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Sara Campbell, World Champion in Deep Diving After 9 Months of Training – How Is This Possible?

Sara Campbell learned to freedive, going from a beginner to world champion in just 9 months. How is this possible? In other sports, it takes years of hard and dedicated training to reach even a national level. Like many other freedivers, Sara simply discovered that she could dive. What does it take then to be a good freediver? Which skills do you have to develop – and what are the challenges? We will follow Sara on a dive to 104 m, illustrating some of the techniques used to achieve these depths and explain how it is physiologically possible to go to beyond 100 m and back again, on one breath. Important mechanisms are: deep relaxation, lung packing, an effective diving response, spleen contraction, the use of free-fall during descent, mouthfill for efficient equalization, blood shift and economic swimming. Some of these things have to be learnt – others come naturally, with a little training. For many of us, it really seems as though we were designed for freediving.

Discovered talent

While most people may not even give a thought to whether they could learn to dive to 30 m depth on one breath, or hold their breath for 3 minutes, those who do try often discover that it is easy. In fact, most people who try to learn this can actually do it. It is amazing just how fast some people, without any previous experience, learn the art of deep and long distance diving or breath holding for several minutes. Unlike many other sports, where it often takes years of intense practice to get to a national level, freediving seems to be more about learning the techniques, rather than maximizing the body's physical performance through years of hard training. It's almost as though we had the ability to dive from the very start.

In 2007 at the age of 35, Sara Campbell, a well experienced yoga instructor, completely without freediving experience, decided that she wanted to try to learn freediving. After starting her training, she went from being a novice in deep diving to world champion in just 9 months. How is this possible? Sara simply discovered she could dive, and followed her ambition which took her to 90 m. She has set several new world records since, including one at 96 m in 2009 (Figure 1). Sara is not the only person catching on quickly in this sport, but is just one example. One of the authors (O.J.) also wanted to try deep diving, and within 2 weeks reached 50m. Over 20 people have now reached 100m or more and the number is increasing every year as new people join the sport and discover that they have a talent for it.



Figure 1. Sara Campbell sets a new world record of 96 m in constant weight deep diving.

Development of records

The sport “apnea” has many disciplines, all of which involve breath-holding. They range from static apnea – holding one’s breath for as long as possible in shallow water – to disciplines where competitors swim down and back up to the surface using their own power, with or without fins. In the constant weight discipline (CWT) the divers use a monofin to reach the greatest possible depth. They follow a line, which they are connected to by a safety cord, down to a bottom plate, collect a tag and bring it back to the surface. In the constant weight – no fins discipline (CNF), the rules are the same but no fins are used. Other disciplines involve pulling oneself down and up on a rope (FIM), and swimming the longest distance possible in a pool either with (DYN) or without (DNF) using fins.

Annual world champion competitions have been held since 1995 in several of the apnea disciplines, and are now held in six disciplines. The records have increased rapidly, and do not show any tendency towards leveling off (Figure 2). This is partly because

of the development of new techniques, and partly because more people are discovering the sport and their own talent for it, improving it further by training. This development of records is unseen in other sports.

