BREATH HOLD TRAINING:
POSITION STATEMENT

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INTRODUCTION

Breath hold training (BHT) is a technique utilised in sport and exercise science to increase athletes' tolerance for oxygen deprivation. Another desired outcome for non-breath-hold sports is improved oxygen delivery. BHT is applied across many different sports, but most work has focused on swimming and water-based activities. There have been significant safety concerns raised about the practice of BHT in Australia and internationally. Much research has focused on the proven risks to athletes and the modest benefits in terms of tolerance to oxygen deprivation.[1-3] The risks of BHT are potentially higher when training limits are pushed in the quest of sporting success.

Given the health risks posed by BHT, medical oversight should be built into all relevant sporting environments. Education and support should be provided to stakeholders to mitigate the risks. Swimming Australia recognised the importance of this issue and created a position statement in 2003.[4] There have been no recent cross-sport recommendations regarding the practice of BHT. This Australian Institute of Sport (AIS) position statement will guide athletes, coaches and support personnel in their considerations of BHT, prioritising athlete safety and wellbeing in the high-performance environment.

WHAT ARE THE DIFFERENT TYPES OF BREATH HOLD TRAINING?

There are a range of activities which constitute BHT; many of these are sport specific. The practice of BHT can involve underwater only, shallow water, deep dives, on-land or above water, passive or dynamic, maximal or sub-maximal durations, repeated or single breath holds. No technique is risk-free, and it is important for athletes, coaches and support staff to be aware of the potential dangers of this training practice.

THE SCIENCE OF BREATH HOLDING

Hypoxia is induced during BHT, as such BHT is a form of hypoxic training, which has been used to improve athletes' capacity for 'oxygen debt'.[5] Hypoxia is defined as depravation of oxygen supply to the whole body or a body region (localised), such that there is a decrease in arterial oxygen concentration. Hypoxic training is used to improve performance in sport disciplines requiring high levels of aerobic endurance, such as swimming, or where access to air is restricted, such as underwater rugby and underwater hockey.[3, 6-8]

There are several specific mechanisms implicated in the theoretical benefits of BHT. Studies have examined the role of glycolytic enzyme upregulation, increased lactate exchange and enhanced tissue oxygen extraction.[8] Others have postulated that hypoxic training induces local adaptations at the muscle level, in terms of increased myoglobin and oxidative capacity, most likely driven by enhanced mitochondrial function and an increase in mitochondrial density.[9]

Specific mechanisms implicated in the adaptations derived from BHT are transient increases in erythropoietin (EPO), haematocrit (Hct) and haemoglobin (Hb) concentrations following breath holding, due to splenic contraction. These have also been found to be increased at rest following a BHT intervention.[5] These positive adaptations are generally accepted to drive higher levels of endurance performance[9] Whether or not these changes include an improved maximal oxygen (VO_2max) uptake remains controversial[10, 11] The complex interaction of multiple factors, like respiratory chemoreflexes (chemical), lung stretch (mechanical), descending cortical output, psychological factors and experience influence the duration (i.e. the breaking point) of maximal breath hold.[7, 8]

Controlled frequency breathing, involving breath holding for 7-10 strokes before taking another breath is a common swim training modality and appears to prevent inspiratory muscle fatigue without any differences to performance outcomes of small sample of competitive swimmers.[12]

BREATH HOLD BLACKOUT AND THE RISK OF DEATH

Breath hold blackout (BHB), also referred to as hypoxic blackout or shallow water blackout, is a potentially lethal consequence of breath hold activities. BHB can result from oxygen deprivation to the brain after extended breath holding, causing loss of consciousness and consequently death by drowning.[13]

Elevated arterial concentration of carbon dioxide occurs during oxygen deprivation and is an important physiological trigger to breathe. Pre-submersion hyperventilation (an increased rate or depth of breathing compared to regular breathing at rest), decreases arterial carbon dioxide concentration, referred to as hypocapnia. Hypocapnia resulting from hyperventilation, removes the natural trigger to breathe,[14, 15] with potentially lethal consequences if loss of consciousness subsequently occurs underwater. This risk is further increased for underwater swimming drills compared to surface swimming when there is an urge to breath, swimmers are more likely to take a breath.

Another risk factor for BHB is the rest period between breath holds. A decreased arterial oxygen concentration following a completed breath hold, potentially coupled with hypocapnia from an increased breathing rate after an earlier breath hold can increase the risk of BHB in subsequent breath holds, even where breath hold duration is not maximal.

It is imperative that water-based athletes, especially swimmers, do not ignore the urge to breathe. Coaches supervising BHT must be vigilant for the risks and must take precautions to mitigate the inherent dangers of this training strategy. BHT should never be undertaken in unsupervised environments due to the risk of BHB and subsequent drowning.

BREATH HOLD TRAINING- RECREATIONAL ATHLETES, JUNIOR AND OLDER ATHLETES

BHT is not appropriate in junior athletes or recreational athletes in most sports given the risks outlined. Junior athletes may not have the maturity to identify and appropriately respond in an emergency. There is a lack of evidence to support any potential benefits in this cohort.

Lung capacity diminishes with age, and there is no evidence to support that this can be reversed with BHT.[16] Consequently, BHT is not appropriate for older athletes.

For athletes in sports where time underwater cannot be avoided, such as underwater hockey and underwater rugby, improving, testing, or training breath hold capacity should not be the focus of training, and the points below for BHT should be adhered to for all sport-specific training.

BREATH HOLD TRAINING IN HIGH PERFORMANCE SPORT

- Some high-performance athletes may engage in BHT strategies as part of their sport.
- Activities that involve increased risk of BHB include free-diving, underwater hockey, synchronised swimming, surfing, underwater rugby and spearfishing.
- Any sport utilising BHT must adopt clear protocols informing its implementation.
- A comprehensive medical examination should be performed as part of a pre-participation screening.
- Athletes, coaches and support staff involved in aquatic sports should receive education about the risks and management of BHB, including that BHB can lead to death or permanent disability from hypoxic brain injury.
- BHT must not be involve unnecessary risk to athlete health and wellbeing.
- Appropriate supervision is required for anyone using BHT. Swimmers should never conduct BHT alone.
- Athletes should be educated that they should not ignore the urge to breathe.
- Never play breath-holding games or challenges.
- BHT training should involve progressive overload, in line with athletes' physical and skill development.
- Athletes should not hyperventilate prior to any underwater efforts.
- Adequate rest periods of at least two minutes should be taken between breath holds to reduce the risk of BHB.
- BHT does not have a role in 'mindfulness' training in terrestrial athletes.
- Sport-specific underwater skill training should be undertaken in shallow water where possible to allow athletes to stand and breathe freely as needed.

CONCLUSION

BHT may have a role for high performance aquatic athletes. Sports implementing BHT as a performance strategy need to understand that studies of performance benefit are limited. Clear protocols should inform BHT in high performance sport environments. BHB can occur even in experienced swimmers, usually without warning. Breath hold challenges or hyperventilation are not appropriate for any age group and should be discouraged. The practice of hyperventilation prior to underwater swimming is life-threatening and education about these dangers is paramount. Any consideration of BHT must prioritise athlete safety above possible performance gains.

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