AIDA3
ADVANCED FREEDIVER

By Oli Christen

v1.06 revised version AUG 2021

CONTENTS

CHAPTER 01

INTRODUCTION TO AIDA3 COURSE

Introducing the course

In your AIDA1 and AIDA2 courses, you experienced a detailed introduction to modern freediving. These courses focus mainly on safety by learning and applying a sound freediving technique. If you have understood and were able to apply these fundamental freedive-skills, the required performances for your AIDA1 & 2 certifications were safely in your reach, without extra training, and certainly without stretching your personal limits.

In this AIDA3 Course, you will now go one step beyond. You learn how to train as a freediver and bring your freediving to the next level, beyond the basics. Systematically and safely you will expand your capabilities as a freediver.

> The "numbers" in freediving are symptom of good technique.
> They are never the result of pushing beyond your limits.

Prerequisites

To enrol in the AIDA3 Course you must:

- Be 18 years of age or older
  (16 years with parent or guardian consent)
- Have completed the AIDA2 Freediver course or passed AIDA Crossover Evaluation (see below)
- Have completed the AIDA Medical Form
- Have completed the Liability Release

Course structure

During this AIDA3 Course, your instructor will conduct:

- Min. 3 theory lessons
- Min. 2 pool sessions
- Min. 4 open water sessions

The content of this manual covers the 3 above-mentioned theory lessons conducted by your AIDA Instructor. The manual does not entirely replace the face-to-face theory lessons: You discuss your understanding of freedive theory based on the Knowledge Reviews at the end of every chapter. Also, a written exam after the third theory lesson has to be passed. After having finalized the exam, your AIDA Instructor will discuss the exam answers with you in order to fill-in every single missing point of knowledge. Hence, you will be able to successfully understand all requirements of the AIDA3 level.

1.1 Paperwork

Before starting your AIDA Course you will need to provide important below-mentioned paperwork to your instructor. By following this procedure AIDA makes sure that you are fit for and aware of the risks of freediving.

AIDA crossover evaluation

If you already have a certification from a freedive organisation other than AIDA, you might not need to start your education with a beginner course when signing up with AIDA for the first time. Your AIDA Instructor will evaluate your knowledge of theory and skills in pool and open water which will allow for an appropriate identification of your level.
Also, if you are an experienced freediver, spear-fisher or freedive athlete without any previous certification, your AIDA Instructor will be able to permit you to skip the beginner level course, once your freediving skills and knowledge have undergone an evaluation and have been proven to meet the requirements of the respective course.

To enrol in this AIDA3 Course, you will need to demonstrate the same skills required for the AIDA2 certification:

- Static (STA): 2+ min
- Dynamic with fins (DYN): 40+m
- Constant Weight (CWT): 12-20m
- Free Immersion (FIM) technique demonstration
- Buddying and rescue technique in all disciplines

These skills have to be demonstrated properly by applying a good command of technique. For example, it is not good enough to simply dive to -16m somehow, you must be able to demonstrate it with an efficient duck dive, good line orientation, efficient body posture, good finning and equalisation technique, a safe bottom turn and efficient use of buoyancy on the ascent.

Your AIDA Instructor will assess your skills and knowledge during a minimum of:

- 1 Classroom session
- 1 Pool / confined water session
- 1 Open water session

This evaluation takes a minimum of one full day or more. Once you have sufficiently mastered all required skills taught in the AIDA2 Course you are allowed to enrol in the AIDA3 Course. In case you are not yet able to pass this evaluation comfortably demonstrating the correct skills and knowledge, do not worry. After the evaluation and before the start of the AIDA3 Course your AIDA instructor will be able to offer you extra training sessions. Neither the evaluation itself, nor the extra training sessions are part of the AIDA3 Course.

For years, AIDA used to maintain a “crossover-table” to evaluate which certification of other agencies allows you to enrol in a certain course of the AIDA Education System. However, the quickly growing freediving market made it difficult to keep a proper overview of all available certifications and related qualifications. Hence, to keep AIDA quality to the highest standards, evaluations take place. Crossover-tables can still been found online, but keep in mind that they are not valid anymore and got replaced by the AIDA Crossover Evaluation as described in this chapter.

Medical statement

The AIDA Medical Statement mentions potential reasons for not making it possible for you to safely freedive. It is comparable to the list of questions used in scuba diving. All questions ticked NO means you are ready to commence with your freedive journey. Any answer ticked YES means you will have to provide written medical clearance by a qualified doctor before the start of your course. For this, please ask your doctor to fill out the designated part of the form. Be honest about your medical condition also about other conditions than those stated in the document, and mention previous minor surgeries or mild cases of asthma. Your examining doctor is interested in receiving a holistic picture of your condition in order to support you to safely engage in freediving. In case you are embarking to a remote island for doing your AIDA Course, please make sure that you are in possession of any needed paperwork BEFORE you leave home. The medical statement must be filled in, signed and handed in to your AIDA Instructor at the beginning of the course.

Liability release (where applicable)

In many countries you will have to hand in a signed AIDA Liability Release prior to any in-water activity. This form is to emphasise that freediving is an absolutely safe activity as long as you follow rules indicated and taught by your instructors. Within more than 25 years of teaching, AIDA Courses was able to maintain an impeccable safety record. We would like to keep it that way. This waiver says that you have understood that you are the most important part of freediving safety.

CHAPTER 02

PHYSIOLOGY

The average person can hold its breath for 60-80 seconds under optimal circumstances. In your AIDA2 course you already proved that you are capable to stop breathing for 2 minutes and more. This is not a miracle, but explainable with basic understanding of human physiology.

2.1 Blood Composition

Approximately 8% of the body weight of an adult person is made up of blood. This results in an average of 4-5 litres for females and 5-6 litres in males, depending on body size. Blood has several functions in the human body:

- Transportation of gasses, nutrients, waste products, hormones and body heat

- Protection from inflammation by providing leukocytes (white blood cells), antibodies and platelets
- Regulation of blood acidity (pH) by interacting with acids and bases, and water balance by transferring water to and from tissues in the body.

The transportation function of blood includes Oxygen (O_2) and Carbon Dioxide (CO_2), which are exchanged between the lungs and the cells in the body.

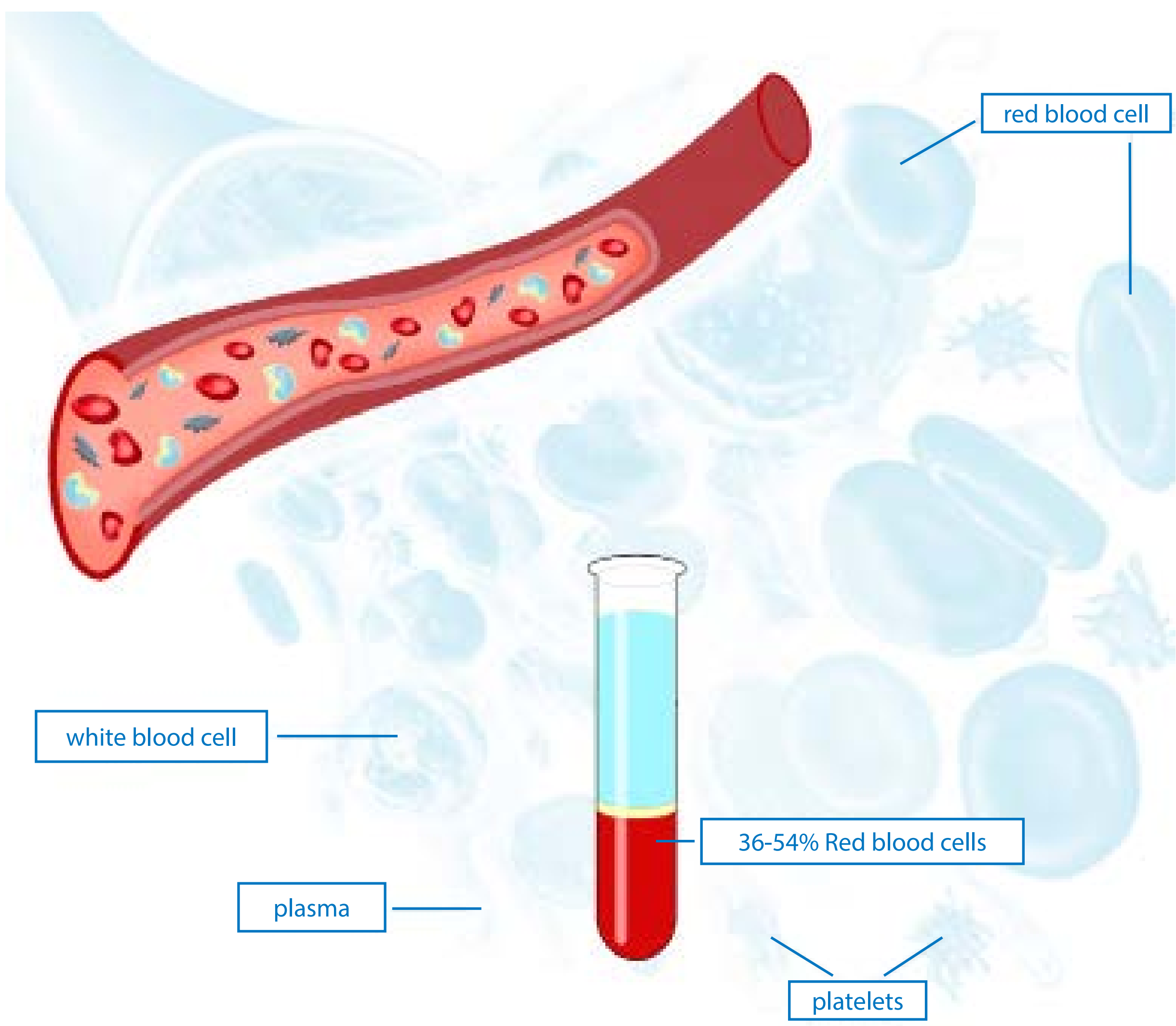


Figure 1: Blood Composition

Composition

Blood is a mixture of red blood cells (RBC, or erythrocytes), blood plasma and buffy coat. The latter contains the white blood cells (WBC, or leukocytes) and platelets. The red blood cells contain an iron-rich protein called haemoglobin, which gives RBCs the red colour. Haemoglobin carries most of the Oxygen transported by the blood.

Oxygenated: red

Oxygenated blood is bright red. This is the case in every healthy person, where the Oxygen saturation is 96-99% at any given time while breathing. You can test this with a simple Oximeter, a device you stick to a finger to measure the oxygenation of the blood. The Oximeter analyses the colour of light reflections from the skin as an indicator of your blood oxygenation. If the oxygenation level is lower than 96% while breathing, you are either exerted or sick. In both cases you should not hold your breath or freedive.

Oxygen depleted: purple

Oxygen depleted blood shifts the colour towards purple. This allows determining the oxygenation level of blood by its colour. A pulse Oximeter does exactly that.

Cyanosis

Cyanosis is often also called "blue lips". As the skin is thinnest on the lips, a change in blood colour can easily be spotted there. Cyanosis does not indicate a dangerously low level of Oxygen in the freediver, but shows the Oxygen level has started to decrease. The level will be normalized within a few breaths and the cyanosis disappears.

As a freediver you cannot feel cyanosis, hence, you depend on your buddy to tell you if it appears! Cyanosis in recreational freediving can be seen as the "first warning sign". It tells you that you are approaching your personal limits and should not push further recklessly.

Note that blue lips can also indicate that the freediver has a slightly lowered body temperature (hypothermia). In this case the colour change derives from a constriction of the blood vessels (vasoconstriction) in the lips and does not indicate inadequate oxygenation. Still it is important to tell your buddy if you note blue lips. In case your diving partner in fact feels cold, you will have to react by conducting some warming up exercises such as swimming for a while, taking a break in the sun or, if nothing helps, by aborting the freedive session. You should not dive when you are feeling cold.

In case the cyanosis persists over extended period of time despite warming up it may be a sign that the freediver should search medical attention.

2.2 Principle of Diffusion

The gas exchange between air and blood happens in the alveoli, the smallest unit of your lungs. Once the inhaled air has reached the alveoli, it is separated from the blood in the surrounding capillaries only by the alveolus and the capillary walls, both just one cell thick. Due to their thin cell walls gasses are able to travel through these membranes in both directions – from air to blood and vice versa -, following the principle of diffusion.

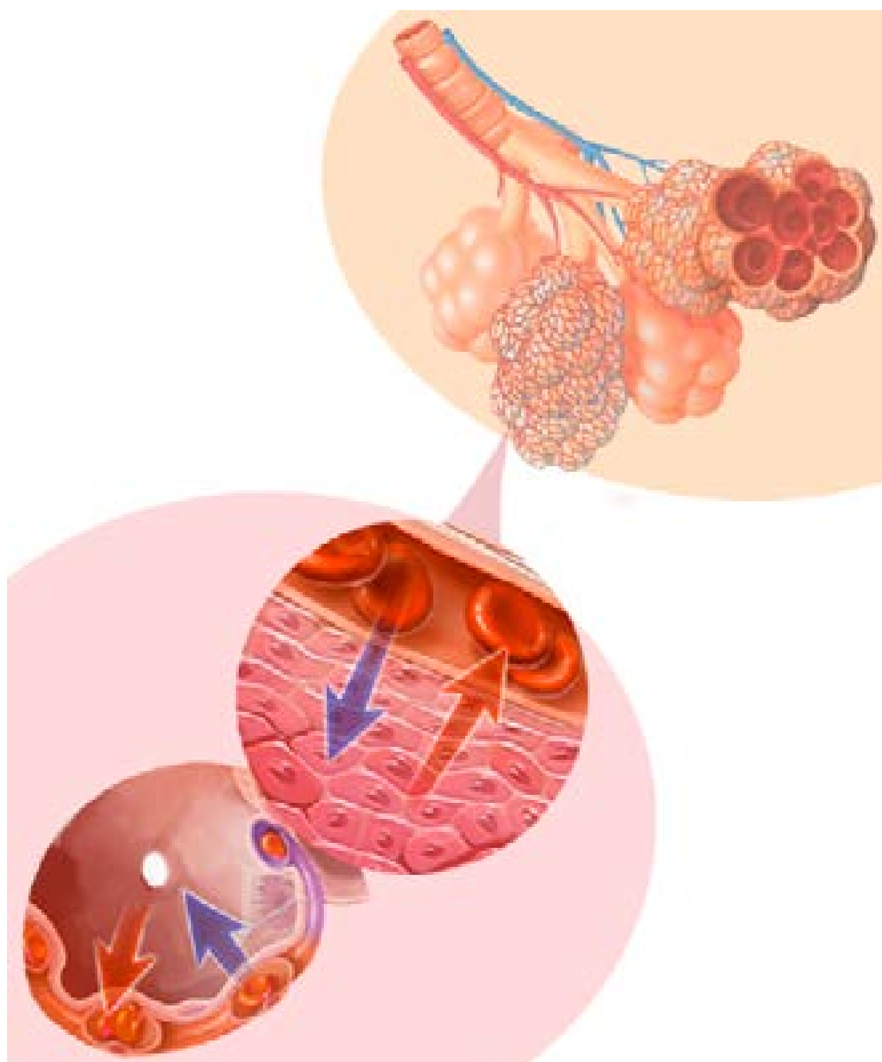


Figure 2: Alveolus and capillary walls, gas exchange

Definition

Diffusion is the natural tendency of a gas to move from an area of high concentration to an area of low concentration.

Gradient

The speed of gas diffusion depends on the steepness of the gradient: The diffusion gradient is the difference of concentration between two areas. The greater the difference, the steeper the gradient, the faster diffusion takes place.

Oxygen & Carbon Dioxide

In the context of freediving we are mainly looking at two components of the gas exchange in the alveoli: Oxygen (O_2) diffuses from the inhaled air in the alveoli into the alveolar blood and Carbon Dioxide (CO_2) diffuses form the alveolar blood into the air in the alveoli.

2.3 Cardiovascular System

The cardiovascular system is the total of all organs and tissues involved in circulating blood and lymph through the body. It is the means of transportation of Oxygen needed for all bodily activities in the brain, in all organs, in all muscles and in other tissues. All cells produce CO_2 as a by-product of their metabolism.

Arteries: Blood vessels carrying blood from the heart to the organs. Usually this blood is saturated with Oxygen (O_2 enriched) and low on Carbon Dioxide (low CO_2).

Veins: Blood vessels carrying blood towards the heart. Usually the blood is de-saturated from Oxygen (O_2 depleted) and saturated with Carbon Dioxide (CO_2 enriched).

Exception: The pulmonary artery is carrying blood low on O_2 from the heart to the lungs, while the pulmonary vein is carrying oxygenated blood from the lungs to the heart.