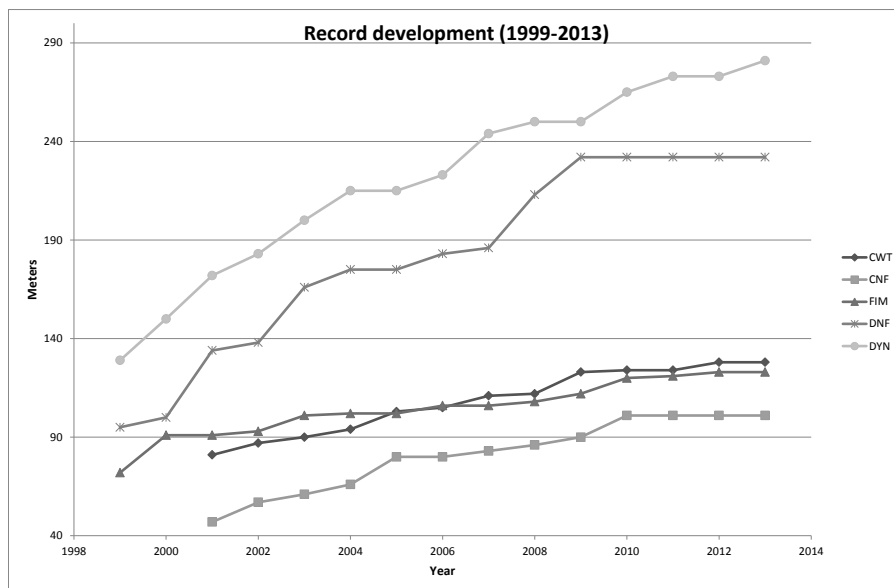


Figure 2. Development of records in five of the six disciplines in which regular competitions take place.

Safety in freediving

It is obvious that when diving without breathing, should anything go wrong, time is limited and margins are narrow, especially during efforts to push individual limits further. However, a solid safety system has been developed for competition diving. It should be emphasized that extended freediving may be very dangerous without these safety systems in place, and that they should be used also during training.

In competition arrangements, the athlete has a number of safety systems to rely on. In deep diving disciplines, the diver swims along or pulls herself down a weighted rope to a predetermined depth, while attached to the rope with a cord. The rope is connected to an anti-ballast system, which could be used should anything go wrong and the diver needs to come back up quickly. But the first safety measure consists of the safety divers. When turning, the diver pulls on the rope - signaling to the safety divers, who swim down and meet the athlete at 20-30m, following her back to the surface. If anything happens to the athlete, e.g., a hypoxic blackout, a safety diver brings the diver back to the surface and, if necessary, performs a rescue “blow tap talk” – an effective method for

reviving the diver. When competing in pool disciplines, safety divers follow the athlete constantly on the surface. After surfacing, in all disciplines, the diver must perform a protocol: remove the mask, make an OK sign, and say “I’m okay,” in order for the dive to be accepted, which is done to confirm the diver is in control and thus to avoid over-ambitious announcements.

Records are also attempted outside of competitions, e.g., in “no limits” freediving, which unlike self propelled disciplines has involved several lethal accidents. In these attempts, a weighted sled is used to reach great depths, and the diver is then passively pulled back to the surface by an inflatable bag. This allows the diver to reach “unphysiological” depths, for which the human body could not have evolved a tolerance and the outcome, therefore, is sometimes fatal.

The most dangerous activity in freediving, however, is when beginners, without the presence of effective safety systems, start training on their own, which can cause lethal accidents even in a pool. It cannot be emphasized enough how important it is to contact established freediving clubs or schools, to learn how to train in a safe manner, and to find other divers with the necessary knowledge to act as safety divers for any maximal efforts attempted. It is also essential that the diver develops his or her diving skills one step at a time, by learning the necessary techniques to overcome each obstacle. Once effective safety measures have been established, what are the major challenges for deep diving?

A dive beyond 100 m

To illustrate what is required to dive to 100 m on one breath, we will follow Sara Campbell, step by step, on a 104 m training dive she did in 2012.

1. Before her last breath, Sara prepares by breathing extra deep using yoga breathing techniques – thus ventilating out more CO₂ from her lungs and slow muscle tissues, while at the same time slightly increasing her oxygen storage.
2. After a last maximum inspiration, she starts “lung packing.” Sara gulps down extra air into her lungs using the oral cavity and tongue as a pump (Örnhagen et al., 1998). Filling her lungs more will provide a larger oxygen reserve during the dive (Schagatay, 2011). In humans, like, for example, sea otters, the lungs are important O₂ stores (Lenfant et al., 1970). A larger starting lung volume will also allow her to tolerate more pressure before the lungs are compressed to their minimum volume.
3. Descending the first few meters, she has to equalize her ears frequently to compensate for the increasing pressure. Otherwise her eardrums may burst. Pressure equalization is a technique most people have to learn, as it requires an excellent control of the epiglottis, soft palate, oral cavity and larynx. Equalization, in the first 30m, is usually carried out

by trying to exhale through the nose, but with the nasal openings blocked by a noseclip the air will be pressed up into the middle ear instead. Some individuals can do this by opening the eustachian tubes voluntarily.

