SAFELY ON THE WATER (recreational kayaking)

v 19 05 25 E (latest major changes overheating and heat stroke p8)
Translation Dutch /English Deepl (https://www.deepl.com) with some changes.

Workshop rescue/self-rescue AKKC 2025 (Antverpia Koninklijke Kano Club vzw)

Introduction: In 2010 I switched to kayaking after a knee injury with recreational badminton. Already in my younger years I liked to swim and as a teenager we could still swim in open air in Antwerp (Belgium), for example in the “Noordkasteel” (the “Northern Castle” closed for recreation in 1969). Later the river Scheldt and other open air waters became too polluted for swimming. So the transition to kayaking was not such a surprise (once a water enthusiast remains a water enthusiast I guess) but the quality of the water was, in a positive sense. By now I have paddled in just about every water in the "neighborhood" with the most memorabele experience being my rescue at the North Sea 4 years ago, when I was 77 (born 1943). By then I had already switched to a so-called "dry suit" so it is only a positive memory (17°C statistical water temperature in October). During my teenage years (50s/60s) I was not aware of the concept of “cold shock”. I was only confronted with it when I had tipped over with the kayak a few times over the course of a few weeks in water of approx. 15°C and, of course, quite a bit older since the “Noordkasteel”. I wore a so-called "wet suit" at the time, a neoprene 3mm. The symptoms were "inhalation reflex" (gasp), "hyperventilation" or "sudden exhaustion". I then started to study these phenomena and I found the "cold shock" and "diving reflex" which was unknown to me, and still is for many kayakers.

The question I asked myself was: how come when diving or jumping in "cold water" (feet first in the water) there is no "inhalation reflex" (in my experience)?

It is obvious that suppression of the "inhalation reflex" (gasping) in connection with "turning upside down" with the kayak is important.

Discussion :

basic // *comprehensive /*

- Equipment

- clothing
headgear / swim cap neopreen / normal clothing - appropriate clothing – spare clothing / dry suit - wet suit / footwear / under suit - undergarments // *gloves (paddle pogies)*
- safety equipment
pfd // *hand flare(s) / whistle / mobile phone / GPS / compass / vhf radio / PLB (with return link) / rope with carabiner / knife / first aid kit / (short) poncho with sleeves and hood / waterproof chemical handwarmers / high energy bar / drinks*
- kayak
spray deck / paddle (-attachment) / pump - sponge // *safety strap (rescue straps) / short loose strap(s) / paddle float(s) / air bags / safety line / spare paddle / deck bag*
- general
- Urination management
https://aviation.derosaweb.net/relief/ReliefSoaringMay2010.pdf
www.flyg.pk2.se/praktiskt/Pee.pdf …..

- Paddling technique
- paddling technique
distance between hands / posture / technique // *backward rising waves*
- support
low brace / high brace / *angle (backwards 45°) // breaking waves*
- injuries
shoulder / wrist

- Rescue / Self rescue

- spray deck
loop / release techniques / *knee strap / side straps /*
- lifejacket PFD
- *safety line*
long - short / quick release belt /
- rolling and/or climbing in after wet exit (various techniques)

What part of the equipment can be considered to carry even as a swimmer, in case of losing the kayak?

- Parts OOPS certificate (Oregon Ocean Paddling Society) .
WEC Document 02-13-2024.pdf (oopskayak.org)

- Wet Exit

Part 1 - with spray deck loop use / **Part 2 -** without spray deck loop use

- self-rescue
climb in / empty the kayak / departure

- assisted rescue
climb in / empty the kayak / departure

Execution :

If desired, practice first in tipping over without spray deck with paddle and kayak recovery.

OOPS CERTIFICATE Part 1

- departure from the large game stairs (guide in the water / on the sill)

- kayak eventually with line attached to stairs

- close the spray deck

- tipping over with paddle parallel to the kayak

- release spray deck with loop

- recover paddle

- turning the kayak back upright

- climb in

- emptying the kayak

- close spray deck

OOPS CERTIFICATE Part 2

- idem without use spray deck loop

- idem with assisted rescue

SAFELY ON THE WATER.

"Safely on the water" can be divided into three parts, knowledge, equipment and practice.

The three parts are interconnected but knowledge is the most important because knowledge alone can help you in the event of an accident or to avoid an accident. Also, consider not piling risk factors on top of each other. An accident, and its possible consequences, are usually a convergence of several factors and events. A typical dangerous confluence of circumstances and accumulation of risk factors, which causes casualties among kayakers worldwide every year, is in spring beautiful weather, warm air, (very) cold water, non-adapted clothing and sailing without a life jacket (PFD).

A prime example of knowledge that can help, even best without practicing:

- As a swimmer, it is inadvisable to try to swim against the current and exhaust yourself quickly, especially in "cold water." "Go with the flow" and wait for help or the right opportunity to harness your precious energy. Exhaustion leads to panic, which can only worsen the situation.

Knowledge of currents (backwater, vortex, rip current,...) and water movements (waves, surf,...) is appropriate. As a swimmer, it is usually interesting to pick the places with surf (breaking waves) to be propelled to the beach. In a gully between sandbanks, usually without surf, you as a swimmer will be pulled towards the sea. But even where there is surf there can be a seaward undertow, the kayak can then be an aid (for example with a safety line) to go with the surf. Trying to swim against the current is usually a bad option (exhaustion) and should be carefully considered according to the circumstances (condition, distance, expected help,...).

In kayaking, one can be expected to tip over. In most cases, in our regions, this is in cold to very cold water, **below 25°C is cold, below 15°C is very cold**.