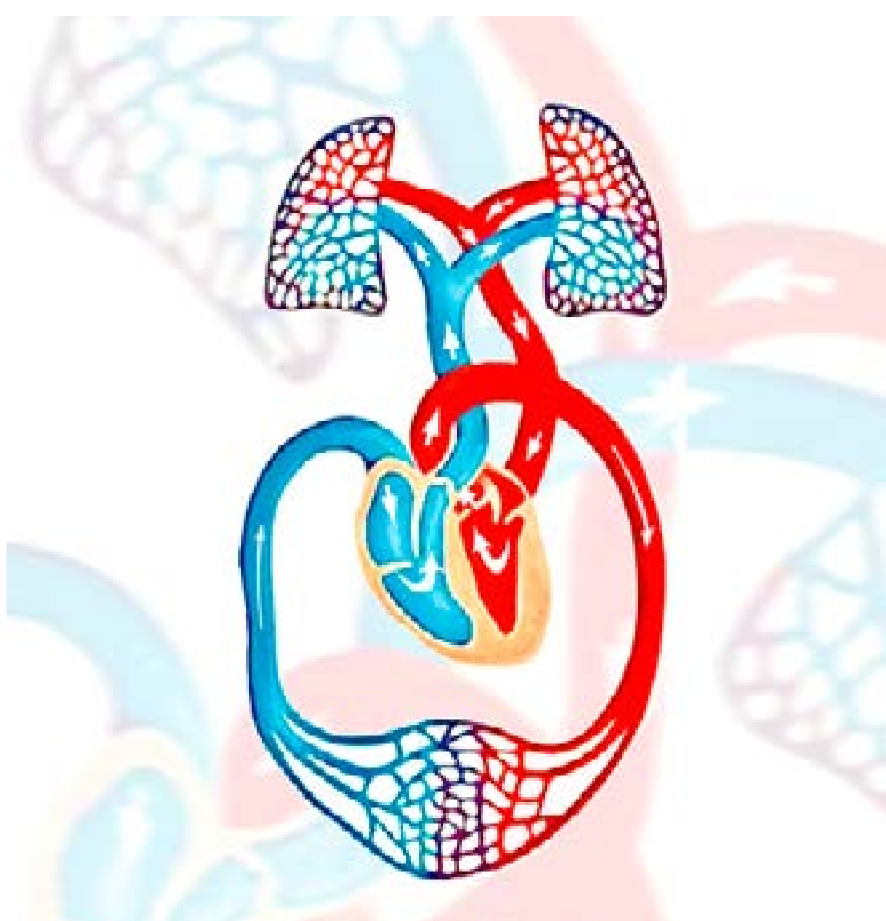


Figure 3: The Cardiovascular System and Blood Colours

Cardiovascular "trip" of O_2

You We have now all information needed to understand the whole journey of Oxygen and Carbon Dioxide through our body. Imagine a few O_2 molecules hovering in front of you, and you are about to inhale them. This is where the journey starts.

1. Inhalation of air including O_2 (see respiratory system in AIDA2)
2. O_2 diffuses into blood (gas exchange)
3. Most O_2 bonds with haemoglobin
4. Transport of O_2 from the lungs to the heart via pulmonary vein
5. Transport of O_2 enriched blood to any tissue (e.g. a muscle in the right hand) via systemic circulation
6. Tissue takes up O_2 and produces CO_2 which dissolves mostly in blood plasma
7. Transport of CO_2 enriched blood to the heart via systemic circulation
8. Transport of CO_2 enriched (and O_2 depleted) blood to the lungs via pulmonary artery
9. CO_2 diffuses into air in the alveoli
10. Exhalation of CO_2 enriched air

2.4 Hyperventilation

Since it is the CO_2 level in the blood that gives the body the "state of breath hold", low CO_2 levels can lead to a hypoxic black out due to delayed (if any) previous warning symptoms.

Reduced blood flow to the brain

Low CO_2 (hypocapnia) can decrease the blood flow to the brain, due to a constriction of blood vessels to the brain (cerebral vasoconstriction). This reduces the Oxygen supply to the brain. Extreme states of cerebral vasoconstriction caused by hypocapnia can lead to a black out while the freediver is still breathing at the surface.

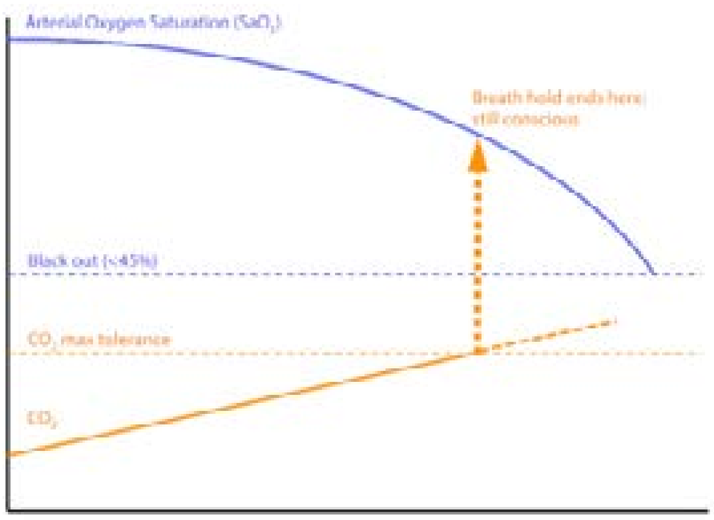
Hyperventilation decreases breath-hold capability

Many of the Oxygen conserving mechanisms as described in "The Mammalian Dive Response (MDR)" (see Chapter 9) are triggered or supported by rising Carbon

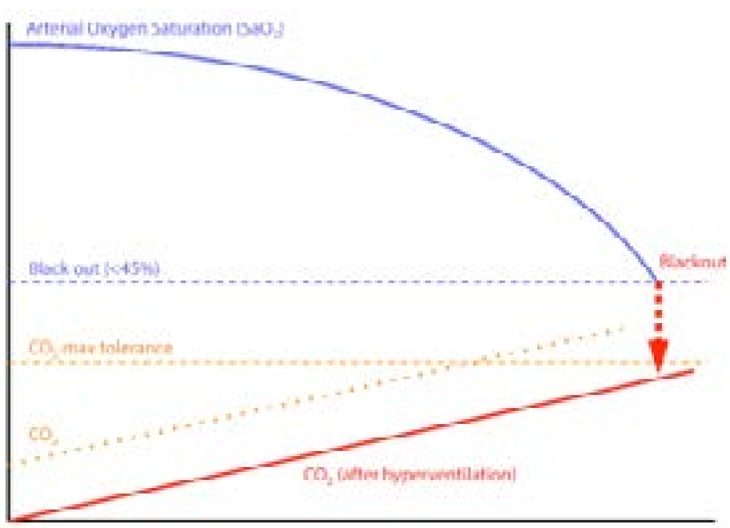
Dioxide levels in the blood during apnea. Hypocapnia is inhibiting the MDR and thus the body will not conserve energy (Oxygen) to the same extent as it would during a breath hold that has been started with a normal level of CO_2. After hyperventilation, a hypoxic state is thus reached sooner than in a breath hold prepared by a relaxation exercise with the according normal ventilation.

Bohr effect

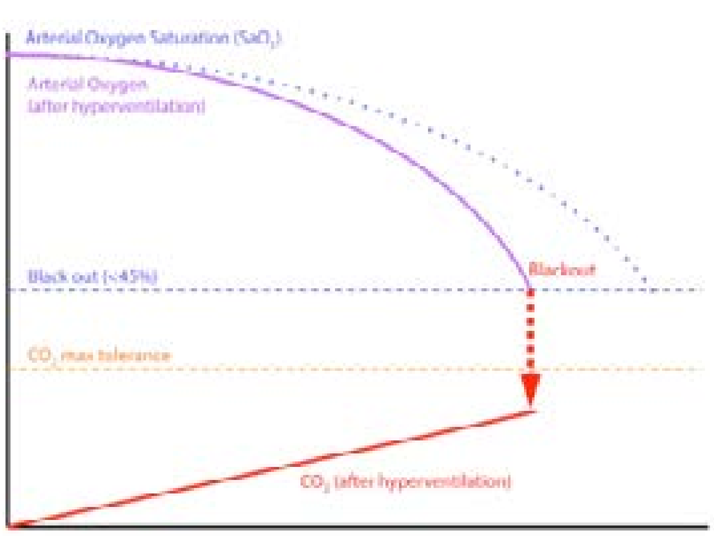
Low CO_2 (hypocapnia) renders the blood more alkaline. This in turn makes the bond between haemoglobin and Oxygen stronger! As a result, the bonded O_2 in the blood is less likely to be released to tissues. This is known as Bohr effect.



During a breath hold, the saturation with Oxygen (blue curve: SaO_2) decreases. Starting with an average saturation of 96–99%, the freediver would black out when reaching roughly 45%. This is very unlikely to happen as the maximum tolerance of Carbon Dioxide (orange) is reached considerably earlier, allowing the freediver to end the breath hold well in time.

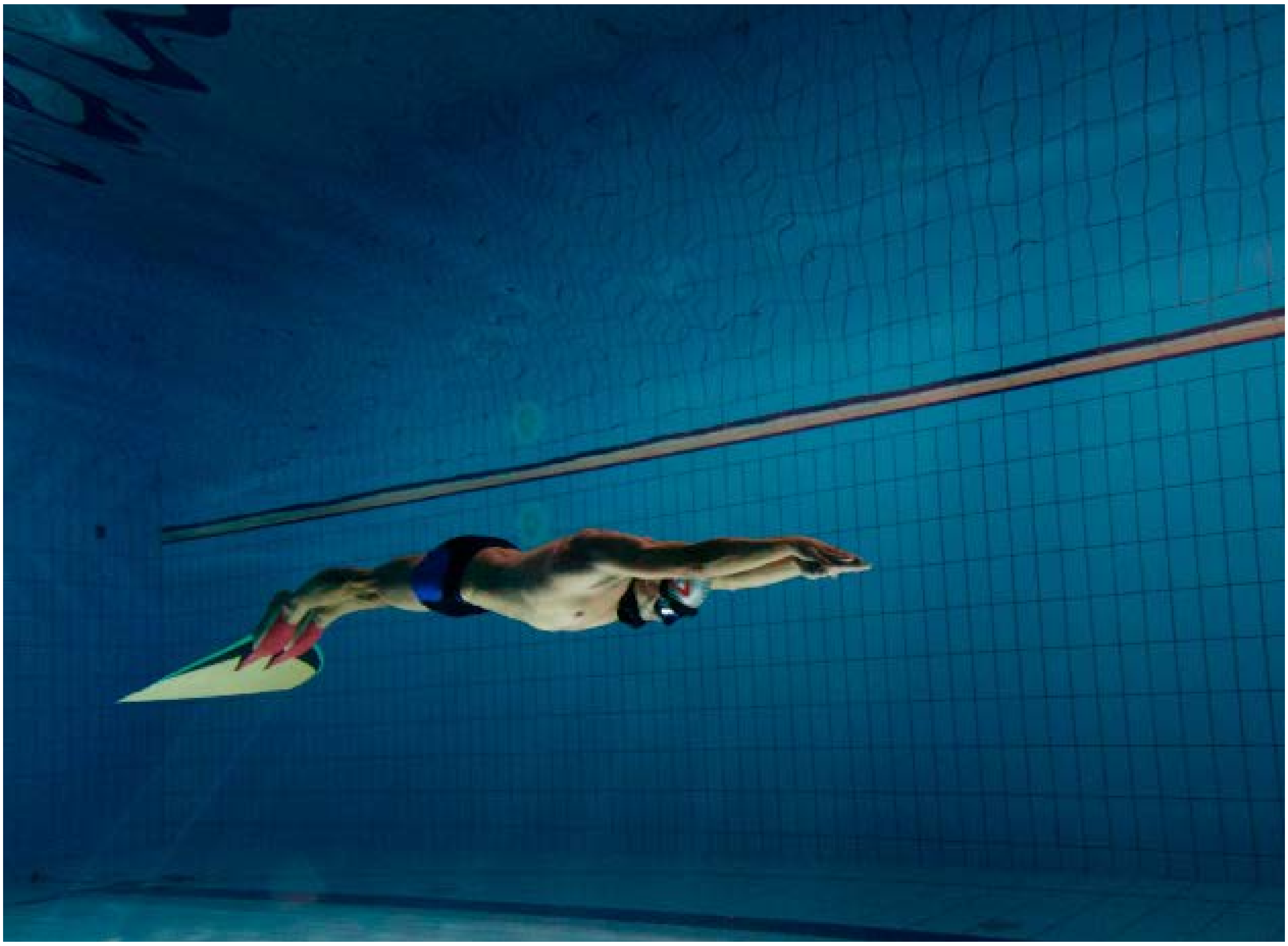


Hyperventilating does not change the level of Oxygen saturation in the blood, but it decreases its content of CO_2 (red line). During a subsequent breath hold, symptoms of rising CO_2 are thus delayed and 45% of Oxygen saturation can be reached before CO_2 levels surpass tolerable levels. This is why hyperventilation leads to black out.



Lower than normal CO_2-levels delay the energy conserving effects of the mammalian dive response (purple) and enhance the bonding between haemoglobin and Oxygen, reducing the release of Oxygen to tissues (Bohr-effect). The freediver thus depletes his O_2 reserves faster and blacks out earlier.

Figure 4: Hyperventilation can lead to Black Out (Illustration concept by W. Trubridge)



Chapter 02 Knowledge Review

What is the function of blood in the human body?

What is cyanosis and why should you warn your buddy about it?

Define diffusion

Define veins, arteries and the particular case of the lungs circulation

Hyperventilating does not change the level of Oxygen saturation in the blood, but it decreases its content of CO_2. True or False?

CHAPTER 03

EQUALISATION

In the AIDA2 Course you learned the basics of equalising your ears and your mask. This chapter displays in detail what is happening during an equalisation manoeuvre and ends with an introduction to the recommended equalisation technique: The Frenzel manoeuvre.

3.1 Elements of the Ear

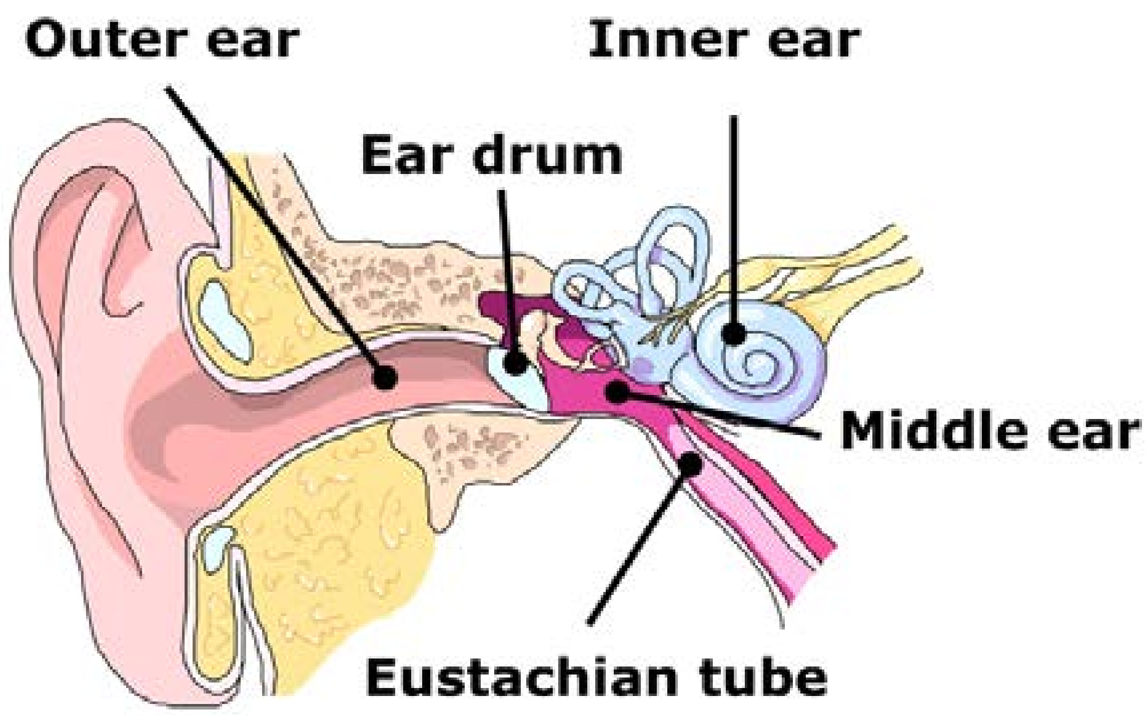


Figure 5: Anatomy of the Ear

Outer ear

The outer ear, or outer auditory canal, is the space between the eardrum and the outside world. During freediving it should be filled completely with water. This happens automatically as soon as you submerge and tilt the head slightly sideways, so that the air in your outer ears can escape. Any remaining (uncompressible) air in your outer ear can make equalisation harder or impossible.

A hood can prevent air from escaping and your outer ears will not completely fill up with water. When freediving with a hood it is thus important to lift it slightly off your face at your temples to allow both your outer ears to fill up with water prior to every dive. Alternatively, you can poke small holes in your hood where your outer ears are in order to allow air to escape automatically when diving.

Ear drum

The eardrum separates the outer ear from the middle ear. It is slightly flexible and thus a very sensitive instrument to register changes in the environmental pressure. As described in AIDA2 there is a difference between the sensation of pressure-change and pain. Feeling pressure is essential for an efficient equalisation technique while experiencing pain while diving is always an alarm signal upon which you should stop your descent immediately.

