

## Free Diving

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Man has been breath-hold diving for as long as he has existed. However, the rapid development of breath-hold sports in recent decades has completely changed our understanding of the limits of human physiology in terms of duration, distance and depth underwater. The successful mammalian diver can postpone the functional collapse that follows apnoea through three main mechanisms:

- enhancement of body oxygen stores;
- acid buffering of metabolic products;
- circulatory reduction and redistribution, leading to metabolic conservation.

Regulation of these responses in diving mammals is essentially identical to that governing the protective reaction to asphyxia in terrestrial animals, the observed differences being largely quantitative rather than qualitative.

Two mistaken concepts dominated understanding of human freediving; firstly that depth was limited to about 30 msw because, as lung gas volume diminished with increasing pressure (Boyle's Law), a point was reached, determined by the ratio of the total lung capacity to the residual volume, where lung tissue would rupture and pulmonary haemorrhage occur. This concept of 'thoracic squeeze' was far too simplistic, mainly because of the shift of blood volume into the thorax with immersion and breath-hold descent. A second concept was that dive duration was limited to only a few minutes by the body's oxygen reserves; when these are exceeded 'apnoeic (hypoxic) syncope' occurs. Whilst the latter is true, the longest recorded human breath-hold time on air is now over 11 minutes, whilst the deepest recorded dive is over 200 msw. How have human freedivers put the lie to these concepts, and do they demonstrate any of the features seen in the diving mammals?

The physiology of the women Ama divers of Japan and Korea has been studied extensively and, apart from their physical fitness, they differ surprisingly little from their non-diving counterparts. The diving reflex, an ancestral trait found in all air-breathing vertebrates, is triggered by facial immersion and breath-holding, producing intense changes that are oxygen conserving, including in humans. As yet unpublished research on apneists performing maximal horizontal breath-hold swims demonstrates significant lactate production which appears to occur prior to muscle O<sub>2</sub> depletion and concurrently with oxidative phosphorylation. Apnoea training, leading to adaptive physiological changes, mental and other preparation and technological innovation have all contributed to extending the limits of human breath-hold diving. Safety in this extreme sport is a serious issue, since syncope whilst immersed leads rapidly to drowning. We are still no match for the whales!

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