For practical reasons, 50 - 60 - 70 °F or 10 - 15 - 21 °C is often given as a guideline. Any personal system that is used is better than no system at all, it is at least an incentive to check water temperature and think about it in relationship to your personal situation and specific activity (10). If you swim in open water every day until the ice gets too thick, the answer will be different from if you don't. If you are one of the elderly, for whom it is normal that strength, resilience and recovery capacity have declined and overall vulnerability has increased, it is also different from being one of the young in the prime of life. You can only make these trade-offs for yourself.

Although one does not have to be able to swim in order to kayak without risk, usually a life jacket is worn, water familiarization, as well as tipping over with the kayak and being able to exit the kayak upside down (wet exit), is important to avoid stress and panic.

Regarding cold water, we have two different reactions:

"Cold shock" and the "diving reflex," both of which are autonomous responses.

- Cold shock is a reaction that occurs when the body, or part of it (the trunk is important in this), is suddenly exposed to cold water **(+/- 10 °C below skin temperature)** and allows the body to switch to higher oxygen consumption to keep the body warm.
- Immersion of the face, even without immersion of the body, can trigger the diving reflex. The diving reflex autonomously closes the airways in a fraction of a second, or one closes them preemptively

oneself, and allows the body to switch to low oxygen consumption in order to provide adequate oxygen to the vital parts (heart, brain,...) for as long as possible.

Both systems have very complex responses, but the problem is that they are contradictory in terms of our cardiovascular (heart and blood vessels) system.

Among other reactions, the "cold shock" tries to speed up the heart rate while the "diving reflex" tries to lower it.

The more severe the shock and the conflicting signals, the more likely it is that the conflict will lead to cardiac arrhythmia's, some of which may be "normal", but in our particular situation they can also be dangerous, either directly or indirectly. Apart from a full cardiac arrest arrhythmia's may interfere with swimming or other rescue attempts. Here again, a PFD can provide the necessary time, even if only a few seconds, to stabilize the situation and whereby the arguments “a good swimmer”, “close to the shore” or “I have my life jacket with me” (but not on) are irrelevant.

Risk factors that can interfere with the proper functioning of the diving reflex are certain medications, drugs, stress factors (panic) and some diseases (epilepsy, ...) or disorders (easy choking when swallowing liquids, ...), old age, genetic factors, ... Covering the face and nose sensors with face cream, diving mask, nose clip,... can weaken the diving reflex (24). Cigarette smoking and alcohol consumption can interfere with other respiratory protection reflexes (27-28).

Exercising both systems, the cold shock and the diving reflex, even mildly, can improve effectiveness, and possibly early detection of functional problems.

Getting the face used to cold water occasionally can be done even at home. Practicing breath holding e.g. during light activity (e.g. walking) can also activate parts of the diving reflex. Swimming and some underwater swimming, even in water at 25 / 28 ° C (indoor pool), is already a good exercise. An underwater rollover is then close to a tip over with the kayak and can help habituation of some water in the nose. Cold water swimming has many benefits, as many avid swimmers will attest, and all "cold water" training is very effective and remains effective long after you stop training, but it is a speciality in itself https://www.zwemfed.be/ijsberen . Training to tip the kayak will also reduce stress reactions and panic, thus not interfering with the normal function of the autonomous reactions (26 -29). We must realize that both systems, the cold shock and the diving reflex, are very individual in their functioning (32) and can be influenced by all kinds of other factors.

It is advisable to prepare exposure to (very) cold water carefully. If cold-water immersion occurs, it is best to take immediate action according to a plan drawn up in advance: get out of the water as soon as possible and call for assistance. Our North Sea Rescue Team in Nieuwpoort harbor told us that most people, for all sorts of reasons, wait too long to call for help when they are in trouble. This makes the situation worse for everyone involved, including the rescuers.

If it is not possible to get out of the water, measures should be taken to minimise heat loss by remaining as still as possible in the foetal position. Clothing should be tightened to reduce the flow of cold water through layers of clothing. But even those who can get out of the water are still at risk and should take measures to prevent further cooling by conduction, evaporation and radiation. Uncomfortable cold and even hypothermia may still occur. If you are not wearing windproof clothing, the options for additional equipment in a kayak are limited. A thin plastic emergency poncho with sleeves and hood may provide sufficient protection and can be worn over the PFD. This is part of the equipment that can be considered to be carried even as a swimmer, in case the kayak is lost.

Since cold shock can cause hyperventilation (rapid uncontrollable breathing), it is important to know that this is a temporary phenomenon that can last from a 30 sec to several minutes. To prevent or

reduce dizziness, it may help to form a shell over the mouth and nose with the hands. Obviously, wearing a PFD will improve the situation. Also, a shell over the mouth and nose will already make it somewhat more difficult for splash water to enter the airways (flush drowning) should there be a risk for that. A certain amount of water in the lungs increases the risk of fatal drowning.
To prevent losing the kayak during hyperventilation, one can use a safety line or hook a leg into the kayak cockpit. If the hands are free, and making a shell over mouth and nose are not necessary, one can hang from the bow or stern of the kayak until the hyperventilation passes. The kayak may need to be turned back upright first, which can be done without risk for full immersion (dangerous during hyperventilation) by taking support, under the kayak, at the cockpit rim (coaming) on the other side from you and then pushing your side up. It is best to practice this procedure.

Hypothermia is a slow phenomenon that we do not easily encounter. Usually, if dressed appropriately to the water temperature, one has about half an hour before it can become troublesome. In fact, it is not exceptional for prolonged hypothermia to be survived without serious permanent damage. However, a form of general exhaustion can occur fairly quickly, which must be taken into account. The fairly rapid desensitization of hands and fingers in very cold water should also be expected. If this occurs, the performance of some actions may become limited or impossible e.g. opening a zipper, opening a hatch, opening a hand torch, opening a watertight container, holding a rope, climbing into the kayak or other vessel... and thus must be provided for (planning for quick action, providing drawing loops, adjusting the equipment,...). Shivering from the cold is a very efficient response of the body to maintain internal body temperature and in itself is no reason to panic. It is, however, an indication that further cooling should be avoided if possible.