Middle ear: Filled with air

The middle ear is the space between the eardrum and the inner ear and is filled with air. This is the part of the ear we have to equalise during diving.

Eustachian tubes

The Eustachian tube connects the middle ear with the nasopharynx. This connection is the reason why the middle ear and the sinuses equalise together by the application of just one correct equalisation technique.

Muscles around Eustachian tubes

Parts of the Eustachian tubes are surrounded by muscles, which are closed in their default position. These muscles contract and thus open up the Eustachian tube orifice every time we swallow, which can be heard as clicking noise. Try it yourself: In a quiet environment, swallow some saliva and you will hear a small click in both your ears. This is why swallowing works as an equalisation technique if only small pressure changes have to be handled, such as during the ascent or decent of a plane.

The more relaxed the muscles around your Eustachian tubes are, the smoother your equalisation technique works. “Hands free equalisation” means that you can intentionally contract the muscles around the Eustachian tubes.

Inner ear

The actual hearing organ is the inner ear, or cochlea. Its position is “inside” the head, roughly behind the eyes. It is filled with liquid and thus does not need to be equalised to changing levels of pressure.

3.2 Anatomy of Sinuses

Figure 6: Overview of the Sinuses

Hollow spaces

The sinuses are a connected system of several hollow cavities in the skull. The largest are roughly one inch or 2.5 centimetres in diameter, while others are much smaller.

Air filled

As the sinuses are hollow, they are filled with air. While the general purpose of the sinuses is not exactly clear, they certainly reduce the weight of the skull and add resonance to the human voice.

Mucus

The sinuses are lined with soft, pink tissue called mucosa, covered by a thin layer of mucus. The mucus helps humidifying the inhaled air and traps irritants before they can enter further into the breathing system.

Importance of proper ventilation

Each sinus has a narrow spot called transition space or ostium, through which the sinus is constantly drained from old mucus, mostly towards the nose. Production of fresh mucus allows old mucus to be expelled together with the trapped irritants. Proper ventilation of the sinuses is thus vital for a constant replacement of old mucus with freshly produced mucus.

Techniques for proper ventilation

Apart from blowing your nose a few times per day, the elimination of old mucus can be greatly supported by certain yogic techniques. The cleansing exercises "kapalabhati" and "neti" are probably the most beneficial ones and can be conducted on a daily basis. Many AIDA Instructors will teach these techniques in special workshops complementary to the AIDA Courses.

Although a quite common practice, it is not recommended to flush the sinuses with seawater for cleansing purposes. Even if this might work sometimes as a short term solution, the risk of infection is very high. Seawater is not the often depicted "clean salty water solution", but also contains pollutants and organisms, including a vast count of germs and other possible causes for infections. You should avoid deliberately infusing this mix into your body. Of course it will still happen. Especially surfers are familiar with sea water dripping from their noses, hours after their last wave. As always, it is of course the dose that makes the difference. Try to avoid ingestion of sea water as much as you can, but small amounts of sea water are usually not a problem.

3.3 Improving Equalization Technique

AIDA2: Introduction to equalization technique

During a descent in water pressure increases, compressing the air in the middle ear. As a result, the eardrum is pushed inwards reducing the air space in the middle ear. To equalise this pressure you must push air into the middle ear through the Eustachian tubes.

See your AIDA2 manual for full description of equalisation.

Avoid Valsalva manoeuvre for freediving beyond beginner level

The Valsalva manoeuvre is a perfectly valid equalisation technique for shallow dives on beginner level, however it will not work at greater depths. Starting with the AIDA3 Course (and beyond) you should refrain using Valsalva and shift to the more efficient Frenzel technique.

Learn and apply Frenzel manoeuvre

If equalisation is no problem for, but you are not sure which technique you are actually using, test yourself with the following steps:

1. Breathe calmly through your nose
2. Pinch your nose with your fingers
3. Pronounce a "T" or a "K"

If these steps lead to an equalisation, then you are applying the basic principles of "Frenzel", also called the Marcante-Odaglia technique. However, if you need to create any tension with your abdomen while applying pressure, then you are doing "Valsalva" or a mixed form. If still unsure, have your buddy put his/her hand on your belly while you are equalizing. If your buddy registers the slightest movement in your belly while you equalise, you are not applying proper Frenzel technique yet.
Your AIDA Instructor can help you with mastering the Frenzel manoeuvre.

Equalisation stretching and tubular exercises

The muscles around the Eustachian tubes are connected with the jaw and (indirectly) with the neck. Gentle stretches of your neck and jaw muscles thus facilitate equalisation. Below you can find some tips and tricks for practicing stretching to support your equalisation.
First stretch: While standing or sitting with a straight spine, allow your right ear to drop down to your right shoulder. Stay there, feel the tension on your left side of your neck, and let go of any tension you find. When you sense no more tension of which you can let go of, raise your right arm, reach over your head and place your right hand on your left ear. Do not pull on your head! Just allow the extra weight of your arm to pull your head down a bit further. Stay for 5-7 relaxed breaths in this position. Then release the hand and let go of the ear first and slowly raise your head back centre. Repeat on the other side by allowing your head to sink to the left.
Second stretch: Allow your right ear to drop back down to your right shoulder in the same matter as before. Then slowly roll your head to the middle, until your chin touches your collarbone and your crown of the head points forward. Keep an erect spine and avoid pulling your head down with your hands – the weight of the head is just enough. Gently keep rolling your head until your left ear has reached the left shoulder. Now reverse the direction, allowing your chin to touch your collarbone

again, before ending the movement on the right side where you started. Repeat a couple of times.

Third stretch (jaw series): Note: The jaw is very fragile and can easily be hurt. It is important to perform the following exercises in a very gentle manner! Stick the tongue out as far as you can, without pulling a face, then retract it all the way back, brushing the tip of the tongue along the roof of the mouth (slightly modified from the original exercise as described in "The Manual of Freediving" by U. Pelizzari/S. Tovaglieri). Repeat a few times. Then, with the tip of your tongue, draw circles on your lips by outlining the lips with your tongue in both directions., Repeat a couple of times. Then gently open the mouth as far as you can without moving any muscles that are not needed to do so. Close the mouth again and repeat a few times. Gently move the jaw from left to right. Keep only a little gap between the teeth. Repeat a few times. Then gently move the jaw front to back. Keep the little gap between your teeth while repeating this a few times. Finally, rotate the jaw gently clockwise, and then in the opposite direction, this is the so-called "camel-chew". Repeat it a few times.

Ease of equalisation

Regardless of what equalisation technique you are using, always aim for perfect application of the manoeuvre by using only the muscles involved in equalisation and relax all others. Tensing the neck or the jaw are common mistakes making it harder for you to equalise.

In the AIDA3 Course your instructor will teach you how to apply the Frenzel-technique properly. An absolute imperative in this technique is to have and maintain a completely relaxed abdomen. The pressure needed for equalising must solely come from your tongue (or your cheeks), while the throat is locked.

At depth, if you can hear a noise coming from your throat while equalising with Frenzel technique it may indicate that you are falsely trying to support your equalisation by tensing the abdomen. The sound that this creates, the so-called "Grouper call", is a certain sign that you simply need to relax you abdomen. Do this by shifting your focus on your abdomen, allowing it to completely relax and then equalise with Frenzel technique again. This is one of the most important ways to an efficient equalisation technique at depth.

Chapter 03 Knowledge Review

There is a difference between the sensation of pressure-change and pain. Please comment.

Why is it not recommended to flush the sinuses with sea water?

Regardless of what equalisation technique you are using, what should be the main focus?

CHAPTER 04

BAROTRAUMA

Barotrauma is a general term for any physical damage caused by a difference in pressure inside one of the air filled cavities of the body and the surrounding water pressure. In diving, barotrauma can appear both during descent and ascent (reverse block).

Failure to equalise

Barotrauma is easy to prevent by eliminating any pressure differences acting on tissues or organs by equalising the changing pressure. If you are not able to equalise, stop your descent! If you still do not manage to equalise completely within reasonable time you will have to abort the dive and re-surface.

Injury

Failure of equalisation alone does not lead to injury! Injury will only happen if you fail to equalise and still choose to move further down (or up, in case of a reverse block on ascent) in the water column.

Stay dry until fully healed

Any barotrauma incident needs to be carefully analysed and injuries properly treated. You are strongly advised to see a doctor. Most importantly it is strongly advised to stay out of the water until full recovery from such an injury in order to avoid the risk of permanent damage.

4.1 Eardrum Perforation or Rupture

Injury to the eardrum is one of the most likely consequences of barotrauma, that is, if you do not abort your descent immediately when your equalization fails.

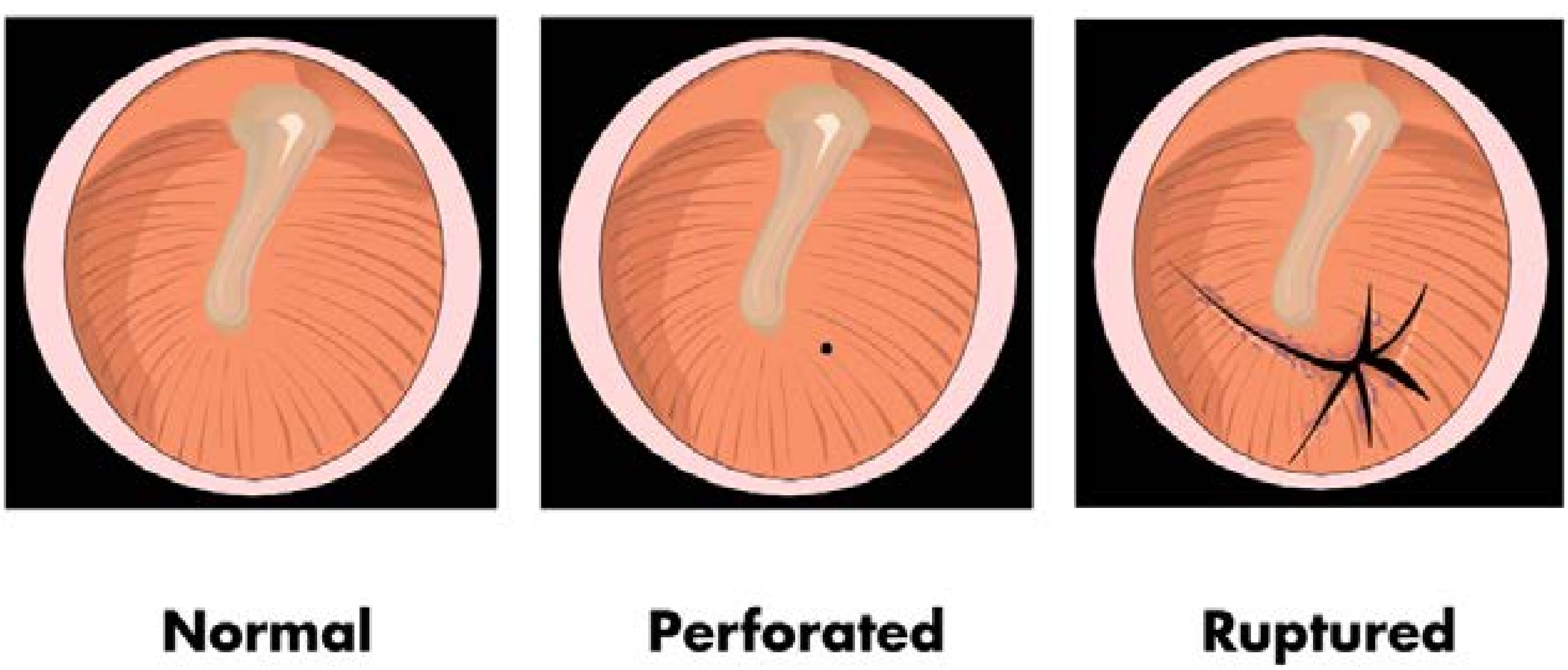


Figure 7: Illustration of normal,perforated and ruptured eardrum

Perforated ear drum: Pinhole

A small pinhole in the eardrum, or perforated eardrum is a form of barotrauma injury.

Ruptured ear drum: Large tear

A large tear or a burst eardrum is called a rupture.

Symptoms

An eardrum perforation or rupture manifests itself with sharp pain. You might also experience vertigo and loss of direction. If the eardrum is damaged, there will also be a temporary loss of hearing to a certain extent. As a consequence of an eardrum injury, water will enter you middle ear and there is a high risk of infection.

Stay dry, see doctor

In all cases you should immediately seek medical attention to clarify the damage on your eardrum and then stay out of the water until it has fully healed. An eardrum perforation can heal itself within a couple of weeks, but treatment may be necessary to prevent infections and help improve your hearing. A larger rupture or a pinhole that does not heal spontaneously might require a surgical intervention.

4.2 Middle Ear Barotrauma

Blood forced into middle ear

If you fail to equalise and do not stop your descend, blood and other fluids might be forced into a middle ear, partially or even completely filling it. This is called a middle ear barotrauma. The fluid in your middle ear is a great risk of infection. Seek medical attention!

Symptoms

A middle ear barotrauma causes sharp, sometimes extreme pain that might persist for days. Also, your ear feels “full” and hearing is muffled or even completely lost. Sometimes you feel like still having “water in your ears” the following day after freediving. In many cases water is trapped in your outer ear by earwax which is in need of an ear cleaning by a doctor. But if this is not the case, then you might have suffered from a middle barotrauma and need to seek medical assistance.

See doctor

If you experience symptoms of a middle ear barotrauma it is imperative that you stay out of the water, and also avoid other pressure changes (like flying). You need to see a doctor.

Healing time: One week to months

With the appropriate combination of medication and time, this injury usually heals within a few days, however, cases of several months have been reported. It is thus important to get clearance from your doctor before going diving again.

4.3 Reverse Block

Failure of automatic equalisation on ascent

In the AIDA2 Course you learned that there is "no need to equalise on ascent". By equalizing during the descent you pushed air into the hollow spaces in your body to counter-balance the rising environmental pressure. This additional air will expand and normally be pushed out of these cavities as you ascent. In rare cases this automatic outflow of air is inhibited and can thus lease to a reverse block.

Sinus or Eustachian tubes

The reverse block happens when the Eustachian tubes (middle ear) or ostium (sinuses) are partially or fully blocked in such a way that the expanding air in the according cavity cannot leave. This manifests in pain in the according cavity, either in the middle ear or the sinus(es). The pain is slowly building up as you ascend.

Cause and prevention

A reverse block can be caused by an acute or not fully cured infection of the airways. Never dive with a cold or congestion! Another possible cause is the wrong application of decongestant medication. Never combine these drugs with diving of any form. Under pressure, these drugs get metabolized faster than at the surface and might cause a congestion of airways much earlier than expected.

How to react when caught in a reverse block

If the pain gets stronger upon ascent and you are not at great depth, immediately grab the rope to stop. This also helps to find orientation in case you should suffer from vertigo. Do not equalise! Remember, equalisation pushes more air into your sinus, but in a reverse block situation there is already too much air in the sinus and/or middle ear.

Give yourself as much time as you reasonably can. Stay calm and indicate to your buddy that there is a problem. You can support the release of the block by stretching the "bad side" of your neck (if pain in the ear is indicating a middle ear problem) and wiggling the jaw. Also swallowing with the nose pinched does help as this sucks the air inwards.

Ascent as slowly as you can, using the rope as a guideline in case you should suffer from vertigo. The trapped air will eventually release.

Alternobaric vertigo (AV): Unequal pressure release in one ear

Alternobaric vertigo (AV) can occur during descent, but is more commonly occurring on ascent when one ear de-pressurises slower (or incompletely) compared to the other. The difference in middle ear pressure can cause the brain to falsely interpret this as bodily movement. Involuntary eye movement, nausea, vomiting, tinnitus and muffled hearing can be symptoms of AV.

Note that symptoms of AV can also be cause by a temperature difference between both middle ears, or by a ruptured eardrum allowing water to flow into one middle ear.

Similar to a reverse block you should stop your ascent by reaching for the rope if you are at a shallow depth. However, at greater depths do not stop and rather keep moving slowly instead in order to not overextend your diving time.

After experiencing AV you should stop diving and see a doctor. Do not freedive before you are medically cleared and fully rested.

4.4 Hood Squeeze

Well fitting hood

A tailored wetsuit does not allow water to flush between the neoprene and your skin. This is also true for the hood – if it is fitting well, water does not enter your ear canal. Not getting ones ears constantly flushed with water is especially comfortable in cold water freediving, but it has a down side, which is air trapped in the ear canal.

Air trapped in ear canal

If the hood seals of very well, air that might be trapped in the ear canal between the hood and the ear drum will get compressed on descent and might cause injury to the ear drum or the ear canal. Experiencing a trapped air pocket in the ear canal feels similar to a common equalisation failure, but of course it is a completely different phenomenon.

Fill ears with water

To avoid having air trapped in the outer ear canal, fill your outer ear completely with water prior to every dive. You can also let water in to your hood while descending. However, this might break up your streamlining and mental focus somewhat, so preferably you have already taken care of that prior to your dive.

Warning: Do not lift your hood off your ears with a jerky movement while diving! If there is an air pocket under pressure trapped in your ear canal, forcefully pulling on the hood can lead to ear canal or eardrum barotrauma.