4. At 30 s dive time, at about a 25m depth, the pressure has reduced Sara's lung volume and buoyancy enough to make her sink. She starts to "freefall" with the body in a hydrodynamic pose. This enables her to save oxygen and enter a deeper state of relaxation.

5. The cold water flowing across her face, and the lung compression, enhances the diving response. A number of reflexes are activated during breath holding to conserve oxygen: during the first 30 s of the dive, her heart rate drops by 20-30%, more in trained divers (Schagatay & Andersson, 1998); vasoconstriction in the limbs concentrates the oxygen delivery to the most vital parts of the body. Effortless freefalling makes the diving response even stronger, and heart rate may drop to 50% of the resting rate.

6. Mouthfill needs to be done at around 40 m – a technique used to be able to equalize further down. Sara fills her mouth with air, shuts the epiglottis, and makes sure the air is not sucked back into the shrinking lungs. Once her lungs are reduced to their residual volume (RV) – their minimum surface volume – it will be impossible to use air from them to equalize her ears. She can then push the air from her mouth into the middle ear by pressing the larynx and the back of the tongue against the upper wall of the oral cavity. If she loses control over the epiglottis, the air in her mouth will be sucked back into the lungs and equalizing of the ears will no longer be possible. The mouthfill maneuver requires excellent control of the epiglottis and larynx, and many freedivers have to temporarily halt their progress into the depths when they reach their RV in order to learn this method.

7. The spleen, which contains an extra reserve of red blood cells, contracts – releasing these cells into the bloodstream and thereby increasing the amount of oxygen which can be transported to the tissues (Schagatay et al., 2001; Richardson et al., 2009). Further into the dive, when hypoxia develops and CO₂ accumulates, the spleen response will be enhanced (Richardson et al., 2012). A large spleen is associated with good freediving ability (Schagatay et al., 2012).

8. Turning at 104 m after 2 min 6 s. At this depth her lungs are the size of oranges, but instead of imploding they are protected by an increased amount of blood flowing in the blood vessels close around them, protecting them from getting crushed when the air inside is compressed by the hydrostatic pressure. This central pooling of blood is called "blood shift" (Schaefer et al., 1968; Craig et al., 1968). Now the strained part of the dive begins. With the vasoconstriction that has occurred, her legs are now relying on anaerobic metabolism for energy. In seals, muscles can use oxygen stored in myoglobin, (Lenfant et al., 1970; Snyder, 1983) but this ability is unknown in humans. Lactate starts accumulating as she swims up, heavy from the negative buoyancy of the deep.

9. At 3 min 30 s dive time, the urge to breathe becomes strong, Sara's chest moves when her lungs urge for air, but she knows her body's indications of hypoxia and keeps a calm and relaxed pace. Stress will only increase oxygen consumption, and here her experience in yoga and meditation provides support. She floats up the last few meters, exhaling just before the surface so that she is able to inhale directly after surfacing.

10. After 4 min 01 s she surfaces. At the surface she uses a technique called "hook breathing" - taking shallow, short breaths. Between breaths, she is breath holding and pressurizing the lungs to increase the oxygen uptake by increasing its partial pressure - but also to reverse the blood shift and increase the circulation of blood more quickly. The first statement uttered by Sara after the dive was "It was easy". This 104 m dive, which was not an official world record because it was done during training, can be seen at: Youtube: <http://www.youtube.com/watch?v=rD5Mg0eiJdE>

Conclusions

It is evident that freediving can be easily learned by most people, given some training, and that some individuals can reach astonishing results in a very short period. Considering that humans are terrestrial mammals, this is clearly remarkable. Since organized annual freediving competitions were introduced in the mid-'90s, with reliable safety systems in place, records have doubled in nearly all disciplines. Many divers, like Sara Campbell, discover that they have an extraordinary talent for it. This could suggest there was once a period in human evolution with selection for performance in and under water, and that our bodies still possess this ability, which can be revived with relatively little practice.

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