If the clothing is wet and there is no spare clothing available, it may be advisable to wring out the wet clothing and put it back on. Wet clothing increases heat loss rapidly as water is a much better conductor of heat than air. Apart from hypothermia, cold and frost can cause slight to very serious injuries. A wind chill below 0°C (combination of wind speed and air temperature) with air temperature above the frost line will not cause frostbite but is an indicator of heat loss that can cause hypothermia and, among other things, numbness of the fingers, which in itself is not serious but can indirectly cause serious problems.

Windproof clothing provides some protection against cold air temperature and wind chill. Even when handling, this clothing will provide some protection in cold water mainly by keeping the upper body warmer, somewhat similar to the neoprene ‘wet suit’ by restricting flow of cold water. Windproof clothing will also prevent further cooling after wet climbing in.

Frost or cold injuries are rather rare in our regions. If they do occur, care should be taken not to re-expose the lesions to cold or frost after thawing. Minor frost injuries are similar to burns and thus require specialised treatment. Severe frost injuries can be very serious.

All in all, drownings in kayaking activity are fairly rare. In Belgium there are on average about 100 fatal drownings per year (worldwide about 500,000) of which only a few, if any, are kayak related.

Safety precautions (for water below 25°C)
A cold shock response can occur at water temperatures below 25°C. The shock severity is proportional to the water temperature, the colder the water the heavier shock. Cold shock becomes likely from a

water temperature around 21°C and peaks around 10 to 15°C. This applies mainly to non-‘cold water’ trained individuals.

Participants for kayak initiation with the following medical conditions should obtain a doctor's advice before participating kayak initiation in open water below 25°C : moderate to severe asthma (uses an inhaler at least once a day), cystic fibrosis or any lung disease; sinus or ear infection, any kind of heart problems or heart disease, seizure disorder (not controlled on medication), high blood pressure or use of blood pressure medication. In addition, candidates for the kayak initiation should be able to hold their breath in air for at least 25 seconds. Maximum breath holding time (BHT) can be significantly reduced after submersion, especially in cold water. Halving BHT at water temperature of 15°C versus water at body temperature is not exceptional.

Those interested can, even at home, perform a simplified test of the Divers Reflex, especially recommended for immersion in colder water, 21°C and lower, best done under medical or para-medical supervision
https://journals.physiology.org/doi/full/10.1152/advan.00125.2013 (steps 6 to 9)

The test may not induce any discomfort. We can expect around 20 bpm decrease in Heart Rate (HR) after 20 to 30 sec of immersed breath holding.

Personal test (picture is dry test, measurements after wet test):
- Room temperature 23.9 °C
- Heart rate at rest : 78 bpm
- Water of 15 °C
- Heart rate measured 85 bpm a fraction of a second after immersion with medium inhalation and breath holding, gradually decreasing to 65 bpm after 20 sec and 61 bpm after 30 sec

The instant increase in heart rate suggests a cold shock, immediately followed by the initiation of the diving reflex.

We can compare this result with breath holding in air:

- Breath holding in air after medium inhalation: start HR 78 bpm after 30 sec 82 bpm
- Breath holding in air after maximum inhalation: start HR 82 bpm after 30 sec 102 bpm.

Heart rate measurement with Geonaute Sport

This experiment allows us to test at least part of the diving reflex. If in doubt about the results, or if you felt any discomfort, either cardiac or respiratory, seek specialised advice. It is also best to consult a specialist if striking values are observed, e.g., a sudden sharp cardiac rhythm drop (e.g., >-30%) (ref 32 fig 1 type A).

It is equally important not to forget to protect yourself from the sun (sun cream, sun-protective clothing, etc.). As with any other reflective surface, water reflects the sun's rays and increases the amount of UV radiation you receive (+/- 10%). Overheating and heatstroke with kayaking is a possibility during periods with a lot of sun, hot air and cold water because clothing is best adapted to the water temperature while kayaking can also be a very intense activity. Usually, as a kayaker, you have water around you that you can use in all sorts of ways to cool off. Keeping your head cool, literally, is already an effective way. Training wet exit and climbing in, or rolling, is also an effective way to cool down. Furthermore, one can adjust the planning of the trip according to the circumstances, departure time, sun/cloud, air temperature, etc.. Providing sufficient drinks and rest breaks is certainly important. It is also advisable to react appropriately to the first symptoms (headache, nausea, vomiting, dizziness, abnormal fatigue...).

Keywords: Kayaking, kayak, cold shock, diving reflex, drowning, heart failure, water temperature, PFD, swimming, wet exit, cold water, cold water training, hypothermia, heat stroke, overheating, hyperventilation, gasping, vertigo, cardiac arrhythmia's, sudden exhaustion, dry suit, wet suit.