Alternatively you can also pinch small pinholes in your hood, exactly at the position of your ears (while you are not wearing your suit, of course). These small holes will allow water to enter (and leave) your ear canal according to the changing pressure.

4.5 Sinus Squeeze

A "squeeze" is a commonly used synonym for a barotrauma. It is a general term for a pressure imbalance in one of the air spaces of the body and the environmental pressure. If this imbalance leads to pain or injury, we call it a "squeeze".

If a partial or full block occurs in one of the sinuses or an ostium (canal through which mucus drains from a healthy sinus), we call it a "sinus block". The reasons for this phenomenon to happen are described below.

On descent

A fully blocked sinus will show very quickly upon your freedive decent. Sharp pain in your forehead, "behind the cheek bone" or even in the teeth sets in immediately upon immersion in water. The pain is caused by reduced or absence of ventilation and makes equalisation of that particular sinus impossible. As the mucosa tissue in such a case is probably strongly irritated and swollen, it is also very sensitive and pain sets in immediately. Under no circumstances you can, should or will want to dive in such a situation.

Blocked sinus(s) caused by congestion

Sometimes a spontaneous or partial block of a sinus can appear while diving. The pain sets in slowly and does not go away upon equalisation. This happens when “old” mucus temporarily blocks an ostium (through-flow) from a sinus towards the nose.

Stop descent or abort dive

If you experience a sinus block, stop your descent immediately by holding on to the diving line, relax and try to equalise again. If the pain does not go away you will have to abort the dive and ascent in a controlled manner.

Check for injury

After surfacing, gently blow your nose into your hand and check the expelled material. If you notice any fresh blood you have hurt the tissue in one of your sinuses. This is a sinus barotrauma and you should stop diving. This injury usually heals within a couple of days. During these days you also have time to recover from the cold or congestions causing the block in the first place.
In other cases, the expelled fluid and or mucus form blowing your nose has a dark brownish-red, almost black colour. This is evidence of a past infection or cold. In this case you do not need to stop freediving immediately and are allowed to proceed to your next dives with great prudence. For instance, you can engage in a slow free immersion dive, being very sensitive and aware to any problem or sensation you are experiencing during your equalisation. Check regularly and carefully if the block has vanished.

4.6 Avoid Blocked Sinuses

The single best advice to avoid a sinus block is: Do not dive with a cold or congestion! Prevention of catching a cold is a matter of a strong immune system supported by healthy lifestyle and cannot be achieved by a magic potion. However, no one of us is exempt from a runny nose and even the best of us can catch a cold once in a while. A healthy diet combined with reduced stress is certainly supporting the healing process.

How to avoid sinus block

Dry air, irritants and allergies are the most common reason for blocked sinuses.

Most of them can be avoided. Try to avoid your known allergy triggers (including foods which seem to cause excess mucus production for some, like dairy products, wheat etc.) and drink plenty of fluids to support the flow of mucus.
Even chronic infections of sinuses might reduce in intensity or even disappear after some time of consequently heeding the advice mentioned in the sections below. However, if the cause cannot be eliminated this way, you will need to see an ENT-specialist (doctor who specialises in Ears, Nose and Throat treatments). Medical short-term treatment of blocked sinuses often includes the usage of antihistamines or decongestants. Please note that you cannot dive while taking these forms of medication.

Inhale steam

Inhale steam several times a day helps to liquidate sticky mucus. Pour hot water in a bowl and put a towel over your head or use the fancier version of respiratory steam inhaler. Sitting in the bathroom with the hot shower running is not recommended, as it uses an excessive amount of energy.

Cleansing pranayama

Ask a qualified and experienced yoga teacher to introduce you to the correct techniques of kapalabhati, nadi shodana and bhastrika. These exercises, applied daily, allow you to drain a blockage when it happens and will help you to minimise the probability of future congestions.
Yogic breathing techniques mostly use fast and deep breathing and are thus clearly qualifying as hyperventilation. These techniques help in cleansing, strengthening and stretching your breathing apparatus, however, they should not be applied right before freediving.

Neti pot

Neti pot is a yogic cleansing technique for nasal irrigation with a saline solution. It is important to learn the correct application to avoid negative side effects or even injury. The water has to be boiled for several minutes first and should have the temperature and salinity of tears. Neti pot is done without any pressure.
A word of caution: Spraying water through your nostrils with pressure (with a plastic drinking bottle or similar) can cause injury and has thus to be avoided.

Sleep bad side up

A simple advice is to sleep with the "bad side up". The mucus of an infected sinus (or middle ear) has to drain towards the nasopharynx and you can support that process by keeping the infected area elevated in order to allow the mucus to flow down.

However, if you suffer from an infection of the outer ear canal you should sleep "bad ear down", yet avoid sealing the auricle in some way. Outer ear infections are much more common than middle ear or sinus infections, but might feel similar. Search medical assistance if you are not absolutely sure about the area of infection.

SISA (Sudden Interrupt Static Apnea)

Another interesting technique for reducing mucus is to simply cease breathing with more or less neutral lung volume without prior relaxation. CO_2 levels will build up rapidly, and you will get a strong vasoconstriction of the mucosa capillaries. This reduces inflammation and allows for ventilation by expelling mucus.

You can also try this technique when you wake up in the middle of the night having one nostril blocked. You will have a good chance to get the nostril ventilated.

Be careful with air conditioning

Avoid air conditioning if you can. ACs tend to not only decrease the temperature

Do not take risks and freedive only if you feel completely healthy

but also the humidity of the air in a room.. If you cannot avoid AC ventilated rooms, increase the temperature to a level you still feel comfortable with. This may be at an average of 26-27°C.

Keep well hydrated

As stated throughout this manual, you lose a lot of fluid while freediving through transpiration, breathing through the mouth or immersion diuresis (see chapter 9.8). Already the slightest dehydration renders the mucus in your sinuses stickier and thus keeps it from properly draining in a natural way.

To keep well hydrated you should always drink a lot of water, juices and isotonic beverages before, during and especially after freediving. If you are freediving from a boat, make sure to always have a water bottle with you and start drinking immediately after finishing your open water session even if you do not feel thirsty. You can even bring a small bottle to the float and have a sip of water in between dives. Pay special attention on keeping well hydrated during air travel, which often precedes freediving.

Chapter 04 Knowledge Review

How do you prevent barotrauma?

What are the symptoms of an eardrum perforation?
How does a middle ear barotrauma occur?

Why is a suspected middle ear barotrauma to be taken seriously and always be checked by a doctor?

Why should you avoid equalising if you are experiencing a reverse block?

What is alternobaric vertigo?

A well fitting hood can be a problem when it comes to hood squeeze. Explain!

How should you react when experiencing a blocked sinus on descent to avoid a sinus squeeze?

What is the best advice to avoid a sinus block?

CHAPTER 05

LUNGS AT DEPTH

5.1 Lung Measurements

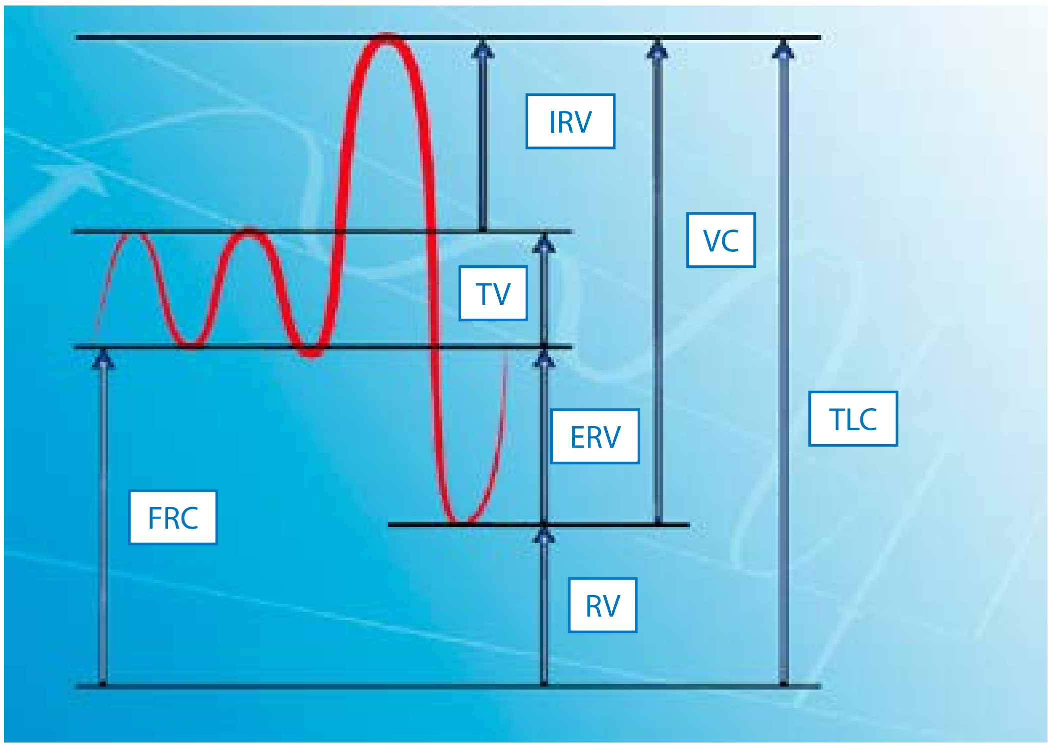


Figure 9: Overview of Lung Measurements

Tidal Volume (TV)

The tidal volume is the amount of air inhaled and exhaled during relaxed breathing. For a relaxed person, one tidal breath is about half a litre (500ml) in volume and is repeated about 10-20 times per minute. Ideally, the inhalation is done by activating the diaphragm while the exhalation is passive: The air is not getting forced out of the lungs, but rather expelled by simply "letting go".

Inspiratory Reserve Volume (IRV) & Expiratory Reserve Volume (ERV)

The inspiratory reserve volume (IRV) is additional amount of air that can be inhaled after a relaxed tidal inhalation. The expiratory reserve volume (ERV) is the maximum amount of air, which can be exhaled after a passive exhalation.

Vital Capacity (VC)

The vital capacity (VC) is the maximum amount of air that can be inhaled into your lungs after a full exhalation. In other words, the vital capacity it is the sum of inspiratory reserve volume, tidal volume and expiratory reserve volume:

$$VC = IRV + TV + ERV$$

The vital capacity is thus the maximum volume of air we can access in one breath. Healthy adults have a vital capacity of 3-5 litres, depending greatly on sex and body-height. Training can increase the vital capacity, mainly by reducing the residual volume (RV, see next).

Functional Residual Capacity (FRC)

The functional residual capacity (FRC) is the volume of air remaining in our lungs after a relaxed exhalation. It can also be described as the sum of expiratory reserve volume and residual volume (see next):

$$FRC = ERV + RV$$

A "passive exhale" is reached when your airways are open and no air flows in or out. You can easily do this by producing a sigh: Relax completely, especially your abdomen, and say "haaa…" until no air comes out of your mouth anymore. Then close your airways. The amount of air still remaining in your lungs represents FRC.

In your future training with AIDA you will learn about a training form called "FRC-diving". It is sometimes falsely labelled with "empty lungs"-diving. By no means the lungs are empty in FRC. In fact, in an FRC the lungs still hold about 50% of the "total lung capacity" (TLC, see below).

Diving on "empty lungs" is dangerous and should be avoided if you are not a very well trained athlete knowing exactly what you are doing. In AIDA Education, there are no so-called dives on "empty lung".

Residual Volume (RV)

The residual volume (RV) is the amount of air remaining in your lungs after a maximum exhalation. In average it is 25% of the total lung capacity (TLC, see below).

While other lung measurements are easy to acquire with a spirometer (a device to measure volumes of air inhaled or exhaled), the residual volume can only be determined indirectly, as it is not possible to "completely empty" the lungs.

In freediving, the residual volume is very important as it determines how deep you will still be able to equalise normally (see Chapter 5.2).

Total Lung Capacity (TLC)

In simple words, the total lung capacity (TLC) is the total amount of air the lungs can hold:

$$TLC = VC + RV$$

Healthy adults have a vital capacity of 3.5-6 litres, depending on their sex and body-height.

Maximising breathing volume

There is a bit of confusion about the question if the total lung capacity (TLC) can be increased or not. A plethora of methods can be found on the web, of which some help to strengthen the breathing muscles, others work on high CO_2 or low O_2-tolerance, and some are just meaningless. Very few of these exercises actually address the "maximum amount of air to be inhaled per breath", which actually means to change the vital capacity (VC), and not the total lung capacity (TLC).

The most efficient way of increasing the vital capacity (VC) is to work with two approaches:

1. Proper one full breath technique as described in AIDA2: Train a slow two-stage inhalation to fill your lungs completely. Applying this technique correctly means accessing your maximum capability to inhale air into your lungs.

2. Reducing residual volume (RV) by means of stretching your muscles involved in breathing, mainly the diaphragm. Lowering your residual volume leads to an increase of your vital capacity VC and thus the amount of air that you have available per breath.

This will be discussed in detail in the following Chapter.

Relaxation phase: Tidal volume

The relaxation phase is the preparation time before a breath hold. The goal of this phase is to become completely relaxed, physically as much as mentally. As your relaxation gets deeper and deeper, you will notice that also your breathing gets calmer. The more relaxed you become, the less air you need to move in and out of the lungs. Your body will always make you breathe the exact right amount of air depending on the current state of activity. There is no need to interfere with that perfectly balanced mechanism.
Breathing with "tidal volume" is something that we allow to happen by relaxing into it.

5.2 Pressure and RV-Depth

As described above, your lungs reach residual volume (RV) after a maximum exhalation. This is the smallest size your lungs are used to and prepared to be at.
Boyle's Law (see AIDA2) now says that "(…) the volume of a gas is inversely proportional to the absolute pressure", which is often demonstrated with an air-filled balloon compressed at depth. During freediving, the air in your lungs reacts on pressure just like the balloon. The deeper you go, the smaller becomes the volume of the inhaled air. At a certain depth, the volume of the inhaled air in your lungs will approach RV.

Approaching RV

Getting close to RV can be felt as rising pressure on your upper torso, or, as a freediver proverb puts it, "RV is close when the elephant steps on your chest".
You need to approach this level – or depth – with utmost care! Avoid jerky movements and control your descent speed by grabbing the diving rope if necessary. Give your body time to adapt, and progress with training slowly over weeks and months.
Failure depth is the depth where RV is reached and normal equalisation will not work anymore. In the following chapter you will learn how to calculate and to specifically train to dive below RV.

5.3 Lung Barotrauma

As with every barotrauma, the term "squeeze" is often used to describe the same injury. Lung barotrauma is a potentially fatal injury. To be very clear:

> Lung barotrauma (squeeze) is a serious injury in any case.

A lung squeeze can happen, but it should not. If you suffer from a lung squeeze and take it too easy, you are acting irresponsibly. Every single incident of a lung barotrauma needs to be properly treated with the support of a specialized medical doctor.

Pressure related Injury

A lung barotrauma is a pressure related injury of the lungs.
A lung barotrauma in freediving is most often caused by diving below residual lung volume (RV) and keeping on descending further without being ready for it. In other words, you go too deep, too early. The body needs time to adapt to depth, and this does not mean days and weeks, but months and years.
Even an experienced freediver can suffer from a lung injury due to other reasons than mere adaption to depth. For example, a lung barotrauma can be caused by a lack of relaxation due to stress or cold temperatures. Both keep the muscles around the lungs from relaxing or stretch sufficiently to adapt to the rising environmental pressure.
In any of these situations, the freediver should have aborted the dive prior to injury, before the negative pressure in the lungs builds up on descent and causes the delicate lung tissue to rupture.

In Scuba diving lung barotrauma is often caused by breath holding on ascent. The compressed gas in the lungs expands beyond the total lung capacity (TLC) and causes a rupture in the lung tissue. This is not very likely to happen in freediving, but in absolutely rare cases a lung barotrauma at depth leads to fluid in the lungs and thus reduces the available volume on ascent. As the air expands close to the surface, the reduced volume for air leads to lung overexpansion similar to diving with compressed air.

Fluid enters lungs

Through the injury of lung tissue, fluid is forced into the airspace of the lungs in order to equalise the negative pressure. Any liquid in the airspace of the lungs makes the gas exchange difficult or impossible.

Signs and symptoms

There are several symptoms that indicate a lung injury upon surfacing after a dive. You might feel tightness in the chest that does not disappear.. The airways might be obstructed to a certain degree, which creates a wheezing sound while breathing. Even after a few breaths back on surface you have a persisting feeling of difficulty to catch your breath. You might have the urge to cough to clear your airways, and if you do so, you are coughing up a pink, foamy liquid. Eventually you might feel a fatigue that does not disappear. If you have one or several of these symptoms, you have very likely injured your airways or lungs.

Emergency procedure

It is very important that you immediately initiate the following emergency procedures if you suffer from one or several of the described symptoms:

Immediately stop diving! Do not help to finish the on-going freedive session e.g. by buddying or pulling up the rope.

Avoid forced coughing, even if you have a strong urge to do so. Cough only once and spit the expelled fluid into your palm. Check the fluid for traces of blood or pink foam.

