Breath-Hold Training Guidance

Purpose of the Guidance

The guidance is aimed at all coaches who undertake breath-holding training in Swimming and Artistic Swimming.

This document aims to:

- Provide an overview of the research on breath-holding and types of breath-hold training.
- Highlight the key considerations when planning breath-hold training.
- Identify the risks and performance benefits of breath-hold training.

Overview

In a world where the boundaries of performance are constantly being pushed, coaches and support staff strive to improve their athletes' underwater and breath-holding abilities.

This Swim England guidance aims to provide the information needed to enable coaches and support staff to effectively integrate breath-hold training into their environments while ensuring that athletes' safety and well-being are never compromised.

In Swimming and Artistic Swimming, athletes could use breath-hold training to enhance their ability to withstand decreasing levels of oxygen (O_2) in their blood and bodily tissues (hypoxia) and increasing levels of Carbon Dioxide. Breath-hold training could also improve $\dot{V}O_{2max}$ by increasing levels of haemoglobin[1] and haematocrit[2] while potentially increasing the levels of Myoglobin[3] in the muscle.

Risks:

It's essential to be aware of the risks involved in breath-hold training practices to ensure the safety and well-being of the athlete. One such risk is hypoxic blackout, which can result in potentially fatal consequences. These risks must be communicated and understood. Further information regarding Hypoxic Blackout is provided later in the document. While the risk of drowning during supervised breath-hold training in competitive athletes is generally low, another concern is the possibility of a seizure.

A seizure during or after breath-hold training could have several serious consequences:

- **Immediate safety risk** – loss of consciousness or seizure activity in water increases the chance of drowning.

- **Driving restrictions** – in the UK, experiencing a seizure often results in a mandatory suspension of driving privileges (typically 6 months seizure-free before a licence can be reinstated). This can significantly affect an athlete's independence, employment, and daily life.
- **Employment and lifestyle impact** – some jobs and activities that require safety-critical decision-making (e.g. operating machinery, working at heights, lifeguarding) may be restricted following a seizure.
- **Medical implications** – a seizure will always require medical investigation to identify the underlying cause (neurological, cardiovascular, or respiratory). Until cleared by a medical professional, the athlete should not attempt further breath-hold training.

Please contact **craig.robertson@swimming.org** if you have any questions about athletes holding their breath in training.

Types of Breath-Hold Training

Two methods of breath-hold training are used in competitive sports: static and dynamic [2, 3].

A static breath-hold is when a person holds their breath without moving, either in or beside a pool. Dynamic breath-hold training involves breath-holding while moving, such as swimming without breathing and aiming for a set distance with a reduced pattern (i.e., every 3-5-7-9 strokes) or during part of a routine. These methods are commonly used for submaximal or maximal durations, with either a single or repeated breath-hold.

When considering artistic swimmers, it is generally accepted that higher performance routine scores correlate with increased breath-hold duration [4]. Meeting that standard is highly linked to the training principles of specificity and overload, whilst not pushing the athletes to ignore their urge to breathe or punishing them for ending a breath hold. Given the substantial contributions from both aerobic and anaerobic metabolism, artistic swimmers need to be able to optimise the metabolic demands of the sport whilst learning to deliver highly choreographed and technical movements under extreme physiological stress [5].

Artistic swimmers need to practice and rehearse the technical aspects of their sport while also using complementary training methods to target the specific demands of the sport. For example, since Artistic Swimming competitions involve prolonged periods underwater combined with intense muscle contractions, it could be beneficial to practice this type of training with technical elements to improve overall performance. Previous studies in Swimming have suggested that short-term periods of controlled breathing or a complete

breath hold can improve pulmonary function and capacity [6-8], which may lead to better oxygen capacity during periods underwater. This is achieved through repeated exposure to hypercapnia, which also leads to decreased pH, encouraging physiological adaptation [9-11].

Hypoxic Blackout

Hypoxic Blackout can be fatal if breath-hold training is done incorrectly. A hypoxic blackout occurs when the brain is deprived of oxygen during extended or multiple breath-holds, leading to loss of consciousness and a possible fatality. The cause of hypoxic blackouts is often a combination of factors, including poor situational awareness, inadequate safety measures, and improper technique [12]. The following pattern typically occurs:

Hyperventilation[4] (consciously or unconsciously) reduces arterial CO_2 levels as it is exhaled at an increased rate. As the breath-hold continues, arterial O_2 levels begin to decrease.