Research and references:

Courtesy of:

- Professor Dominique Adriaens (U Ghent), author of the book "In het spoor van de mens" (which put me on his trail), for providing the AI search engine ELICIT https://elicit.com/ and various documents related to my search.
(1) Respiratory drive during sudden immersion in cold water
https://www.sciencedirect.com/science/article/abs/pii/S0034568787800373
(2) The diving response of mammals: Toward neural control
https://www.frontiersin.org/journals/neuroscience/articles/10.3389/fnins.2020.00524/full

- Professor Heather Massey, Senior Lecturer in Sport, Health and Exercise Sciences and member of the Extreme Environments Laboratory and the Clinical, Health and Rehabilitation Research Team at the University of Portsmouth, for providing several papers.
PhD projects: Cold water immersion, cold water swimming, thermal physiology, thermoregulation in ectodermal dysplasia.
(3)'Autonomic conflict': another way to die during cold water immersion?
https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/jphysiol.2012.229864
(4) Cold water immersion: kill or cure? https://physoc.onlinelibrary.wiley.com/doi/10.1113/EP086283
(5) The human diving response, its function, and its control -
https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1600-0838.2005.00440.x

- Professor Chris Button - Otago University, supervisor of a student (Kane Cocker) who is researching a related subject (2024).
https://www.academia.edu/68199497/Behavioural_analysis_of_human_survival_characteristics_following_sudden_water

- Professor Gordon Giesbrecht, PhD, FAsMA, FAWM, FEWM University of Manitoba for recommending “Auerbach's Wilderness Medicine, 2-Volume Set 7th Edition - October 19, 2016 https://www.gettextbooks.com/author/Paul_S_Auerbach CHAPTER 8
Immersion into Cold Water - GORDON G. GIESBRECHT AND ALAN M. STEINMAN

The video https://www.youtube.com/watch?v=8nH3i7Fv5IU&t=41s Beyond Cold Water Boot Camp USA - 4 Phases of Cold Water Shock - demonstrates a jump into water of 45°F (7.2°C) with full immersion, surfacing, gasping and hyperventilation followed by a short swim and sudden exhaustion.

Disclaimer:

I would like to stress that I do not wish to give the impression that these people, who have taken the time to reply and provide additional information despite their busy schedules, have in any way agreed with my document or subjected it to a thorough examination.

Objective:
We limit ourselves to discussing the parts of the OOPS (Oregon Ocean Paddling Society) ‘Wet Exit Certificate’ because that seems to us to be the most fundamental.
https://www.oopskayak.org/resources/Documents/WEC%20Document%2002-13-2024.pdf

Method:
Equipment: kayak, spray deck, PFD (Personal Floating Device), paddle, appropriate clothing.
Environment: open air (water temperature usually below 25°C) or covered swimming pool (25 to 28°C).

The parts are:

- 1 -

- Learning to tip over without spray deck.
- Inhaling, breath holding and turning over (180°).
- Exit the kayak underwater (wet exit).
- Exhale on the surface with closed lips
  in case of hyperventilation cover mouth with shell formed by hands
- Recover the paddle (paddle swim, self-rescue)
- Turn the kayak upright without submerging the head

- 2 -

- Learning to tip over with spray deck closed
- Inhale, breath holding and tipping over (180°).
- Releasing the spray deck (technique: pushing the loop forward and then away from the kayak)

Practicing releasing the spray deck without loop use. Loosening the spray deck sometimes fails because the loop is not found, used incorrectly (pull), too tight, or for unknown reason. Pushing out with the hands on the kayak next to the body also sometimes fails for a variety of reasons. With the new spray deck developments there is an adjustable strap across the spray deck at the level of the knees so that releasing the spray deck can also be done with the knees or with the hands by pulling off the sides. In some spray deck versions there are straps on the sides of the spray deck that can also be used for releasing if the loop does not work.

- Exit the kayak underwater (wet exit).
- Exhale on the surface with closed lips (pressure in the lungs)
in case of hyperventilation cover mouth with shell formed by hands.
- Recover the paddle (paddle swim, self-rescue,...)
- Turn the kayak upright without going under water with the head

Practice:

In practice, the situation will differ from the exercises.
We mainly distinguish between "flat water" and "turbulent water." The latter can be waves of different shape, wavelength and height, with or without surf, or turbulence due to currents, obstacles and the like with possible splash water.
This variety will give rise to different conditions of "tipping" and rescue or self-rescue along with swimming. We assume that the kayaker cannot "roll" (so-called eskimo roll) or the roll fails. So the starting position and physical reactions can also be quite diverse. From calm paddling on flat water with expected (bow wave,...) or unexpected (looking backwards, wave coming up from behind,...) to intense constant fighting with the elements and realizing in a split second that one "can't make it" and tip over. Those who can roll are going to try, those who can't, or the roll fails, must exit the inverted kayak underwater or turn upright with assistance. In doing so, various "stress moments" can occur, the roll fails, spray deck doesn't release, help doesn't come.... . This along with cold, possibly cold shock and/or diving reflex, consciously breathing in and holding breath, the latter whether by diving reflex or voluntary. Surfacing and exhaling. Hyperventilation and/or "vertigo" (orientation loss) after surfacing and sudden exhaustion is then also among the possibilities in “cold” or “very cold water”.

The kayaker who rolls over must scan the cockpit edge upside down in the water to the loop of the spray deck, then push off the spray deck, exit the kayak and come to the surface. For kayakers who can roll, it is not abnormal to have to try it several times before it works (or not), and it can also happen that, if you are paddling in a group, you stay upside down in the kayak and ask for help, e.g. by knocking (drum) on the kayak bottom so that you can pull yourself up by the bow (or hand) provided (or another technique). In my opinion, all well past the time of the ‘inhalation reflex’ in ‘cold water’ unless it is blocked or delayed. An unknown factor is also clothing. In ‘winter’, many kayakers do wear dry suits, then the most severe ‘cold shock’ will be avoided, but there is a wide variety of clothing. Personal health and possibly (cold water) training is also difficult to factor in.

Experiences and Assumption:

During the 70 years or so that I have been swimming recreationally, I have experienced that when I "slowly" enter the water along steps or ladders in an indoor swimming pool at 25 to 27°C water temperature, or open air water via a beach or the like (water temperature usually somewhere below 25°C but not “very cold”), I sometimes experience cold shock with an immediate "uncontrollable inhalation reflex" (gasping). If I jump into that same water (feet forward) or dive (head forward) I do not have that inhalation reflex (otherwise I would probably have drowned long ago).