Breathe gently, slow and shallow, even if this might be hard while feeling exhausted. Control your breath and focus on relaxation.

Tell your buddy what symptoms you experience. Do not try to hide any symptoms or feeling of discomfort.

Move slowly in order to keep your heart rate low. Your buddy will do all the work for

you and pull you back to the boat or to shore.
If available, breathe Oxygen. The liquid in your lung interferes with proper gas exchange. This can be compensated to a certain extent by breathing pure Oxygen.
It might also make you feel less tired.
Seek medical assistance after every incident in which you have experienced one or more of the described symptoms.

Stop diving for at least one week, seek medical help

It is vital to give your lung tissue enough time to completely heal. In any case you stop diving for at least one week. Failure to do so might lead to relapses, chronic injuries and death.
As it is difficult to judge for yourself if you have allowed enough time to heal it is important to get clearance by a specialized medical doctor before going diving again.

5.4 Avoiding Lung Squeeze

It is self-evident that a lung barotrauma, popularly also called a lung squeeze, has to be absolutely avoided. All too often lung injuries have been downplayed by freedivers as a minor mishap on their heroic journey to greater depths. There are freedivers on record comparing a lung barotrauma in freediving to a torn hamstring in soccer. Nothing could be further from the truth. Repeated squeezes do result in chronic conditions. Freediving before a complete recovery from a lung barotrauma can be fatal.

Self awareness is key

Freediving on every level is about self-awareness and never about numbers. Some of the greatest freedivers of all times with multiple world records and world championship titles to their name have never experienced a squeeze (and some never even blacked out!). This was only possible due to their respect for and awareness of their physical and psychological limits as well as their persistent and gradual training over extended periods of time.
Personal limits can change from day to day, and you have to become aware of these slight shifts. One day you are up, one day you are down. This is life and so is freediving.

Dive relaxed or do not dive

The only safe way to approach freediving is through relaxation. From your first day with AIDA you learned how to consciously calm your body and mind by applying relaxation techniques. At times relaxation is easy to achieve, and on some days it seems to take an eternity to "switch into freedive mode". Always allow for the time you need to find that switch.

Stop diving if stressed or cold (shivering)

Stress is the opposite of relaxation. Stress creates tension in your mind and your body. Your breathing and heart rate are elevated. In a pool dive, this will simply shorten your dive time (or distance) because you will burn your energy reserves faster. But a dive to depth is different. Your body and your mind need to adapt to the feeling of getting compressed by the rising environmental pressure. If you try to resist that feeling – consciously or unconsciously – you are likely to hurt yourself. If you feel stressed you are likely to build up dangerous resistance. Stress takes your attention away from self-awareness.

The solution is simple: Be honest to yourself and do not dive if you feel stressed in any way. If you do not feel confident to do a certain dive, then do not do it. Indicate to your buddy that you skip your dive, go back to your relaxation exercise and allow yourself the time you need.

If you get cold, your body will start shivering to create heat. Now you have only two options. Either you start moving to warm up, or ignoring the shivering. Both options are not good enough for freediving as both will tense you up more, losing your relaxation. Hence, if you start shivering, stop freediving and exit the water to warm yourself up.

Stretching of intercostal muscles

The muscles around our thorax and especially the ones we use for breathing can be trained just as any other muscle in our body. Training means strengthening as much as lengthening, you should not do the one without the other. Strengthening your breathing muscles allows you to freedive for an extended time without tiring, but it is mainly the lengthening that allows you to dive deeper.

Caution: Do not use a technique called "packing" for full-lung stretches! In the past, freedivers used "full lung stretches" in an attempt to augment their vital capacity (VC). As we know now, these techniques seem to be associated with long-term damage of lung tissue, especially when combined with "packing".

Packing (see AIDA4 for a full explanation) is not needed for deep freediving. But old habits die slowly. There are still many websites, books and instructors recommending the combination of packing and stretching. Remember, organised freediving education and especially the associated research is still a very young discipline of only thirty-something years. Thus, knowledge about physiology related to freediving evolves quickly and we all have to keep learning and adapting constantly.

Stretching of diaphragm: Uddiyana bandha

You can train the flexibility of your breathing muscles at the end of the exhalation and

Figure 10: Uddiyana Bandha to Stretch the Diaphragm

thus reduce the residual volume (RV) of your lungs by exercising uddiyana bandha. You can learn this technique from your AIDA Instructor or your yoga teacher in more detail. Below you can find a short summary of the technique.

In broad strokes, uddiyana bandha is done in these steps:

1. Warm up your breathing muscles by your choice of gymnastics, sun salutations and/or breathing exercises (bhastrika, full yogic breathing, etc.)
2. Take a more than shoulder wide stand, lean forward with your hands are resting on your tights or knees
3. Exhale completely and lock your throat
4. Pull your navel in towards the spine and then up towards your thorax. Your chest is expanding while the diaphragm gets sucked upwards.
5. Hold
6. Release all muscles
7. Open your airways and let the air flow in gently, restarting to breathe
8. Repeat from step 3 onwards

As a variation you can do this sequence while being seated instead of the leaned forward stance.

Apply correct turn at depth

In your AIDA2 Course you learned how to correctly stop your descent and start your ascent by performing a forward tumble turn. This is of even greater importance when you dive around or beyond your residual volume. Execute your turn at depth slowly and gracefully, always moving in a forward roll. Avoid aggressive or jerky actions in general, and do not perform “opening” movements like the infamous “parachute turn”.

Slow adaption and inducing blood shift

Every great journey starts with the first step. And then follows another step, and yet another again. You can gradually increase your depth by going beyond your previous limits in small steps. Do repeated dives to an achievable depth to allow your body and mind to adapt before setting a new goal, which should be challenging, but not too far away from what you have already accomplished. Give yourself time, enjoy the progress and stay safe.

Start your freedive sessions with a series of warm-up dives to allow your body and mind to adapt and "switch into freedive mode". Chapter 8.1 elaborates in detail how you can design your personal warm-up ritual.

Giving yourself time during warm-up allows your body to induce the blood shift, which is a part of the mammalian dive response. This essential part of freediving is described in Chapter 9.

Chapter 05 Knowledge Review

What is the residual volume?

What is the most efficient ways of increasing the vital capacity?

What is the failure depth?

There are several symptoms that indicate a lung injury upon surfacing after a dive.
Name at least two of them.

Give four or more good advices that help to avoid lung squeeze!

CHAPTER 06

BUOYANCY

Buoyancy control is a fundamental skill in freediving, both in terms of safety and energy saving. Being “too heavy” is obviously dangerous as you might sink from the surface or you might overexert yourself while returning to the surface from a dive.
But also the opposite can be true. Being “too light” does not always mean to be safe in freediving. You might overexert yourself on the first half of your dive by swimming down against too much buoyancy.
Buoyancy control is thus a skill to be applied and adapted to the intention of every freedive session, and sometimes, every single dive – you might have to adapt your weights even from dive to dive.

6.1 Archimedes Principle

Definition

The buoyancy of any object can be calculated by Archimedes' principle:

> "An object partly or fully immersed in a fluid is buoyed up by a force equal to the weight of the fluid displaced by the object."

Archimedes' principle states that with your body partially (swimming) or completely immersed (diving) in water, you will experience an apparent loss in weight, which is equal to the weight of the water you displaced by the immersed parts of your body.

6.2 Neutral Buoyancy (NB)

The downward force of your body in water is simply your weight. The upward, or buoyant, force on your body is that stated by Archimedes' principle. Deduct the weight from the buoyant force and you get buoyancy. Neutral buoyancy (NB) is thus established when the resulting upward force is zero:

Your weight = Buoyant force

Remain at same depth effortlessly

As a freediver you have reached neutral buoyancy when holding your depth is taking place without any effort - you are neither floating up nor sinking down. To test this you have to be patient. Descent by means of free immersion to the depth where you estimate you will be neutrally buoyant. At that point you shape your thumb and index finger of one hand to an "ok-sign" with the rope passing through the O-shaped hole. Let go of the rope with the other hand and allow your whole body to relax. Particularly, do not try to hold your body still in water; rather allow the body to flop, twist and turn wherever it wants to go. In this static state, count slowly down from ten to one in your mind. If you have not moved up or down during the whole countdown, then you have found your depth of neutral buoyancy.

In case you are moving upwards during your countdown, you need to correct your position by pulling yourself a little deeper. Sinking down during your countdown is an indication that you are too deep and need to pull yourself a bit towards the surface along the line. Adjusted your depth accordingly by one arm's length and restart the countdown. Repeat that procedure until you either need to re-surface or can finish by finding your neutral buoyancy. Usually it takes a few consecutive dives to establish perfect neutral buoyancy.

You can make good use of your warm-up dives at the beginning of every open water session and engage in playing this "neutral buoyancy game".

Set neutral buoyancy according to the dive

You should adjust your neutral buoyancy according to the target depth in your dive session by taking more or less weight. The goal is always to minimize the effort for your planned dives. Neutral buoyancy set to less than -10m is unsafe, as it will make your ascent harder. Setting your neutral buoyance deeper than -20m will make your descent more difficult. The deeper your planned dive is, the deeper you will also set your neutral buoyancy.

As a rule of thumb you can set your neutral buoyancy to one third of your target depth. This means, neutral buoyance is only a topic for dives deeper than -30m. For shallower dives, the neutral buoyancy stays set to a safe minimum depth of -10m.

Shallow NB does NOT replace lack of technique

It is important to note that setting your neutral buoyancy too shallow is in no way a replacement for a lack of freedive technique. If you have a hard time descending from the surface at the beginning of your freedives it is essential to work on your duck dive technique. Taking too much weight on your belt is irresponsible and dangerous.

6.3 Free Fall

You are leaving beginner freediving behind

In your AIDA2 Freediver Course you were diving above the point of neutral buoyancy or descending only slightly below it. Going considerably deeper than neutral buoyancy will cause the air in your lungs and the tiny bubbles in the neoprene of your wetsuit to further compress and you will continuously loose more and more buoyancy. This shifts the balance between the down-force of your weight and the upward directed force of buoyancy towards the downward force:

Your weight > Buoyant force

Gradually, you become negatively buoyant and you feel like being "pulled" effortlessly to depth - you start to "free fall".

On descent past (deeper than) NB

On your descent you build up some speed by finning or pulling yourself down along the line. As you get close to your depth of neutral buoyance you will notice that you are able to maintain that same speed with decreasing effort. A few more kicks (or pulls) get you almost effortlessly past neutral buoyancy and soon you will be able to keep the same speed without any further propulsion. Your free fall has begun and will take you to your target depth.

Streamlining & relaxation

Freefalling is a static breath hold plus streamlining and equalisation. You want to maintain a maximal streamlined vertical body posture with your head in line with your body axis. This can be achieved with a minimal physical effort while the focus stays on complete relaxation. A free fall sometimes seems to be very slow and the rope in front of your eyes just does not seem to move. Freefalling needs patience and confidence. It is a good moment to resume your relaxation exercise and keep focusing on a good equalisation technique.

Keep your head in body axis during free fall. If you look down, your tilted head not only creates a lot of water resistance, but also changes your body posture into a "banana shape". This will gradually lead your body away from the perfectly vertical dive line and turn it into a horizontal position. Eventually you will end up in a parachute-jump-position with your belly pointing down. Just as a parachute jumper slows down his fall through air by assuming this position, it will also slow down or even stop your free fall in water.

Workshop: FREE FALL STEERING

by J. Sunnex and W. Trubridge

There are two planes in which the body can deviate from a perfect vertical free fall during the descent: the sagittal plane and the frontal or 'coronal' plane.

1. Sagittal Deviations

The sagittal plane separates the left and right sides of your body. So a deviation on this plane means you are either 'tipping forward,' into the line or 'leaning back' away from the line. Sagittal deviations can be caused by having too much weight on the front or back of the body, or by not keeping the legs straight and relaxed. Remember that the top half of the body is generally more buoyant than the bottom, so when we are upside down this presents problems in the free fall. It would be like having an arrow with weighted feathers. Hence, having the weight positioned as close as possible to the head, e.g. around the neck, is benefiting the free fall.

Since the head leads the free fall, tipping forwards will mean you will eventually start to brush against the descent line itself, while leaning back will mean you will become distanced from it, and your lanyard will become taut and exert drag on the line.

In both cases moving the head and neck forwards or backwards respectively can correct the position. Note that the head should not be hyperextended in these corrections. The gaze remains on the rope in front of you while the head and the neck only move slightly..

2. Frontal Deviations

The frontal / coronal plane separates the front and back of your body. So a deviation on this plane will mean that you are falling a little more to one side or the other. This is most commonly caused by an imbalance of weighting, for example if there is a heavier weight on one side of your weight belt. Alternatively it can be caused by one side of the body being in greater tension, for example if you are letting the rope pass through the fingers of one hand in the free fall. If you notice that you are regularly falling more to one side then try and isolate the cause of this and correct that imbalance rather than accommodate it with corrections to trajectory. The way to correct any deviations is explained below.

It is easy to notice when you are falling more to the left or right side, as the rope will start to move into the left or right field of vision. It is important to correct

these deviations before they become significant, otherwise you will have to break streamline in order to correct the free fall or try and find the rope again.
When free falling in CNF (constant weight no fins) and FIM (free immersion), the feet can be used to correct frontal deviations, in a similar way to the tail rudder of an airplane. Externally rotating one foot slightly will create a little more drag on that side which will mean that side of the body will travel more slowly and the body will turn in that direction. So to move towards your right you would externally rotate the right foot just a little bit.
When freefalling in CWT (constant weight with fins), frontal deviations are less common, as the bi-fins or monofin act the same way that feathers work on an arrow - keeping the body in line. With bi-fins, corrections can be made in a similar way to FIM and CNF, by creating a small amount of drag on one side of the body. When diving with the monofin, increasing the length of one leg (straightening it out a little bit more) will cause a movement towards the opposite side.

Ascend against negative buoyancy

Upon arriving at your target depth you reach for the rope, make your forward tumble turn and pull on the rope to start your ascent. You will notice that you have to put quite some effort in your fin kicks (or arm pulls) to gain speed, as you have to swim up against negative buoyancy. Focus on your perfect fin kick or, if you are on free immersion, on steady arm-pulls, and of course keep streamlining your body.
As you ascend close to your depth of neutral buoyancy you will notice the inverse effect of the descent: You can maintain the same speed with decreasing effort. As you pass the point of neutral buoyancy it only takes a few more fin kicks (or arm pulls) until the air in your lungs has expanded enough to give you the buoyancy to be lifted effortlessly. You can thus stop moving and simply float up back to the surface.

Safe Oxygen

Investing only as much effort as needed to maintain a certain speed is the key to deep freediving. At the start of the dive you have to swim against buoyancy, then you can continuously decrease your effort until you enter free fall. Going from “full throttle” to free-fall is not an abrupt change, but a smooth and gradual transition.

Once in free fall, you will save a great deal of energy and thus Oxygen.

This can be shown in an example: A CWT dive to -30m might seem equal to a horizontal swimming distance of 60m. But let us have a look at the dive, assuming neutral buoyancy is set to -10m:

- Descent 0-10m strong kicks
- Descent 10-20m gradually relaxed kicks
- Descent 20-30m free fall
- Ascent 30-20m strong kicks
- Ascent 20-5m gradually relaxed kicks
- Ascent 5-0m ascent by buoyancy
  (meters are approximately)

In this example, the effective distance along which you are kicking hard is no more than 20 meters, another 25m is gradually more relaxed and a total of 15m is actually effortless. This represents the dynamic of a well-executed freedive.

Self awareness: Stop descent immediately in case of discomfort

As always in freediving it is important that you dive guided by your self-awareness and not "by the numbers". Stop your descent immediately if you feel any discomfort during your free fall. Grab the line, relax and start your ascent in a controlled way.

How to train free fall

When training free fall you are targeting two goals: Firstly, finding the ideal starting point of the free fall and secondly, cultivate perfect streamlining.
Chapter 6.2 explained how to find neutral buoyancy. The point from which on you can start freefalling is deeper than that. You need to find this depth on your own. In the following an example for CWT, but it can be applied in FIM as well:

1. Count your kicks until you reach neutral buoyancy
2. Keep finning for another four kicks (count one leg only to avoid confusion, e.g. "right"..."right"..."right"..."right"..."stop")
3. Stop kicking, keep streamlining and start freefalling
4. Check your speed

The descending speed should stay more or less the same in free fall as it was while kicking. If the speed drops considerably, you stopped kicking too early (too shallow). During your next dive, add two kicks and check again.
Finding the balance between strong kicking and free falling will need some sensitivity and experimenting regarding how much power you invest in your fin kick. It is usually not only a matter of kicking or not kicking, but reducing the strength of the kicks gradually. By repetition you will start to feel your speed quite precisely and will learn how much energy you need to invest to keep the speed constant.