Usually, an increase in CO_2 in the blood would trigger a strong urge to breathe, and the athlete would end the breath hold attempt (Figure 1). Due to hyperventilation, arterial CO_2 levels are too low to trigger this, and the urge to breathe doesn't occur as early (Figure 1). This, combined with low O_2 levels, can cause the athlete to go unconscious. Once unconscious, the body reacts by initiating a breath. However, while submerged, the lungs fill with water. Without immediate assistance, this could lead to a fatality.

This same situation may occur when breath-holds occur without sufficient recovery time. Decreased arterial O_2 levels and increased breathing rates after a previous breath hold can increase the risk of Hypoxic Blackout, even without an athlete's maximal breath-hold duration.

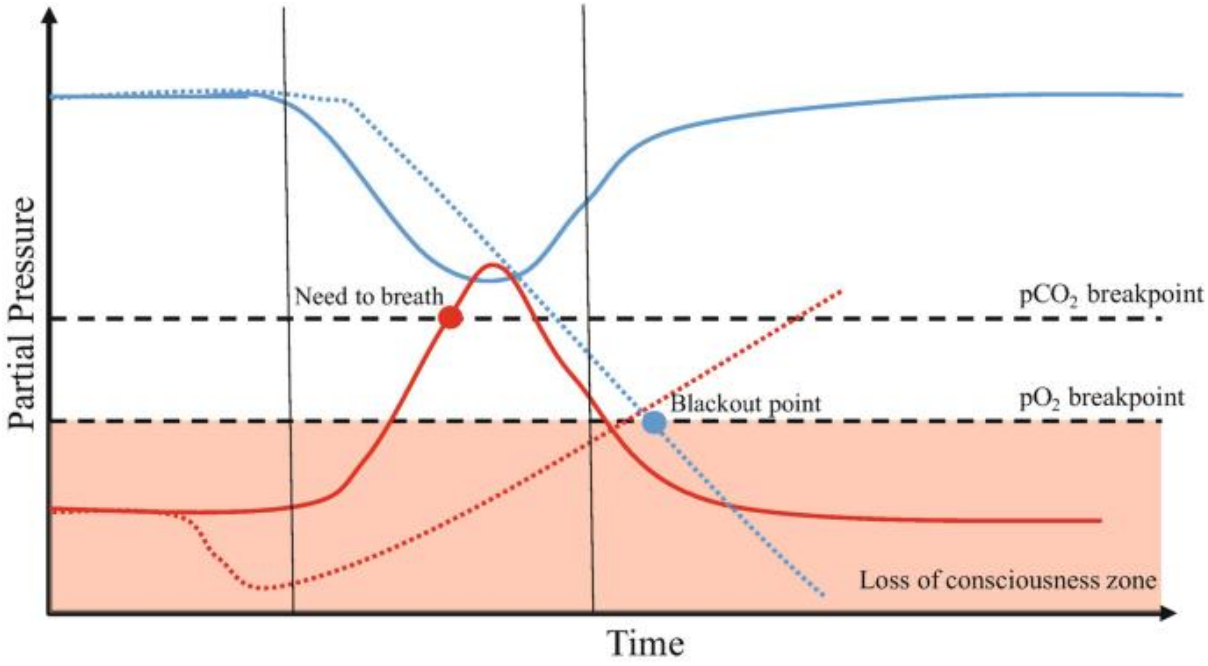

Figure 1. How Oxygen and Carbon Dioxide Levels respond to breath holding in the body. The solid line is a typical response without hyperventilation. The dashed line is a typical response with a hyperventilation [1].

Loss of Consciousness, Treatment & Return to the Pool Protocol

Loss of consciousness occurs due to depleted oxygen reserves. The lack of oxygenation may lead to unconsciousness and be fatal. Laryngospasm[5] can be triggered when attempting to clear the airway, resulting in further aspiration of water and increasing hypoxemia, potentially leading to hypoxic cardiac arrest after a period of the heart rate slowing significantly[6]. This process could happen within seconds to minutes [12].

In any case, if an athlete experiences a form of drowning and has had to be rescued, basic and advanced life support should be given if required by an appropriately trained person (for example, Royal Life Saving Society UK approved or equivalent), followed by the individual immediately being taken to the hospital for further care.