I also never experienced a pressure to inhale in the first seconds or ten seconds or so after jumping or diving, although in my younger years I sometimes stayed underwater as long as possible. Then sometimes the pressure to breathe did clearly began to increase.

This would mean that the "diving reflex," which is started by touching the face with water (nose, around the eyes, forehead) and self blocking breathing, delays the "inhalation reflex," started by the cold shock.

Tipping with the kayak with face facing the water (low brace, roll,...) would then be a recommended technique. This assumption has to be investigated.

The starting position for the "eskimo roll," face to the water.

The "low brace" to try to prevent tipping. This is also face to the water.

The "high brace" is a last effort not to tip over, back to the water, face away from the water.

Pictures from Northseakayak https://www.facebook.com/northseakayak.northseakayak

In this last position (partial turning over with high brace) I experienced an immediate "inhalation reflex" (gasping) by cold shock with afterward the reflection that at that moment my mouth was very close to the water. The "high brace" did work (exceptionally for me) but I won't try it again in such circumstances. I was wearing a neoprene 3mm wet suit at the time.

After some experiences with full tipping over, wet exit and cold shock (hyperventilation, sudden complete exhaustion), my clothing below 25°C water temperature is now a "dry suit" with appropriate undergarments (fleece coveralls of different weight, plain or "thermal" underwear etc). Perhaps because of my age or because I swim less, I have become more sensitive to "cold shock". This does require some puzzling in summer with water temperature, air temperature, cloudiness, time of departure/arrival etc. but in our climate it is not really a big limitation.

My assumption was initially supported by Gooden's thesis:
- https://academic.oup.com/bja/article/79/2/214/247461 Immersion, near-drowning and drowning – British Journal of Anaesthesia 1997

Gooden BA. Why some people do not drown. Medical Journal of australia 1992
“Gooden postulated that immediately on face immersion the diving response apnoea prevents water aspiration into the lungs. Even if water does enter the larynks he postulated that reflex glottal spasm prevents further penetration into the lungs.”

...60% of the annual open water immersion deaths in the UK occur within 3m of a safe refuge, and two-thirds of those who die were regarded as “good swimmers”.

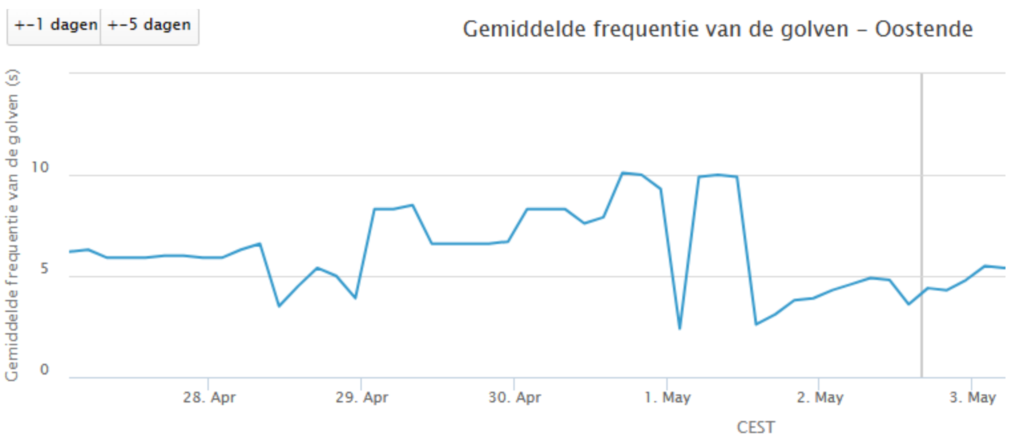
Conclusion:

Extending my assumption, it appears important to avoid "cold shock," and its with the "diving reflex" conflicting impulses to the heart and blood vessels, if possible. This along with all the other "risk factors" in order to be safe on the water. So we are looking for a scientific study that investigates whether the "diving reflex" with breath holding (voluntary or by reflex) suppresses or delays the "inhalation reflex" (gasping) from cold shock. So far, research on simulated helicopter crashes (North Sea related) seems to give us some indicative data (5).

Of course my hypothesis that cold shock induced gasping is inhibited or delayed when a "solid Diving Reflex" is activated is still to prove, whatever my personal experience may be. On the other hand it seems not advisable to weaken the divers reflex (nose clip, diving mask, ..) for no good reason, on the contrary, especially in circumstances where cold shock, with his dangerous respiratory responses, can occur. Here to, the rule to avoid stacking risk factors on top of each other is valid (cold water, old age, illness, unsuitable clothing for the water temperature, weakening the diving reflex with nose clip/diver mask,...).

Thus, both reflexes, divers reflex and cold shock, are largely opposite but usually, if accumulation of risks is avoided, everything will go well. In cases where it does not, drowning can occur. This drowning can be fatal, or if not too much water enters the lungs it will still require at least a day or more of vigilance to avoid problems afterwards.
Personally, I now avoid cold shock by wearing a "dry suit" from a water temperature <25°C. This is because of my age and the use of medication that can cause heart rhythm disturbances. In addition, I avoid tipping over by using stabilizers (floats), because I have found that my balance is no longer optimal, with some models depending on activity.
https://blogimages.seniorennet.be/kajak/attach/174656.pdf Delta wing mini outriggers for kayak