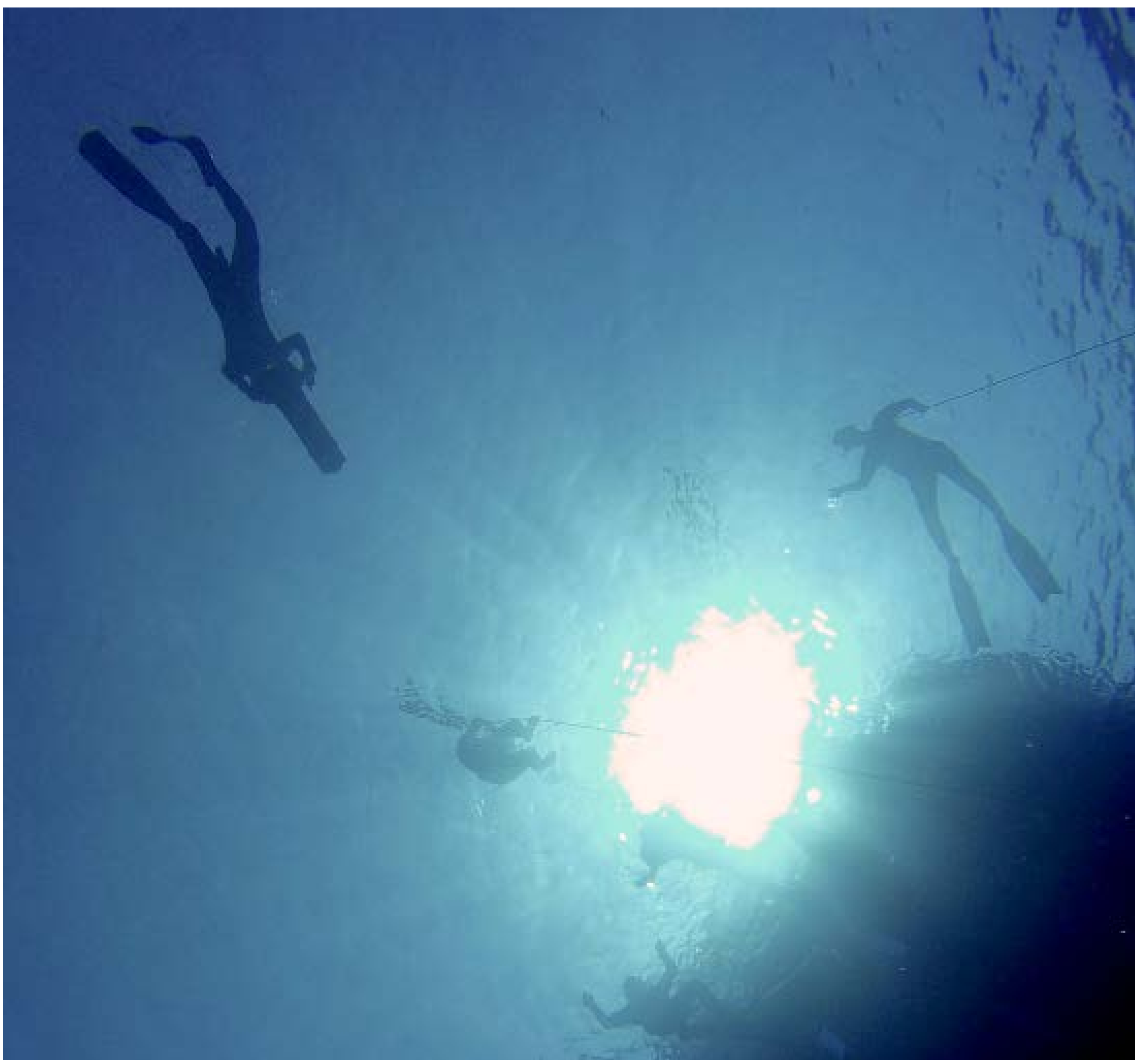
Once you are in free fall, streamlining is the key to a successful dive. A streamlined body is a balance between a relaxed yet straight posture to keep you in a vertical position. Streamlining does not mean that you have to be stiff and overly tense in your body; you would lose too much energy and gain not much speed by doing so. Simply stay relaxed, keep your head straight in body axis with your eyes closed or fixed on the rope. This allows your body to stay in a straight position and thus, you will fall in a vertical line.

Chapter 06 Knowledge Review

Being "too heavy" is obviously dangerous but being "too light" does not always means to be safe in freediving. Please comment.

Explain and comment on this: "Setting your neutral buoyancy shallower does not replace good technique."

If you fall off-balance during freefall, what are your main means to correct that?



CHAPTER 07

HYPOXIA AND BLACK OUT

Black outs are the single greatest reason why freediving sometimes has a bad name in public opinion. However, as a well-educated freediver that you become by training with AIDA you should never even come close to a hypoxic state causing a black out. Suffering from symptoms of low Oxygen as in a "samba" (or LMC, see AIDA2) or even a black out (BO) is considered as a lack of skill and knowledge and has no place in recreational freediving.

7.1 Hypoxia

Definition

This is the common medical definition: "Hypoxia is an inadequate supply of Oxygen in the body as a consequence of a low partial pressure (see chapter 7.3) of Oxygen in arterial blood".

In freediving we more commonly refer to the saturation of blood with Oxygen, or in short the "oxygenation". The saturation in a healthy person while breathing normally is at 96-99%. If the saturation drops below 86%, it is considered severe hypoxia. However, the reading has to drop to 45-50% until the person will show extreme symptoms of hypoxia such as unconsciousness.

Cerebral hypoxia

Hypoxia due to a decrease of Oxygen supply to the brain or parts of the brain, despite adequate blood flow to the rest of the body, is called cerebral hypoxia. It means there is enough blood flow to the brain, but the saturation of the blood with Oxygen is decreased.

Consequences of cerebral hypoxia

If there is a continuous shortage in the delivery of Oxygen to the brain it will have radical consequences like unconsciousness (BO, see AIDA2), brain damage, and death. As explained in AIDA2, the consequences of hypoxia depend on the doses: Brain damage might already occur when you expose yourself repeatedly and extensively to states of "mild hypoxia" while still being conscious.

> It is important to note against some belief that there is no benefit in blacking out as a training method. The brain will not adapt to work under low Oxygen circumstances by repeatedly inducing black outs.

Mild hypoxia: Loss of motor control (LMC)

First symptoms of cerebral hypoxia are a reduction in short term memory, cognitive disturbances and decreased motor skills. This is what well call in freediving loss of motor control (LMC, see AIDA2), which happens only at the surface, after a dive.

7.2 Ischemia

Definition

Ischemia is a shortage of blood supply to an organ, caused by constriction or blockage.

Oxygenation ok, but blood flow is not

The oxygenation of the blood can be perfectly fine, but the blood flow itself is locally constricted which leads to and undersupply of blood in certain body parts. This body part, or organ then suffers from the consequences of an ischemia.

Cerebral Ischemia

Reduced blood flow to the brain is called cerebral ischemia. For the brain it does not make a difference if there is not enough Oxygen (hypoxia) in the blood or a shortage of blood delivered to it (ischemia). In both cases, repeated or extended exposure to such conditions will have severe consequences. It is thus important to know the difference between the two causes, so it can be avoided or dealt with.

Causes for cerebral ischemia

An insufficient supply of blood to the brain can be caused by low blood pressure, which can be a known effect when people stand up (too) fast. Another reason is an outside compression of a blood vessel, as it may occur when wearing a hood that is too tight (”hood squeeze”, see also Chapter 4.5). Sometimes an ischemia can be caused by an air pocket trapped under the suit. The air pocket gets compressed upon descent, which can in turn compress a blood vessel in contact with it. This affects the blood flow through that blood vessel. This mostly affects freedivers in equipped cold water diving with dry suits, but it is also possible to trap some air in an unlucky place when a custom made freedive suit is put on somewhat carelessly and large bubbles of air get trapped between the skin and the suit.

7.3 Daltons Law

Definition

“The total pressure exerted by a mixture of gases is equal to the sum of the partial pressure of each of the different gases making up the mixture – each gas acting as if it alone were present and occupied the total volume.”
On the surface we breathe a mix of approximately 79% Nitrogen 21% Oxygen, equal to a partial pressure of Nitrogen of 0.79 bar and Oxygen of 0.21 bar. Safe limits for the partial pressure of Oxygen for us humans range from 0.16 bar through to 1.6 bar. But as always, the poison lies in the doses. Our reaction to extreme partial pressures of Oxygen depends greatly on the duration for which we are exposed to them.

7.4 Shallow Water Blackout

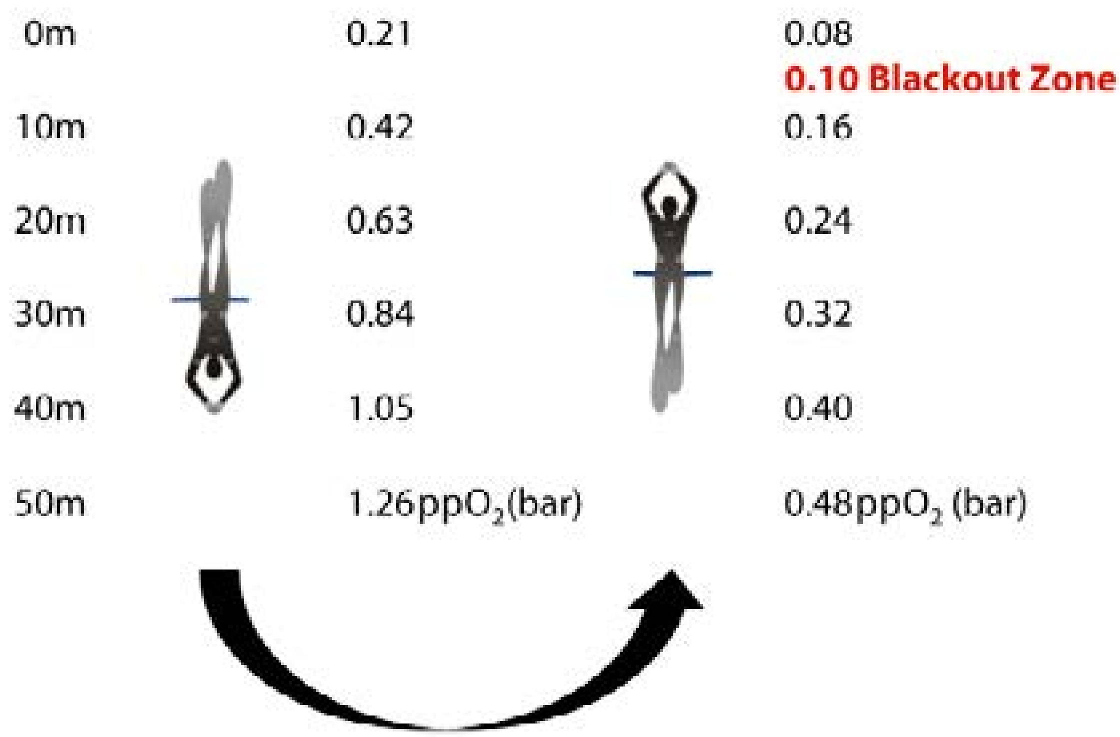


Figure 11: Schematics of a Shallow Water Blackout

Pressure related hypoxia on ascent

In short, a shallow water blackout is pressure related hypoxia on ascent. There is a bit of confusion about the term shallow water blackout. Some organisations and individuals use it to describe any black out that happens in shallow water, such as in a swimming pool or a bathtub. In freediving, we use the term shallow water blackout in a different and exactly defined way:

1. Loss of consciousness caused by hypoxia towards the end of a freedive
2. The hypoxia is caused or heightened by the changing water pressure when freediving down and up in water

This is how a shallow water black out develops (see Figure 11): On descent the lungs are compressed due to the increase in the surrounding water pressure. This causes a steep gradient in the partial pressure of O_2 between the lungs, blood and tissues, which makes O_2 distribution to the tissues very efficient (see principle of diffusion in chapter 2.2).

Ascent reduces diffusion gradient

After you have reached your target depth and start the ascent, the environmental pressure will decrease and the gradient in partial pressure of O_2 between the lungs, blood and tissue becomes less steep. It is suspected that in extreme cases the gradient even reverses. In the last meters of the ascent tissues will be "robbed" of O_2 in order to compensate for the low partial pressure of O_2 in the lungs.

Unconsciousness at an average of 0.1bar ppO_2

Most people will fall unconscious when the partial pressure of Oxygen (ppO_2) in their alveolar blood falls below 0.1 bar. Ten meters of water effectively doubles the partial pressure of Oxygen to 0.2 bar putting the diver above the blackout threshold until he or she reaches the 0.1 bar limit on ascent. This will lead to a shallow water blackout. A ppO_2 of 0.18 at ten meters makes a blackout between four meters and the surface inevitable.

The closer to the surface, the greater the relative drop in pressure

The danger for a shallow water blackout is greatest in the last few meters of the ascent, where the relative change in pressure is the quickest. From -30m (4bar) to -20m (3bar) the pressure drops only by one quarter, while between -10m (2bar) and 0m (1bar) it decreases by 50%.

Role of safety divers

This explains why the last 10m of your ascent are the most critical part of a freedive and illuminates the importance of safety divers. Most troubles and incidences, if any, occur close to the surface. Hence it is standard procedure in AIDA to have a safety diver meeting you at a depth of at least -10m. For deeper dives it is recommended that the safety diver meets you deeper in order to accompany you during the ascent for approximately the last third of your dive.

7.5 Surface Intervals in Freediving

Until recently it was thought that decompression sickness (DCS) occurred only to divers that breathe compressed air, such as in scuba or technical diving. These divers breathe in a great amount of Nitrogen (N_2) under pressure. When a scuba diver ascends too quickly, the N_2 dissolved in the tissues will "come out of solution"

in the blood forming bubbles. These bubbles can block blood flow to certain tissues, creating damage known as decompression sickness.
The evolvement of freediving over the years has now evidence that that DCS can also affect freedivers. As Freediving still is a very young scientific field, the body of knowledge about it is growing quickly. However, it is not exactly clarified yet how much Nitrogen a freediver accumulates at what depth in what time. Observations of the last 20+ years suggest that these two factors may vary considerably from one person to the next depending on different variables. The same is true for different people's susceptibility to develop symptoms of decompression sickness (DCS) while or after freediving.

Signs and Symptoms of DCS

Below you can find a list of symptoms that may indicate DCS:

- Prolonged fatigue
- Pain in arms, legs or torso
- Dizziness or vertigo
- Shortness of breath or painful breathing
- Local numbness, tingling or paralysis

As a freedive buddy you can observe the following signs in the diver, potentially indicating DCS:

- Blotchy skin rash
- Rubbing joints
- Staggering
- Coughing spasms
- Collapse
- Unconsciousness

If you experience any or several of these symptoms or signs, immediately stop freediving and seek medical assistance. If available, breathe pure Oxygen until you reach the next medical facility.

Rules of Thumb

In your AIDA3 Course you are allowed to dive as deep as -30m. To calculate a safe surface interval for these depths you can use a simple rule of thumb:

- surface time = 2 * dive time

Here an example:

- Dive time 30 sec: 1 min surface interval
- Dive time 2min: 4 min surface interval
- etc.

For dives deeper than -30m, two different rules apply. These rules are discussed in detail in your AIDA4 Course:

- Freediving to 30-55m: Surface time = depth(m)/5
- Freediving deeper than 55m: One dive in 24h

These rules of thumb are there to provide a great safety margin, which possibly keeps all freedivers safe from developing symptoms of DCS. However, the amount of Nitrogen you gradually build up is also related to the number of dives you perform, your fitness, your health, and many other factors. Always stay vigilant and react immediately in case you notice anything unusual.

Chapter 07 Knowledge Review

Why is there no benefit in blacking out?

Give examples how a cerebral ischemia can occur?

What is the meaning of the term shallow water blackout in freediving?

Decompression sickness occurs only to divers that breathe compressed air, such as in scuba. True or false? Comment!

CHAPTER 08

TRAINING CONCEPTS

On paper, the following three training concepts, or “tables”, look similar, yet, all of them have quite distinct objects:

1. Warm-up tables: Designing a freedive session (pool or open water) with the goal of a single maximum performance dive.
2. CO_2 tolerance tables: Designing a training session with the goal of improving your tolerance to CO_2.
3. O_2 training tables: A concept of extreme freediving to improve your functioning with low Oxygen levels.

During your AIDA3 Course you learn how to apply the first two concepts and adapt them to your personal needs. As these needs vary according to the training level and individual characteristics of every freediver, it is hardly possible to simply copy a table from another person. You need to develop your very own training table. Through the application of these concepts you will improve your performance rather quickly and will need to adjust your tables continuously to keep them challenging in order to maintain an optimal training effect.

8.1 Warm-up to Max Performance

Figure 12: Freediver Performing a "Hang"

Allow time for the body to go into "freedive mode"

Before a personal maximum performance you need to put your body and mind in "freedive mode". You reach this state by allowing for some time to relax your muscles, allowing the heart rate to settle, allowing the breath to ease and so on. How much of a warm-up a freediver needs depends on quite a few variables, such as experience, physical activity before the session, stress-level, and more.

In open water, warm-ups usually include a few slow, shallow and rather short dives, in the pool they consist mostly of a series of short breath holds. During the warm-ups the freediver remains absolutely focused on relaxation and the upcoming dive, while ignoring as much as possible what is going on around him or her.