Breath-Holding Training and Performance

Key Considerations for Coaches

- Athletes ***must not hyperventilate*** before any underwater breath-hold efforts.
- Compete for speed (high intensity), ***not distance***, when carrying out underwater breath-hold training.
- ***Never ignore a strong urge to breathe***.
- Athletes should ***never conduct breath-hold training alone*** or in public swimming sessions. ***Supervision is always required by a coach with an*** **understanding of breath-hold training and when someone may be in difficulty and a lifeguard present who can respond if notified by the coach** (for example, Royal Life Saving Society UK pool lifeguard).
- For competitive athletes, age and stage of development matter less than the coach's knowledge and the athlete's training background — the priority is safe, progressive overload in practice
- Care should be taken when an athlete is returning from illness.

Competitive Swimming Specific

- ***Rest periods should be at least 2 minutes between maximal breath-hold efforts*** (maximal duration at maximal speed).
- For non-maximal breath-hold efforts (not maximal distance holding maximal speed), athletes should have at least 30 seconds between breath-holds.

Artistic Swimming Specific

- ***Rest periods should be at least 2 minutes between maximal breath-hold efforts*** (maximal duration at maximal intensity).
- The rest periods should be tailored to the specific routine for breath-hold exercises that are not maximal (not maximal duration at maximum intensity). If a new routine is introduced, appropriate progressions should be implemented to meet individual needs.

Summary

Breath-hold training is commonly used in Swimming and Artistic Swimming, but should be approached cautiously. Coaches and staff should be aware of the associated risks and have safety measures in place, e.g., risk assessment. Even experienced athletes can unexpectedly suffer from Hypoxic Blackout. Understanding that hyperventilation before underwater swimming can be dangerous is crucial, and educating athletes, coaches, and support staff is essential. Proper breath-hold training can have physiological benefits, such as increased aerobic capacity and CO_2 tolerance, which may help improve performance. Nonetheless, safety should always be the top priority over any performance benefits.

Reference List

1. Bennett, M. and T. Cibis, *The Underwater World and Diving Physiology*, in *Engineering and Medicine in Extreme Environments*, T. Cibis and C. McGregor, Editors. 2022, Springer International Publishing: Cham. p. 57-87.
2. Schagatay, E., *Predicting performance in competitive apnea diving. Part II: dynamic apnea.* Diving Hyperb Med, 2010. **40**(1): p. 11 - 22.
3. Schagatay, E., *Predicting performance in competitive apnea diving. Part I: Static apnea.* Diving Hyperb Med, 2009. **39**(2): p. 88 - 99.
4. Ponciano, K., et al., *Physiological responses during the practice of synchronized swimming: a systematic review.* Clinical physiology and functional imaging, 2018. **38**(2): p. 163-175.
5. Viana, E., D.J. Bentley, and H.M. Logan-Sprenger, *A physiological overview of the demands, characteristics, and adaptations of highly trained artistic swimmers: a literature review.* Sports Medicine-Open, 2019. **5**: p. 1-9.
6. Lemaître, F., et al., *Apnea training effects on swimming coordination.* The Journal of Strength & Conditioning Research, 2009. **23**(6): p. 1909-1914.
7. Lavin, K.M., et al., *Controlled-frequency breath swimming improves swimming performance and running economy.* Scandinavian journal of medicine & science in sports, 2015. **25**(1): p. 16-24.
8. Trincat, L., X. Woorons, and G.P. Millet, *Repeated-sprint training in hypoxia induced by voluntary hypoventilation in swimming.* International journal of sports physiology and performance, 2017. **12**(3): p. 329-335.
9. Toubekis, A.G., et al., *Severe hypoxemia induced by prolonged expiration and reduced frequency breathing during submaximal swimming.* Journal of sports sciences, 2017. **35**(11): p. 1025-1033.
10. Woorons, X., et al., *Exercise with hypoventilation induces lower muscle oxygenation and higher blood lactate concentration: role of hypoxia and hypercapnia.* European journal of applied physiology, 2010. **110**: p. 367-377.
11. Woorons, X., et al., *Prolonged expiration down to residual volume leads to severe arterial hypoxemia in athletes during submaximal exercise.* Respiratory physiology & neurobiology, 2007. **158**(1): p. 75-82.
12. Bart, R.M. and H. Lau, *Shallow Water Blackout.* 2020.