This balance problem was evidenced by some unexpected capsizing at sea. Probably due to an unnoticed change in wave height or wavelength, the kayak suddenly becomes unstable and if balance and reaction are then not optimal, one capsizes. On inland water or on land (biking,..), I haven't noticed a problem so far but some simple tests show a solid deterioration of balance.
https://blogimages.seniorennet.be/kajak/attach/174568.pdf Evenwicht en reactie



https://datalab.marine.rutgers.edu/ooi-lab-exercises/lab-6-ocean-waves-linking-the-marine-atmosphere-and-the-ocean-surface/lab-6-3/ Wave dynamics. (simplified formula $L=1.5\ T^2$)

In terms of the individual situation, the medical examination for divers seems to me to be very related. https://cardioexpert.nl/uploads/documents/duiken/fitness_to_dive_recreatieve_duiken_update.pdf

A balance examination can be done at different locations e.g. https://www.uzleuven.be/nl/evenwichtsonderzoek Research shows that once over 65 years of age a follow-up can be useful. https://www.stichtinghoormij.nl/nl-nl/duizeligheid-en-evenwicht/uitval-evenwichtsfunctie/presbyvestibulopathie

https://kanot.com/sakerhet--miljo/nyheter-sakerhet--miljo/sakerhet/2024-05-21-flytvasten-raddar-liv---varje-dag

Half would have survived!

Every year, about thirty people drown in Sweden in connection with recreational boating accidents. On average, 80 percent of drowning victims are men between the ages of 50 and 90, and as many as 90 percent do not have a life jacket when they are found. Analyses of drowning accidents carried out by the Swedish Transport Agency and the Swedish Life Saving Society show that probably half would have survived if they had used life jackets.*

References and Notes:

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Glossary :

- bradycardia : decreased heart rate
- tachycardia : increased heart rate
- vasoconstriction : constriction of blood vessels
- apnea : cessation of breathing
- hypernea: inspiratory reflex (irrepressible)
- hyperventilation : rapid breathing (irrepressible)
- hypoxia: lack of oxygen in the blood
- larynx: larynx
- glottis: gap between the vocal cords
- hypothermia: hypothermia
- cutaneous : skin

https://idra.world/share-your-graphical-abstract/drowning-and-aquatic-incidents-dictionary/

1) https://www.sciencedirect.com/science/article/abs/pii/S0034568787800373 Respiratory drive during sudden cold water immersion

Sudden decreases in cutaneous temperature induce an immediate ventilatory response, which has been termed the inspiratory or ‘gasp’ reflex. This respiratory response has been implicated as a contributing factor to cold water immersion drowning.

(2) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7290049/ The Mammalian Diving Response: Inroads to Its Neural Control

We have speculated that the Diving Reflex is the most powerful autonomic reflex known. ...

Indeed, covering paranasal areas with petroleum jelly or numbing these areas with anesthetic eliminates the autonomic responses induced by submersion ...

We consider the AEN as the “gatekeeper” nerve since it is the first to sense noxious gases or water entering the nasal passages. ...

Peripheral **physiologists know the stimulus (underwater submersion) as well as the output (e.g., an apnea via central inhibition of respiration,** bradycardia via the vagus nerve, peripheral vasoconstriction via the sympathetic NS), but most elect not to explore central integration. ...

This implies that perhaps the moniker “DR” is misleading and in fact a misnomer. Perhaps a purpose of this enigmatic reflex is to indeed to preserve life of the organism…

“Master switch of life” (Scholander, 1963)..

(3) https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/jphysiol.2012.229864 ‘Autonomic conflict’: a different way to die during cold water immersion?

Abstract : **Cold water submersion can induce a high incidence of cardiac arrhythmias in healthy volunteers. Submersion and the release of breath holding can activate two powerful and antagonistic responses: the ‘cold shock response’ and the ‘diving response’.** The former involves the activation of a sympathetically driven tachycardia while the latter promotes a parasympathetically mediated bradycardia. We propose that the strong and simultaneous activation of the two limbs of the autonomic nervous system (‘autonomic conflict’) may account for these arrhythmias and may, in some vulnerable individuals, be responsible for deaths that have previously wrongly been ascribed to drowning or hypothermia. In this review, we consider the evidence supporting this claim and also hypothesise that other environmental triggers may induce autonomic conflict and this may be more widely responsible for sudden death in individuals with other predisposing conditions.

(4) https://physoc.onlinelibrary.wiley.com/doi/10.1113/EP086283 Cold water immersion: kill or cure?

More recently, **it has been suggested (Shattock & Tipton, 2012) that a larger number of deaths than once thought may be attributable to arrhythmias initiated on immersion by the coincidental activation of the sympathetic and parasympathetic division of the autonomic nervous system by stimulation of cutaneous cold receptors around the body [sympathetic activation (cold shock)] and in the oronasal region on submersion or with wave splash [vagal stimulation (diving response)].** This ‘autonomic conflict’ is a very effective way of producing dysrhythmias and arrhythmias even in otherwise young and healthy individuals, particularly, but not necessarily, if a prolonged breath hold is involved in the immersion (Tipton et al. 1994). It seems that predisposing factors, such as long QT syndrome, ischaemic heart disease or myocardial hypertrophy, are necessary for fatal arrhythmias to evolve (Shattock & Tipton, 2012); many of these factors, including drug-induced long QT syndrome, are acquired. Non-fatal arrhythmias could still indirectly lead to death if they cause incapacitation and thereby drowning (Tipton, 2013).

Even in ice-cold water, t**he possibility of hypothermia does not arise for at least 30 min in adults.**

Death during rescue is most commonly associated with a **collapse in arterial pressure when lifted vertical from the water and kept in that position for some time (**Golden et al. 1991).