Physical and mental relaxation

The main purpose of warm-ups is to relax. Relaxation of the mind and the body are connected in a self-enforcing, positive cycle. The more you allow to calm your mind, the more your body will be at rest which will in turn allow again to relax your mind. As extensively discussed in AIDA2 it is good advice to focus on physical stillness by applying a relaxation practice. The act of focusing on your relaxation technique itself will calm your mind and keep it from wandering.

During warm-up dives, your awareness stays on the here and now. In the last relaxation phase before the maximum attempt, visualizing every phase of a dive prepares you mentally for the upcoming performance (see chapter below).

Induce mammalian dive response

Apart from the mental preparation, the series of physical adaptions induced by a your warm-up dives (also called warm-up table) can be summed up under the term mammalian dive response. This central concept of freediving is discussed in chapter 9.

Visualization and "no warm-up dives"

Some freedivers take advantage of mental training to perform a warm-up. For the mind and the body it does not make a major difference if you are actually performing a dive in reality, or if you are just visualizing it – the physical and mental reactions are quite similar. There are experienced freedivers who take this concept successfully to the extreme and perform so-called "no warm-up" maximum attempts. Freedivers who engage in this practice conduct their warm-up by applying a series of relaxation techniques and visualized dives on land, boat or water surface. The maximum attempt itself is actually the first real dive of the day.

Visualization is not only a valid and powerful concept to warm-up but for freediving in general. You can successfully train the sequence of whole dives by performing them in your mind only. Imagine yourself doing the dive, go through it in great detail and step by step: See yourself doing the three steps of the duck dive as you have learned in AIDA2, then feel how your body settles into a compact and hydrodynamic diving position with a straight head, how you manage your first equalisation with ease, how your perfect fin-kick sets in.. and so on. You finish the visualized dive by with three (or more) recovery breaths and signalling an ok sign to your buddy.

Visualizing your dives has an amazing effect on the quality of your real dives: You can literally program your mind by repeated visualization and then simply "press play" when your real dive starts.

"Save the legs"-approach

Warm-up dives are always done in free immersion (FIM)

One of the limiting factors in constant weight freediving is the tolerance of the active muscles, mainly the legs, to lactic acid towards the end of a dive. After reaching the maximum tolerance level of lactic acid your muscles might simply stop working which indicates a phenomenon called "heavy legs". It is thus important to perform the warm-up dives with the least possible physical effort to avoid an unnecessary build up of lactic acid. Free immersion (FIM) technique is thus the best choice for your warm-up as you are pulling yourself down and up the line in a slow and relaxed way, while keeping the body as relaxed as possible. By doing so you can allow yourself ample time under water, while creating only a minimal amount of lactic acid.

Examples of warm-up tables

Figure 13 displays a classic example for a warm-up table to a maximum performance in STA (static apnea). Using the "first contraction" as a timer allows you to measure your dives quite precisely. Like this you will avoid accidentally pushing yourself too far already during the warm-up dives. Note that when you are for example a bit nervous and thus not yet fully relaxed, you will also reach your contraction a bit earlier.
Instead of measuring time for your warm-up session, it is possible to use the appearance of the

Relaxation	Breath Hold
3 min	first contraction
3 min	first contraction
3 min	first contraction
6 min	Maximum Performance

Figure 13: Example for a warm-up table in static apnea (STA)

"first contraction". Taking time as a guide for warming up may not suit your body's needs of that specific day. For example, one day a three-minute breath hold might be easy for you, while on other days you would push your limits with that performance already. Instead, allow yourself to feel the contractions caused every time by roughly the same level of Carbon Dioxide in your blood. Depending on your physical and emotional condition on a given day you will reach this level quite fast, while on others, more relaxed days you will spend much more time on breath hold until you experience your first contraction.

After preparing and writing down your warm-up table you can hand it over to and discuss it with your buddy. It will be then his/her job to talk you through your whole warm-up sequence. This includes giving you a time announcement to the end of your breath hold (e.g. in static) and reminding you of the nature of the next breath hold.

> Example: "Up next is your third warm-up, during which you will go to first contraction and then you go on holding your breath while I count down one minute for you. You have two and a half more minutes to relax, enjoy your time. My next announcement will be at the 2-min mark."

With experience you will find what works best for you as a warm-up sequence. Some freedivers like to do three warm-ups as demonstrated in the example above, while

Buddy team in static apnea (STA)

others prefer to start their maximum attempt without a single warm-up dive. It is up to you to design your personal warm-up table and there is certainly no "one best way".

The warm-up as shown in Figure 15 is a quite popular table in competitive DYN-freediving. Most of the relaxation happens outside the pool before the table even

Relaxation	Dry STA or DYN
3 min	Dry STA to first contraction
3 min	Dry STA to first contraction + 20 Sec
3 min	DYN 25m
5 min	Maximum Performance

Figure 14: Warm-up table for DYN

Relaxation	STA or DYN
3 min	STA 1min followed by 25m DYN No breathing in between
5 min	Maximum Performance

Figure 15: Warm-up table including STA-DYN

starts. Once the athlete gets into water it will only take him or her 10 more minutes until the maximum performance is attempted. Shortening the time in water allows the freediver to use the thinnest possible wetsuit (if any at all) without getting cold.

In static-dynamic, the freediver will do a static breath hold of a given time (count-down given by the coach or buddy), then without any break or breath, start a DYN-dive of an easy distance. After this performance it is important to allow ample time to recover before the maximum attempt starts.

Like in dynamic apnea it is important to save the energy in your legs for an upcoming maximum attempt in diving to depth with fins (CWT). All warm-up dives are thus done

Relaxation	Pull Downs (FIM)
3 min	Slow FIM to -10m, (or neutral buoyancy), then pull up slowly
3 min	Slow FIM to neutral buoyancy depth, hang 30 Sec, pull up slowly
3 min	Slow FIM to neutral buoyancy depth, hang to first contraction, pull up slowly
5 min	Maximum Performance

Figure 16: Warm-up Table to Maximum Constant Weight Performance

by pulling down and up on the dive line. There is no physical movement involved apart from the pulling action, the rest of the body of the freediver remains in perfect relaxation.

For the warm-up table in Figure 16 the freediver needs to bring a watch for the second warm-up, which might not be ideal. Similarly to warm-ups to STA, it is a good idea to use the first contraction to gauge the length of the "hang" at depth. From that point onwards the freediver can simply add a countdown in his/her head. Counting in your head is good enough, as a warm-up table generally does not need to be super precise, but it should be super relaxed.

Keep in mind that you need to adjust this table to your personal needs, preferences and training goals. As in training tables (see following chapter), warm-up tables are a very an individual process which becomes something like a routine or, for some, even a ritual by repeating it over and over again. But do not get too attached to your routine. You can still perform a perfect maximum attempt, even though you may have been interrupted or distracted during your warm-up. The power for relaxation is within you, not within your warm-up table.

8.2 CO_2 Training Tables

Training tables are a systematic and very effective way to train your breath-hold

Freedive competitions are the ultimate test for "maximum attempts" capacity. Each table is a series of breath-holds designed to increase either your tolerance to high CO_2 or your tolerance to low O_2. Each table focuses on one of these two objectives and you should not "mix" O_2 with CO_2 training.

Tolerance to CO_2

A CO_2-table is constructed in way so that the CO_2 level in your body increases with each breath-hold. The purpose of these tables is to train and increase the tolerance to CO_2 both physically and mentally.

Static or dynamic

CO_2-tables can be done in absolute relaxation (static) or while being physically active (dynamic). When you do a dynamic CO_2-table you will also train your tolerance to lactic acid in your muscles (See also AIDA4 for training program design).

Wet or dry

You can conduct your CO_2 tolerance training in the dry, for example while relaxing on your bed (static) or while walking through a park (dynamic). Of course both can also be done in the pool or confined water, but as soon as you train with breath-holds in water you will always need to have a qualified buddy in your proximity to watch over you during the training. Remember: Training next to each other is not good enough as a safety procedure. You are safe if one buddy is diving while the other is watching. Then switch roles.

No hypoxic condition

A well-designed training table is tough due to the high CO_2 levels it creates in your body. The table allows you enough time between breath-holds to re-establish a good level of O_2 in your body, but not enough time to fully offload excess CO_2. This means, while your CO_2 level will rise during the table and make it challenging, you will not put your body in a hypoxic state at any time.

Design Principle 1: Breath hold time is constant

Every freediver has an individual level of breath-hold time and CO_2 tolerance, which means that training tables become most effective only if you specifically design them for your personal use. The first of a few basic design-principles is this: The breathing time varies, while the breath-hold time stays constant. In a classic CO_2 table (as in Figure 17), the breath-hold time is given, while the breathing time is gradually reduced with every round.

Design Principle 2: Approx. 50% of your maxSTA

To design your first CO_2-table according to this principle you will need to measure

Breathing	Hold
2 min	2 min
1 min 45 sec	2 min
1 min 30 sec	2 min
1 min 15 sec	2 min
1 min	2 min
45 sec	2 min
30 sec	2 min
15 sec	2 min

Figure 17: Example of a STA CO_2 tolerance training table, based on time

your current maximum static breath hold time (maxSTA) first. You may make use of a warm-up table (see previous chapter) to do so. Once you have established your maxSTA, take 50% of maxSTA as a starting point to design your CO_2 table.

> Example: If your maxSTA is 3min 20 sec, use 1 min 40 sec breath hold times to design your first CO_2-table.

Design Principle 3: Eight STA or 20 DYN breath-holds

A classic static CO_2-table usually consists of eight relaxed breath-holds. In a dynamic table however you are physically active, which means you produce more CO_2. Due to that reason, the breath-hold times in a dynamic table are significantly shorter than in a static table. It is thus recommended to design the table to 20 rounds, or 20 breath-holds.

In the CO_2-table as shown in Figure 18 you will repeat every line four times, before moving on to the next line. As the table has 5 lines, you will end up with 20 breath-holds.

Breath	Distance	Repetitions
1 min 15 sec	25 m	4
1 min	25 m	4
45 sec	25 m	4
30 sec	25 m	4
15 sec	25 m	4

Figure 18: Example of a Dynamic CO_2 Table, Based on Time

Time-based tables

If you do a STA-table while relaxing on your bed you can easily time yourself with a stopwatch. There are also a great variety of apps available online with which you can program your personal table or even have your table calculated automatically. The app will then “talk” you through your table just like a buddy would do. Remember that any breath-holds alone have to be performed outside of water.

If you choose to train in water you will have to have a buddy to watch over you at all times. Your buddy can also talk you through your CO_2-table, taking over the role of watching time and repetitions.

Count based tables (breaths, steps, etc.)

All tables discussed so far are based on time (seconds and minutes). However, there is another very effective way to design your tables in which you count your breaths instead of measuring time. So for example, instead of breathing for 30 seconds you breathe for five breaths. This method allows you to control your table even more precisely as five full breaths (vital capacity (VC), see chapter 5.1) is a well-defined volume of air and easy to repeat.

In a time-based table it is sometimes hard to scale how much you are actually breathing. 20 seconds of relaxed abdominal breathing (tidal volume (TV)) is very different from 20 seconds of using your whole vital capacity (VC). Counting breaths is thus a more precise way of designing your CO_2 tables (see Figure 19).

A dynamic table can be performed without the use of any time measurement at all. For example in a "walking apnea" table you can breathe for 10 steps, then hold your breath for 30 steps. This is a good training pattern of a dry dynamic CO_2 table that does not require for checking time (see Figure 20).

Relaxation	Hold
8 Breaths	2 min
7 Breaths	2 min
6 Breaths	2 min
5 Breaths	2 min
4 Breaths	2 min
3 Breaths	2 min
2 Breaths	2 min
1 Breath	2 min

Figure 19: Example of a Static CO_2 Training Table, Based on Breath Counts

Another classic example for a dynamic table in the pool could look like this: 5 breaths, then dive (DYN) 25m distance, 5 breaths, then dive 25m distance, 4 breaths…etc.

8.3 O_2 Training Tables

CO_2 tolerance training as described in the preceding chapter can lead to remarkable

Jogging while Breathing	Jogging on Breath Hold	Repetitions
30 steps	50 steps	4
25 steps	50 steps	4
20 steps	50 steps	4
15 steps	50 steps	4
10 steps	50 steps	4

Figure 20: Example of a Dynamic CO_2 training table, based on step-counts

results. But no matter how highly trained your tolerance of CO_2 is, you will still notice the rising level of Carbon Dioxide in your blood. The point of training these tables is to become able to deal with and even benefit from positive effects associated with rising CO_2, such as the onset of the mammalian dive response (see chapter 9).

By being highly tolerant to Carbon Dioxide it is possible to prolong a breath hold to such and extend that you might get hypoxic towards the end of the dive. Body and mind can be trained to a certain extent to still function normally under these extreme conditions by so-called hypoxic or low-O_2-tolerance training. But this form of training is not a part of recreational, but extreme freediving. In recreational freediving you will never expose yourself to a situation where you display symptoms of low Oxygen. There is absolutely no gain in exposing yourself to repeated hypoxic states, loss of motor control or even black out.

Buddy escorting a freediver that comes up from a maximum attempt

Chapter 08 Knowledge Review

What is the “save the legs”-approach?

What is the rationale of a CO_2 table?

CHAPTER 09

THE MAMMALIAN DIVE RESPONSE (MDR)

For a very long time, up until recently doctors would claim that it is impossible for humans to dive beyond relatively moderate depth on a breath hold, as the rising environmental pressure would compress the lungs of the freediver to such an extent that damage is inevitable. But soon freedivers would dive deeper and not only survive their dives but also resurface perfectly healthy. This represented a scientific challenge for the medical world.

In addition, it was not known what makes it possible for professional breath hold divers, such as the Japanese Amas, Greek sponge collectors or spear fishermen to perform repeated breath holds of an astonishing durations while being physically active. Even more astounding was the fact that the same divers could not necessarily repeat these breath hold times on land, even while being completely relaxed and not wasting energy on physical movement.

Some of these mysteries where explained by the discovery of a concept that we call today the mammalian dive response (even though the effect can also be observed in other species). This phenomenon can be observed in all aquatic mammals like whales or dolphins, but exists also in weaker form in land mammals, including humans.

9.1 Definition and Effects

There is an academic controversy regarding the mammalian dive response (MDR), which even begins with its name. The MDR is a combination of several stimuli triggering a series of reactions (also called "adaptions"). It is also often and falsely called "dive reflex". However, a "reflex" is defined as one stimulus (like the heat of a flame) leading to one reaction (like pulling the hand back from a hot plate), which is clearly not the case in MDR.

The hyperbaric science that led to the discovery of the mammalian dive response is a rapidly growing field, and updates to the topic are published in close succession. This chapter gives an overview of the current knowledge in regard to freediving.

Series of adaptions

The mammalian dive response is a series of reactions or adaptions:

- Peripheral vasoconstriction
- Bradycardia
- Spleen effect
- Blood shift / Haemo compensation
- Hypo metabolism

Series of triggers

One or several of following conditions, or triggers, cause the adaptions:

- Apnea (rising CO_2)
- Immersion in water
- Rising pressure (lung volume below residual volume (RV))
- Low temperature

Triggers and adaptions have to be understood as an interactive and complex system with many possible pathways. For example, high Carbon Dioxide (hypercapnia) causes peripheral vasoconstriction, which induces surplus of fluids in the torso (central hypertension). The nervous system responds to this with Bradycardia (lowering of the heart rate) to normalise the total output of blood volume from the heart to the circulatory system (cardiac output). There are other pathways that flow through and simultaneously with this and all together create the MDR.

Conserve Oxygen

One of the main effects of the MDR is that it helps us to conserve Oxygen throughout a dive. This beneficial effect is supporting a breath hold by decreasing the heart rate (Bradycardia, see above) and slowing down metabolism in general which is reducing the Oxygen consumption of the body.

Use Oxygen more efficiently

Secondly, the MDR is allowing our bodies to use the Oxygen in our body more efficiently throughout a breath hold. The blood flow to non-vital muscles and organs is reduced. These non-vital muscles that do not get a sufficient blood supply can still work for an extended time in anaerobic mode. This state is achieved when the demanded workload from a muscle is higher than the supply of Oxygen to it. The muscle will continue working until its energy storage is depleted.

Prevention from lung barotrauma

Thirdly, and potentially most importantly the MDR supports the protection of the lungs at depth. One of the most important parts of the MDR is the blood shift (see below). Without the blood shift it would not be possible for mammals and thus for us humans to dive deeper than roughly 25-35 meters without injury.

9.2 Peripheral Vasoconstriction

Constriction of blood vessels in extremities

“Vaso” means (blood-) vessel, and vasoconstriction is the narrowing of blood vessels. It is the opposite of vasodilation, the widening of blood vessels. Peripheral means the vasoconstriction is occurring in the extremities of the body, mainly the legs and arms, including feet and hands.

Less Oxygen available in extremities

The constriction of the blood vessels reduces the blood flow to the extremities, and thus less Oxygen is transported to the muscles in these areas. The affected muscles will still work for a certain time, but will deplete their energy reserves in an anaerobic process (AIDA4 elaborates on this topic in detail).

More Oxygen available for brain and vital organs

Saving the Oxygen on peripheral muscle action means that there is more blood available in the torso, where it is needed for the brain and the vital organs to function normally for an extended time without breathing.

