen breathing has been extensively investigated as a way of reducing DCS risk before altitude decompression and space walks. Oxygen breathing is also routinely employed during decompression from deep air dives to accelerate the washout of nitrogen from the tissues, thus both shortening decompression time and lowering the risk of DCS. In 2009, a study examined what effect breathing oxygen at ambient pressure for 30 minutes before a dive would have on post-dive bubble formation. The divers participating in the experiment stopped breathing oxygen 15 minutes before the dive. They did two dives, 100 minutes apart, to 30m (100ft) for 30 minutes with breathing oxygen 15 minutes before the dive. The divers were randomly assigned to the control group, which continued their routine decompression, and the experimental group, which stopped breathing oxygen 15 minutes before the dive. The experimental group showed a significant decrease in post-dive bubble formation.

A further study found that loss of body fluids during a dive correlated with bubble count, as measured approximately one hour after surfacing: the greater the fluid loss, the higher the bubble count. This suggests that it is also very important to rehydrate AFTER a dive, especially if you are doing more than one dive a day.

4. Pre-dive hydration

Drinking water before a dive is an easy way to reduce the risk of DCS. When you are well hydrated during a dive, you minimise the negative effects associated with post-dive dehydration. The best way to stay well hydrated is to drink before you get thirsty, a little at a time, say a cup of water every 15-20 minutes. Drinking a large amount of water too fast will increase diuresis, the phenomenon that makes you want to pee, and will not hydrate your tissues. A recent experiment involving military divers showed that drinking a saline-glucose beverage before diving significantly decreased the quantity of bubbles in a diver’s circulation after the dive.

A New Book for Scuba Divers!

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Preconditioning

A study found that pre-dive heat exposure in a sauna significantly decreased circulating bubbles in the bloodstream after a dive.

Preconditioning

4. Pre-dive heat exposure
Researchers also conducted studies to determine what effect pre-dive heat exposure in a sauna would have on bubble formation after a dive. Sixteen divers underwent a 30-minute infrared dry sauna session, followed one hour later by a dry chamber dive to 30m (100ft) for 25 minutes. Test results showed that the sauna exposure significantly decreased circulating bubbles after the dive.

5. Pre-dive vibration
In the old days, combat divers and commercial divers would drive their boat fast out to the dive site but return to shore slowly after the dive in the belief that this strategy would reduce the risk of DCS. The PHYPODE researchers decided to see if science could back up the theory and found that 30 minutes of whole-body vibration, (such as you would receive in a speedboat driven fast) before a dive could indeed reduce the quantity of bubbles produced after the dive.

6. Biochemical preconditioning (with dark chocolate)
The vascular endothelium is an organ you probably do not know you have. It is a single layer of cells that completely covers the inner surface of all
the blood vessels in your body. Several studies on both animal and human subjects have shown that hyperbaric exposure results in dysfunction of the vascular endothelium. This may be the result of oxidative stress resulting from hyperoxia during diving and recent experiments have shown that taking antioxidants prior to diving can reduce the negative effects that diving has on endothelial function. Preconditioning by taking an antioxidant such as vitamin C might reduce endothelial inflammation at depth and thus limit gas bubble formation. Recently, some Belgian scientists studied the effects of dark chocolate on bubble production and endothelial impairment associated with diving and found that consumption of dark chocolate had a positive effect on the endothelium, although it had no significant effect on the quantity of bubbles developed during a dive. Other recent studies discovered that eating 30 grams of dark chocolate two hours before a breath-hold free dive can prevent endothelial dysfunction, which is normally observed after free diving as well as scuba diving. The flavonoids in dark chocolate seem to be the key ingredients. They generate nitric oxide secretion and decrease platelet adhesion, which makes it less easy for bubbles to form and maintain stability.

Conclusions
Further research is required into all of the effects described here, but a few things are clear:
1. Divers should stay in good physical shape and maintain cardiovascular fitness.
2. Pre-dive procedures can help reduce decompression stress. Some help maintain endothelial function. Others are better at reducing bubble production.
3. Pre-dive oral hydration, exposure to heat, whole body vibration and oxygen breathing may represent relatively easy ways of reducing DCS risk.

For a more detailed summary of the PHYPODE findings on pre-conditioning, read Simon’s book, Scuba Physiological – Think you Know All About Scuba Medicine? Think Again! available as an e-book via Amazon stores worldwide. For more information, go to: Simonpridmore.com.
Updated: Pre-hospital management of DCI guidelines and “mild” DCI

A paper was recently published in the March issue of Diving and Hyperbaric Medicine, which discusses the pre-hospital management of DCI. The lead author is Professor Simon Mitchell, Head of Anaesthesiology at the University of Auckland, New Zealand and a EUROTEK stalwart.

The guidelines for pre-hospital management of decompression illness (DCI) have not been formally revised since 2004 when a Divers Alert Network / Undersea and Hyperbaric Medical Society workshop was held and five consensus points were agreed upon.

Thirteen years have passed, and therefore aspects of the management of DCI in the field have been reviewed by a multinational committee. The key issues addressed were:

• First aid strategies for DCI
• Remote triage of possible DCI victims by diving medicine experts
• Evacuation of DCI victims
• Effect of delay to recompression in DCI
• In-water recompression

These subjects were discussed at a dedicated workshop at the 2017 UHMS Annual Meeting in Florida, and at subsequent meetings of the expert committee.

Defining ‘mild’

An emphasis was placed on resolving controversies around the definition of “mild DCI” arising over 12 years of practical application of the 2004 workshop’s findings, and on the controversial issue of in-water recompression.

The expert group conducted a thorough literature review and contributed a lot of objective evidence, all of which is cited.

Signs and symptoms

“Mild” DCI signs and symptoms include:
• Fatigue
• Musculoskeletal pain
• Some skin sensory changes
• Rash
• Subcutaneous (under the skin) swelling

Some Key points

All divers who become unwell after diving should be discussed with a diving medicine physician as soon as possible.

When to recompress

Recompression and hyperbaric oxygen therapy is the gold standard treatment for DCI. However, some divers with symptoms or signs meeting the definition of mild DCI may be managed without recompression therapy.

Determination that a case is “mild” and that the patient can be managed without recompression can only be made by a diving medicine physician on a case-by-case basis.

In DCI cases arising in locations without ready access to a suitable recompression chamber, in-water recompression (IWR) using oxygen at a maximum depth of 9msw (30ft) can be considered provided:

• The team is trained, certified, practiced, and suitably equipped.
• The patient is not suffering from hearing loss, vertigo, vomiting, altered state of consciousness, shock, respiratory distress, or a degree of physical incapacitation that makes return underwater unsafe.

It should be noted that IWR may not result in a complete resolution of DCI, and all divers undergoing IWR should be discussed with a diving medicine physician as soon as practicable.

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