(5) - https://onlinelibrary.wiley.com/doi/epdf/10.1111/j.1600-0838.2005.00440.x

The human diving response, its function, and its control

Face immersion

Direct contact of water on the forehead, eyes, and nose is a potent stimulus for eliciting the diving response (Schuitema & Holm, 1988; Daly, 1997). These areas are supplied by the trigeminal nerve where stimulation causes inhibition of respiration and excitation of vasomotor centers and cardiac vagal motoneurones (Elsner & Gooden, 1983). **These cardiovascular responses potentiate the diving response by further reducing the heart rate and vaso-constriction occurring during a dry breath-hold** (Andersson et al., 2002). **Facial cold receptors are more strongly excited by immersion in water with a reduced temperature (10–15°C)**

However, face immersion in cold water reduces the ventilatory drive in humans (Mukhtar& Patrick, 1986). Eventually, the drive to breathe becomes too much to ignore and involuntary respiratory contractions begin to occur (Whitelaw et al.,1981). **Breathing is avoided by tightly contracting the glottis and thus closure of the upper airway.**

The diving response serves the purpose of preserving life. **Under conditions where respiration ceases and the face becomes submerged, the diving response is initiated.**

(6) -
https://www.researchgate.net/publication/237094715_Cardiovascular_and_Ventilatory_Responses_to_Dorsal_Facial_and_Whole-Head_Water_Immersion_in_Eupnea

Cardiovascular and Ventilatory Responses to Dorsal, Facial, and Whole-Head Water Immersion in Eupnea

Thus it seems that the primary ventilatory dive response (decreased ventilatory drive) is initially overridden in subjects who are allowed to breath. The initial cold-shock response predominates with increased tidal volume and minute ventilation.

It is interesting that the cold-shock response (as evidenced by increased minute ventilation and tidal volume) initially predominated over the dive response. **It is possible, however, that the dive response may not have been fully activated given that breathing was maintained in all trials.**

The emergence of the cold-shock response prior to the oxygen-conserving dive response suggests that individuals who must enter cold water should not dive in, or jump in such that their head is submersed. **Rather, whenever possible, individuals should enter feet first and keep their head above water to decrease the chance of immediate drowning.**

NOTE: this recommendation does not apply to our activity but is obviously prudent.

(7) - https://journals.sagepub.com/doi/10.1177/00258172211053127 **The experience of drowning**

(BHT = Breath-holding time)
If submerged directly into cold water, BHT is likely to be significantly shorter than that which can be achieved in air. This is due to the respiratory drive evoked by sudden skin cooling and the resulting cold shock response20 (Figure 1). For swim-suited, or normally clothed individuals, this response peaks in water somewhere between 10°C and 15°C.21 Maximum BHT can be reduced to as little as 0.2 s and average 9.5 s when wearing heavy normal clothing and submerged into 5°C water.22 In the same scenario, and even with specialist protective clothing ('shorty wet suit' or 'dry' suit), maximum BHT can be as short as 1.2 and 8.9 s, respectively,22 and average around 20 s in water up to 15°C.23 During a simple simulated submerged helicopter underwater escape in water at 10°C, participants wearing a specialist helicopter passenger dry suit and underclothing had an average maximum BHT of 17.2 s.24 The corresponding figure for 15°C was 21 s and 20.5 s in water at 5°C.23 **The insignificant difference in these times between water temperatures is attributed to the high level of immersion-protective clothing worn.**
The breakpoint of breath-holding triggers involuntary gasping which, if the airway is submerged, results in the aspiration of water. On immersion in cold water, breath-holding, as noted, is significantly curtailed by a gasp response that can be 2–3L in volume,21 that is, greater than the reported lethal volume of aspiration for drowning (see next section). **In cold water, the combination of the end of breath-holding and immersion of the face can also result in hazardous cardiac arrhythmias and sudden cardiac death25** (Figure 1). This cause of death may be missed at post-mortem as a disturbance to the electrical conductivity of the heart cannot be identified, and agonal gasping may result in the aspiration of water and apparent drowning.

It is concluded that BHT in cold water (5°C) in individuals wearing heavy normal clothing averages around 9.5 s, increasing to an average of around 20 s with a specialist immersion 'dry' suit and underclothing.

NOTE: *Time the breath can be held (Tmin) and (Tgem) in sec*

1 - water temperaure 5°C clothing: heavy normal	*Tmin 0.2*	*Tgem 9.5*
2 - water temperaure 5°C clothing: dry suit or wet suit	*Tmin 1.2*	*Tgem 12.2*
3 - water temp. hour 15°C clothes: dry suit or wet suit	*Tmin 20*	*Tgem 20*
4 - water temperature 10°C clothing: dry suit + underwear	*Tmin*	*Tgem 17.2*
5 - water temperaure 5°C clothing: dry suit + undergarment	*Tmin 21*	*Tgem 20.5*

The documented values of 0.2 and 1.2 sec is of particular significance for us because it is not long enough for our application. The 0.2 sec seems to me to be an uninhibited "inhalation reflex" due to cold shock (gasping). However, in most of these experiments a nose clip was worn (except partially in ref 23) so that an important part of the diving reflex (inside of the nose) was eliminated. Thus, it does appear that, with few exceptions, the diving reflex significantly delays the inhalation reflex (gasping) due to cold shock. Further study of the references (22, 23, 24) or similar works seems interesting for our application. (The clothing has evolved in the meantime).

I estimate that breath holding should be at least 4 to 5 seconds for a "wet exit". To get upright with assistance, I estimate 15 sec. The data from these studies can already give us an idea for "worst case" values.

- ref 22
https://www.researchgate.net/publication/20381378_Protection_provided_against_the_initial_responses_to_cold_immersion_by_a_partial_coverage_wet_suit
Each subject remained on a mouthpiece and wore a noseclip throuhout each experimental period.

- ref 23
https://www.researchgate.net/publication/13899680_An_examination_of_two_emergency_breathing_aids_for_use_during_helicopter_underwater_escape
The AP is provided with a nose clip ..