Lactic acid build up

The blood circulation does not only deliver Oxygen to muscles, it also the means of transport for any waste products away from the muscles, such as CO_2 or lactic acid. Reduced blood flow due to peripheral vasoconstriction is also inhibiting this cleansing process and leads to the build up of lactic acid in the muscles of the legs and arms.
This explains why your legs might start to feel quite “heavy” in an extended dive, or especially during a CO_2 table. While the surface intervals of your table are long enough to replenish your Oxygen level, the breaks are not long enough to dispose of all excess lactic acid in your leg muscles before starting the next breath hold performance.

Tolerance training

Tolerance training to lactic acid is an integral part of CO_2 tables. But every non-freediving athlete knows many other forms to work on that tolerance, as it can also be trained with conventional interval training.

Surface Intervals

The slow disposal of lactic acid due to peripheral vasoconstriction makes it important to allow an extended surface interval before a challenging breath hold dive. Warm-up tables as discussed in chapter 8.1 suggest a minimum of four minutes before attempting the maximum performance. For general rules about how to calculate your surface intervals between dives please refer to chapter 7.5.

9.3 Bradycardia

In general, Bradycardia means a slow resting heart rate of below 60 beats per minute (bpm) in adults. Medically speaking it is a type of cardiac arrhythmia, or irregular heart rhythm, but is not considered to be a problem until the heart rate drops below 50bpm under normal conditions. Freediving, in many aspects, cannot be considered as a frame of "normal conditions", and heart rates considerably below that may occur. There are no known negative consequences of heart rates considerably lower than what is medically marked as "abnormal". The heart is a muscle and its reduced activity is a welcome effect under special circumstances such as breath holding in order to extend the conservation of energy.

Slow-down of heart beat

In untrained humans Bradycardia slows the heart rate by ten to 25% per cent, while in trained freedivers a drop of 50% from their normal resting rate can be observed.
There is a correlation between peripheral vasoconstriction and Bradycardia: The stronger the peripheral vasoconstriction, the steeper the drop of the heart rate.

Trigger: Facial immersion

The onset of Bradycardia is already triggered by the immersion of the face into the water alone. Freedivers take advantage of that: Especially in preparation for a maximum performance in a pool discipline they will repeatedly put their face in bowl filled with cold water. This allows them to drop their heart rate already before entering the water.

9.4 Spleen Effect

Spleen: reservoir for red blood cells

While the full volume of blood in our body circulates through the spleen, this organ acts as a reservoir of red blood cells. These red blood cells are stored and held ready in case of an emergency (e.g. an accident with serious bleeding) or any other condition where a better Oxygen transport capacity throughout the body might be needed.

Spleen contraction

Under special circumstances, for example during apnea, extra Oxygen carrying capacity is needed. In this situation the spleen contracts and releases the stored red blood cells into the blood stream.

More Oxygen carriers available

The higher count of available red blood cells enables the body to bind more Oxygen in the blood and thus enhances the breath hold capacity of a freediver.

9.5 Blood Shift / Haemo Compensation

In 1962 Enzo Maiorca was the first freediver to dive deeper than -50m without getting hurt. What he accomplished was previously considered to be harmful for humans, as the rib cage was expected to crush inwards due to the rising water pressure. But it was not before 1974 when a study on Jacques Mayol finally discovered the mechanism that allows mammals, including humans, to dive even considerably deeper than that: The blood shift, or haemo compensation.

Blood in chest area

Due to peripheral vasoconstriction an increased amount of blood is available in the torso to support the vital organs and the brain.

Blood vessels of alveoli increase in size

When a freediver dives below residual volume (RV, see chapter 5.2), the lungs can still be further compressed because of the blood shift. The blood vessels of the alveoli take up more blood and increase in size!

Compensation for volume loss due to pressure

The absorption of blood into the blood vessels of the alveoli enhances their volume (haemo compensation). The alveoli thus can take up the space the air in the alveoli would occupy under surface pressure. Imagine an alveoli as an orange: The fruit flesh is the air volume inside the alveoli, while the peel is the blood vessel around that “air pocket”. When this orange is taken deeper and deeper under water, the volume of the fruit flesh gets smaller and smaller as the air compresses, but the peel swells up to compensate for that loss of volume. The overall size of the orange is thus shrinking far less than the fruit flesh alone: At depth the orange is simply made of less flesh and more peel. (Of course in the real world an orange does not compress in size at depth as it is made up of liquids and solids, but you get the point.)

Preventing negative pressure in the lungs

The above mentioned allows the air in the alveoli to compress to a much smaller volume than expected, without compromising the overall volume of the lungs. The blood shift is thus preventing negative pressure to appear in the lungs.

Supporting prevention from lung barotrauma

The blood shift is helping to prevent the lungs from lung barotrauma. Diving below residual volume is not harmful as such. However, a major cause for lung barotrauma is diving below residual volume, and continuing going deeper, even if there is already negative pressure inside the lungs due to a lack of flexibility of the chest and the diaphragm. The blood shift is delaying the onset of negative pressure in the lungs, and is thus allowing us to dive deeper. It is very important to approach such dives with small and controlled steps and perform repetitive dives to allow ample time for the body to adapt before increasing depth. The blood shift is not a free ticket to push recklessly forward but a physical reaction on a changing environment, which needs a lot of time and training to become more and more effective. Flexibility of the chest area (reducing residual volume RV, see chapter 5.4) to give way to pressure, combined with the blood shift allows safe dives to great depths. But both of these factors need months and years to develop and adapt. So give yourself time, be patient and dive with absolute self-awareness:

> Always be prepared to abort a dive on the first perception of discomfort in your chest. Remember, great freedivers do not suffer from barotrauma, samba or black out.

9.6 Hypo Metabolism

Metabolism is the total of all chemical transformations within the cells of a living organism. This quite abstract definition includes very specific bodily activities like digestion. Many of these chemical activities take up Oxygen to transform nutrition into energy and body heat.

Low metabolic rate

Hypo metabolism describes the state in which all the biochemical processes of the body are slowed down and reach a level below what would be considered a "normal level". This can be noticed by the reaction of your stomach to freediving. As the digestion is getting to a halt during freediving, the body might react and expels food still being in the stomach by throwing up.
Hypo metabolism thus reduces the bodily uptake of Oxygen, making it available for the vital organs and the brain during the breath hold.

Possible side effect: Hypothermia

All biochemical reactions of the body emit heat and thus create body heat. If a freediver remains in a hypo metabolic state over an extended period of time, he or she might feel cold faster. In extreme cases this condition can even result in a lowered body temperature (hypothermia), shivering and thus an inability to relax.

9.7 Inducing the Mammalian Dive Response (MDR)

MDR naturally weak in humans

The mammalian dive response is strongly developed in marine mammals, however, in untrained humans it is rather weakly established. Despite its poor development in humans, a splash of cold water in the face leads to an immediate drop of the heart rate. This is called Bradycardia and is a major part of the mammalian dive response.

Stronger through training

The mammalian dive response can be seen as a mechanism in our body that has not been used much over the years. This is usually the case for most non-freediving people. Starting to freedive can be compared to trying to find the buttons of this forgotten mechanism, blow the dust away and learn how to push them. By repetition, that old rusty mechanism will get back into gear and run more smoothly with every repetition. As almost everything in freediving, it will take some patience and training. Over time the mammalian dive response will become stronger, quicker and more effective.

Warm-up before maximum

Inducing the mammalian dive response is one of the main reasons to do warm-up dives (see chapter 8.1) before a maximum performance.

9.8 Immersion Diuresis

Due to peripheral vasoconstriction

Due to the peripheral vasoconstriction, the amount of blood available in the extremities can be lowered considerably and made available to the central organs such as the heart, the lungs and large internal blood vessels.

Too much fluid in the torso

This leads to a considerable increase of blood volume in the pulmonary circulation, which is interpreted by the body as a fluid overload.

Triggers urine production

The kidneys will then immediately start to produce urine, which is the easiest and fastest way for the body to reduce the perceived excess blood volume: You have to pee.

Danger of dehydration

It is thus important to drink a lot before, while and even more so after freediving. Fluids are released and your body potentially becomes dehydrated.

Chapter 09 Knowledge Review

What is the mammalian dive response (MDR)?

Why is the blood shift vital for deep freediving?

CHAPTER 10

FREEDIVER CODE OF CONDUCT

Mind your surroundings

Mind your long fins

Mind marine life

Do not remove anything from the sea / Do not leave anything in the sea

Mind the dive site

Be a role model

APPENDIX A

KNOWLEDGE REVIEW

2. PHYSIOLOGY

What is the function of blood in the human body?

Answer: Transportation of gasses, nutrients, waste products, hormones and body heat; Protection from inflammation; Regulation of blood acidity (pH), and water balance by transferring water to and from tissues in the body.

What is cyanosis and why should you warn your buddy about it?

Answer: Cyanosis is also called "blue lips". As the skin is thinnest on the lips, a change in blood colour due to decreasing level of Oxygen can be easily spotted. However, blue lips can also indicate that the freediver is hypothermic. In both case, it is important to warn your buddy about it because a freediver cannot feel its own cyanosis.

Define diffusion.

Answer: Diffusion is the natural tendency of a gas to move from an area of high concentration to an area of low concentration.

Define veins, arteries and the particular case of the lungs circulation.

Answer: Veins are blood vessels carrying blood towards the heart. Arteries are blood vessels carrying blood from the heart to the organs. The pulmonary artery is carrying blood low on O_2 from the heart to the lungs, while the pulmonary vein is carrying oxygenated blood from the lungs to the heart.

Hyperventilating does not change the level of Oxygen saturation in the blood, but it decreases its content of CO_2. True or False?

Answer: True.

3. EQUALISATION

There is a difference between the sensation of pressure-change and pain. Please comment.

Answer: Feeling pressure is essential for an efficient equalisation technique while experiencing pain while diving is always an alarm signal upon which you should stop your descent immediately.

Why is it not recommended to flush the sinuses with sea water?

Answer: Seawater is different from "clean salty water solution". It also contains pollutants and microorganisms that can cause infections. Try to avoid ingestion of sea water as much as you can, but it is not a problem if it happens on a small basis.

Regardless of what equalisation technique you are using, what should be the main focus?

Answer: Only use the muscles involved in equalisation and relax all others. Tensing the neck or the jaw are common mistakes that can lead to failure of equalisation.

4. BAROTRAUMA

How do you prevent barotrauma?

Answer: You can prevent barotrauma (also called "squeeze") by eliminating any pressure differences acting on tissues or organs by equalising the changing pressure. If a barotrauma occurs, remember these 4 words: "Stay dry, see doctor".

What are the symptoms of an eardrum perforation?

Answer: sharp pain, vertigo and loss of direction.

How does a middle ear barotrauma occur?

Answer: If you fail to equalise and do not stop your descend, blood and other fluids might be forced into a middle ear, partially or even completely filling it.

Why is a suspected middle ear barotrauma to be taken seriously and always be checked by a doctor?

Answer: The fluid in your middle ear is a great risk of infection, which can lead to a middle ear infection.

Why should you avoid equalising if you are experiencing a reverse block?
Answer: equalisation pushes more air into your sinus, but in a reverse block situation there is already too much air in the sinus and/or middle ear. Ascent as slowly as you can, using the rope as a guideline in case you should suffer from vertigo. The trapped air will eventually release.

What is alternobaric vertigo?
Answer: Alternobaric vertigo (AV) is commonly occurring on ascent when one ear depressurises slower (or incompletely) compared to the other. The difference in middle ear pressure can cause the brain to falsely interpret this as bodily movement. Involuntary eye movement, nausea, vomiting, tinnitus and muffled hearing can be symptoms of AV.

A well fitting hood can be a problem when it comes to hood squeeze. Explain!
Answer: If the hood seals off very well (which a well fitted hood does!), air that might be trapped in the ear canal between the hood and the ear drum will get compressed on descent and might cause injury to the ear drum or the ear canal.

How should you react when experiencing a blocked sinus on descent to avoid a sinus squeeze?
Answer: If you experience a sinus block, stop your descent immediately by holding on to the diving line, relax and equalise again. If the pain does not go away you will have to abort the dive and ascent carefully.

What is the best advice to avoid a sinus block?
Answer: do not dive with a cold or congestion and keep well hydrated.

5. LUNGS AT DEPTH

What is the residual volume?
Answer: The residual volume (RV) is the amount of air remaining in your lungs after a maximum exhalation. In average it is 25% of the total lung capacity (TLC).

What is the most efficient ways of increasing the vital capacity?
Answer: First, practicing proper "one full breath" technique (two-stage inhalation, see AIDA2) will allow you to fill your lungs completely. Second, practice diaphragm stretching will reduce the residual volume and thus increase vital capacity.

What is the failure depth?
Answer: Failure depth is the depth where residual volume (RV) is reached and normal equalisation will not work anymore.

There are several symptoms that indicate a lung injury upon surfacing after a dive. Name at least two of them.
Answer: You might feel tightness in the chest that does not go away. Your airways might be obstructed somewhat, which creates a wheezing sound while breathing. Even after a few breaths back on surface you have a persisting feeling of difficulty to catch your breath. You might have the urge to cough to clear your airways, and if you do so, you are coughing up a pink, foamy liquid. Last but not least you feel a fatigue that does not go away.

Give four or more good advices that help to avoid lung squeeze!
Answer: Dive with self awareness, dive relaxed or do not dive, do not dive if you are shivering, stretch your intercostal muscles and diaphragm, apply correct forward tumble turns at depth, adapt slowly to depth.

6. BUOYANCY

Being "too heavy" is obviously dangerous but being "too light" does not always means to be safe in freediving. Please comment.
Answer: Being weighted to light, you might overexert yourself on the first half of your dive, while you swim down against too much buoyancy!

Explain and comment on this: "Setting your neutral buoyancy more shallow does not replace good technique."
Answer: Setting neutral buoyancy too shallow means to dive overweighted. But if you have a hard time starting your freedives you need to work on your duck dive technique. Simply taking too many weights on your belt to start your dives is irresponsible and dangerous.

If you fall off-balance during freefall, what are your main means to correct that?
Answer: Head position in body axis, straight body posture, even weight distribution on the belt, correct speed, relaxation of body parts, gliding along the line with one hand, other.

7. HYPOXIA AND BLACK OUT

Why is there no benefit in blacking out?

Answer: It is not the case that the brain will adapt to work under low Oxygen circumstances by repeatedly inducing black outs.

Give examples how a cerebral ischemia can occur!

Answer: Low blood pressure, getting up (too) quickly, hyperventilation leads to cerebral vasoconstriction, tight hood in the neck area, someone is strangling you, air pocket under the suit, others.

What is the meaning of the term shallow water blackout in freediving?

Answer: It means loss of consciousness caused by hypoxia towards the end of a freedive. The hypoxia is caused or heightened by the changing water pressure when coming up from a freedive.

Decompression sickness occurred only to divers that breathe compressed air, such as in scuba. True or false? Comment!

Answer: False. Decompression sickness (DCS) can also affect freedivers, as depth and ascent speed both play a role, not only "bottom time" as in scuba diving.

8. TRAINING CONCEPTS

What is the "save the legs"-approach?

Answer: One of the limiting factors in constant weight freediving is the tolerance of the active muscles, mainly the legs, to lactic acid towards the end of a dive. This is the phenomenon of "heavy legs": Muscles might simply stop to work after reaching the maximum tolerance level of lactic acid. Therefore, warm-up dives should be performed with the least possible physical effort.

What is the rationale of a CO_2 table?

Answer: A CO_2-table is constructed in way so that the CO_2 level in your body increases with each breath-hold.The table allows you enough time between breath-holds to re-establish a good level of O_2 in your body, but not enough time to fully offload excess CO_2. The purpose of these tables is to train and increase the tolerance to CO_2 both physically and mentally.

9. THE MAMMALIAN DIVE RESPONSE (MDR)

What is the mammalian dive response (MDR)?

Answer: The MDR is a combination of several stimuli triggering a series of reactions that will allow you to conserve oxygen, to use oxygen more efficiently and it will protect you from lung barotrauma.

Why is the blood shift vital for deep freediving?

Answer: When a freediver dives below residual volume (RV), the lungs can still be further compressed because of the blood shift: The blood vessels of the alveoli take up more blood.

CREDITS

Main Author
Oli Christen

Responsible for AIDA International
Jean-Pol François

Medical advice
Per Westin

Illustrations
Francine Kreiss with Felice Mastroleo

Proof-reading
Felice Mastroleo
Christian Langer
Jonathan Sunnex
William Trubridge
Walid Boudhiaf
Claude Chapuis
Carlos Coste
Nicole Heidenreich
Michael Heinzl

Layout
Jussi Rovanpera
Sun Choi

Photographs

Kimmo Lahtinen:	Cover, 6, 14, 23, 34, 45, 53, 62, 67, 70, 77, 86
Matt Beanland:	1
Luca Vaime:	15, 65, 76
Jussi Rovanpera:	32, 51, 61, 63
David Trubridge:	42
Daan Verhoeven:	87

AIDA3 Advanced Freediver V1.06 revised version Aug 2021