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KNOWLEDGE SERIES

THE PHYSIOLOGICAL EFFECTS OF BREATH-HOLDING

Understanding oxygen, carbon dioxide, the brain, the heart, muscles and safety limits

OXYGEN

CO_2

BRAIN

SAFETY

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Why was this guide prepared?

Breath-holding is more than simply “not breathing.” Once ventilation stops, the body continues to use oxygen, carbon dioxide accumulates and the brain and circulation rapidly adapt to the change.

In underwater sports, this process often occurs together with exercise, water pressure, cold, physical contact and psychological stress. A quiet breath-hold at rest is therefore not physiologically identical to breath-holding during Underwater Rugby.

This guide explains the major physiological changes caused by breath-holding and separates expected sensations, performance limits and danger signs.

Contents

What happens first?

When breathing stops, the air in the lungs is no longer refreshed with new oxygen. The brain, heart and muscles continue to work, so oxygen consumption continues.

During the first seconds, discomfort may be minimal. As carbon dioxide rises, the urge to breathe gradually becomes stronger. This urge is often driven by carbon dioxide before oxygen reaches a critical level.

Feeling little urge to breathe does not guarantee that oxygen remains safe, especially when rapid or deep breathing has been used beforehand.

Oxygen and carbon dioxide change together

During breath-holding, oxygen falls while carbon dioxide rises. These gases affect the body in different ways.

Rising carbon dioxide strongly stimulates the respiratory centres and creates an urge to breathe. Falling oxygen may remain relatively silent until it becomes more severe.

Athletes commonly notice chest effort, diaphragm contractions and a growing need to breathe. These may be expected, but darkening vision, loss of coordination or confusion suggest that the safety limit may have been crossed.

Why does the urge to breathe appear?

Respiratory centres in the brainstem are sensitive to carbon dioxide and changes in acidity. As carbon dioxide rises, blood pH tends to fall and the drive to breathe becomes stronger.

Involuntary diaphragm contractions may appear. These contractions are part of the body's attempt to resume breathing. Experienced athletes may recognise the sensation better, but familiarity does not remove danger.

The urge to breathe should be understood as a body signal, not treated as an opponent that must be defeated.

What is the diving response?

Facial immersion and breath-holding can trigger components of the human diving response. Heart rate may slow, peripheral blood vessels may constrict and circulation may be prioritised toward the heart and brain.

The strength of this response varies. Water temperature, training, stress, exercise and individual characteristics all influence it.

In Underwater Rugby, exercise raises heart rate while the diving response may act in the opposite direction. The final heart-rate response is therefore variable rather than fixed.

How is the brain affected?

The brain is sensitive to changes in oxygen. Rising carbon dioxide can widen cerebral blood vessels and increase blood flow, but this protective effect may become insufficient when oxygen falls markedly.

As oxygen declines, decision-making, attention, coordination and visual processing may deteriorate. Athletes do not always recognise this decline accurately in themselves.

Darkening vision, ringing in the ears, sudden dizziness, loss of movement control or slowed thinking are serious warning signs. Breath-holding should not continue when these occur.

How are the heart and circulation affected?

During breath-holding, heart rate may fall while peripheral vascular resistance and blood pressure rise. The cardiovascular system attempts to adapt to changing oxygen and carbon dioxide levels.

Exercise increases the muscles' oxygen demand. The heart and circulation are then exposed to the combined effects of high effort and breath-holding.

Healthy trained athletes usually tolerate these changes, but individual assessment is important with heart disease, arrhythmia, severe hypertension or unexplained fainting.

Muscles and performance

Working muscles consume oxygen and produce energy. As breath-holding continues, oxygen delivery may fall and anaerobic energy production becomes more important.

Muscle burning, loss of power and less precise movement may occur. When judgement and motor control deteriorate together, safety risk rises in contact-based underwater sports.

Training can improve movement economy and tolerance of discomfort. It does not make oxygen deprivation harmless.

Why is hyperventilation dangerous?

Hyperventilation means breathing faster or deeper than necessary before a breath-hold. It lowers carbon dioxide and delays the urge to breathe.

Oxygen consumption continues. An athlete may reach a dangerously low oxygen level before feeling a strong need to breathe. This increases the risk of shallow-water blackout.

Hyperventilation may appear to extend performance, but it is not a safe method.

Breath-holding during exercise

Breath-holding at rest is not the same as breath-holding during intense effort. Active muscles consume oxygen and produce carbon dioxide more rapidly.

In Underwater Rugby, sprinting, turning, physical contact and ball work all increase oxygen demand. A duration that feels manageable at rest may become much more demanding during play.

Athletes should respond to body signals and game conditions rather than chasing a fixed time. Timely surfacing is part of performance.

What can training change?

Regular training can improve recognition of discomfort, movement economy and psychological calm during breath-holding. The diving response may become more pronounced in some athletes.

Mechanisms such as spleen contraction can temporarily increase circulating red blood cells. Carbon-dioxide tolerance and the muscles' use of oxygen may also improve.

Training does not remove the safety limit. Experienced athletes can still lose consciousness and may notice danger later because they tolerate discomfort better.

Expected sensations and danger signs

EXPECTED	TAKE SERIOUSLY	EMERGENCY
Urge to breathe	Darkening vision	Loss of consciousness
Diaphragm contractions	Dizziness	Seizure-like movement
Muscle burning	Loss of coordination	Blue colour
Fatigue	Confusion	No normal breathing

Expected sensations may include the urge to breathe, chest effort, diaphragm contractions, muscle burning and fatigue.

Darkening vision, marked dizziness, loss of coordination, confusion, sudden weakness and inability to control movement are serious warnings.

Loss of consciousness, seizure-like movement, blue discolouration or failure to resume normal breathing are emergencies. The athlete must be removed from the water and emergency action started.

Safe breath-holding rules

1. Breath-hold practice must never be performed alone.
2. The observer must actively watch the athlete rather than merely remain nearby.
3. Hyperventilation should not be used.
4. Symptoms should not be ignored for a time record.
5. Fatigue, illness, sleep deprivation, alcohol and sedating substances can increase risk.
6. After a blackout, the athlete should not return to the water that day.
7. Medical assessment is needed with suspicious symptoms or heart-lung disease.

Children and adolescent athletes

Young athletes may push their limits to impress teammates or please a coach. Competition can also make them reluctant to report symptoms.

Coaches and parents should replace “stay down longer” with “report symptoms early and make your safe ascent on time.”

Breath-hold exercises must match age, development and swimming ability. Shame, record pressure and comparison undermine a safe learning environment.

Final note and references

Breath-holding reveals the body's powerful adaptive systems. Heart rate, blood vessels, cerebral blood flow and muscle metabolism can all change within minutes.

Some changes support performance, but falling oxygen does not always produce a strong warning. Safety does not come from defeating the urge to breathe; it comes from interpreting body signals correctly and surfacing before risk escalates.

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This guide is for general information and does not replace individual medical assessment or treatment.