The STASS contains a mouthpiece but is not provided with a nose clip.

- ref 24
https://www.researchgate.net/publication/15536986_A_simple_emergency_underwater_breathing_aid_for_helicopter_escape

A nose-clip was worn throuhout each submersion.

(8) - https://www.researchgate.net/publication/20465406_The_Initial_Responses_to_Cold-Water_Immersion_in_Man The Initial Responses to cold Water Immersion in Man.

It was suggested that emotional factors may complicate this response in humans; this was subsequently confirmed when **greater ventilatory responses were obtained from subjects immersed in open-water compared with correspondenting laboratory conditions. It would also appear that some unhabituated subjects can consciously suppress the cold-shock ventilatory response.**

(9) - https://pubmed.ncbi.nlm.nih.gov/21458133/ A proposed decision-making guide for the search, rescue and resuscitation of submersion (head under) victims based on expert opinion

The mammalian "diving response" is an oxygen conserving triad of apnoea, bradycardia and selective vasoconstriction, which is known to be stronger in children than adults.

(10) https://journals.sagepub.com/doi/10.1177/00258172231182601
Extreme physiology in the dock

The arms are particularly susceptible to cooling, being long, thin cylinders with superficial nerves and muscles. It can take as little as **10 minutes in 5C water** to cool these nerves and muscles to about 27C, the temperature where they cease to function, and loss of proprioceptive feedback and physical incapacitation occur. This can result in swim failure, the inability to self-rescue and drowning. It takes about **20 minutes** to reach the same point **in water at 12C**.

Anybody who has worn a dry suit knows that there is no such thing, but it sounds a lot better than "a bit wet suit". However, if you don't know that a little leakage is normal, and you go into the water wearing a dry suit and yours leaks, you can think "I've got the one that leaks!", then your psychology can become very negative; despair is the opposite of hope.

NOTA: *It can be very important for your psychological well-being to know that a bit of leaking of a "dry suit" is of little or no importance for your survival. With kayaking you can also be wet from sweating and this also has a negative effect on insulation and heat loss in the long term when in the water. The advertised "breathability" of a kayak dry suit is in reality very limited in surface when you are wearing a spray deck and PFD and your legs are in an air tight closed kayak. Panic is far more dangerous than a water leak in a dry suit. Even the best dry suits can start leaking in an emergency situation with an exceptionally heavy usage. It is what it is, and you can't do anything about it. Don't let a leak in your dry suit divert your attention from more important urgent actions.*

(11) - *https://cardioexpert.nl/uploads/documents/duiken/fitness_to_dive_recreatieve_duiken_update.pdf*

Recreatieve duikers

Cardiovasculaire veranderingen bij duiken. Het eerste waarmee de duiker geconfronteerd kan worden is het aandoen van de uitrusting en het met zo'n 10 – 20 kg uitrusting lopen naar de waterkant. Dit vereist de nodige inspanning. De omstandigheden aan de kust en in het water (bv rotsachtige bodem, branding, stroming, getijden, temperatuur van lucht en water, zicht) en bijvoorbeeld een boottocht over een onrustige zee met als gevolg zeeziekte kunnen de inspanning nog vergroten en bijdragen tot stress, en de hiermee gepaard gaande bloeddrukverhoging en tachycardie. **Bij het te water gaan moet men rekening houden met 2 belangrijke effecten: de duikreflex en immersie. De duikreflex, met name geïnitieerd door contact van het gelaat met koud water,** veroorzaakt bradycardie en perifere vasoconstrictie waardoor de bloeddruk stijgt. Bij immersie zal door de hydrostatische druk bloed vanuit de perifere venen naar het hart en de longcirculatie worden verplaatst. Ook een lage watertemperatuur met daardoor een perifere vasconstrictie draagt aan dit effect bij. **Geschat wordt dat het bloedvolume in de thorax met ongeveer 500 - 700 cc toeneemt.**

(12) - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6389676/ Sudden Unexpected Death and the Mammalian Dive Response (MDR)

Facial cold or facial immersion, even in the absence of bodily immersion or submersion, may elicit the MDR (Campbell et al., 1969; Gooden, 1972; Hurwitz and Furedy, 1986; Foster and Sheel, 2005). In a small subset of neonates, a short burst of warmth in the facial region also elicits the MDR (Smith et al., 1976; Allen et al., 1979). Activation of the MDR by facial immersion facilitated its experimental observation in many laboratories (Elsner et al., 1971; Hurwitz and Furedy, 1986; Wittmers et al., *1987)*. **Even without submersion, apnea triggers the MDR.** Apnea normally occurs when the body is submerged in water and hypoxia, even in the absence of facial cold or bodily immersion/submersion, rapidly activates the chemoreflex (Braga et al., 2007). **It is well documented that a robust response is typically elicited by combining apnea and facial immersion** (Elsner et al., 1966, 1971; Campbell et al., 1969; Hurwitz and Furedy, 1986; Shamsuzzaman et al., 2014).

Activation of the MDR is the final pathway to sudden cardiac death (SCD) in some cases of sudden infant death syndrome (SIDS), sudden unexpected death in epilepsy (SUDEP), and sudden cardiac death in water (SCDIW, fatal drowning). **There is no single cause in any of these death scenarios, but an array of, unanticipated, often unknown, factors or events that activate or interact with the mammalian dive reflex. In any particular case, the relevant risk factors or events might include a combination of genetic, developmental, metabolic, disease, environmental, or operational influences.** Determination of a single cause in any of these death scenarios is unlikely. The common thread among these seemingly different death scenarios is activation of the mammalian dive response. The human body is a complex tightly coupled system at risk of rare catastrophic failure when that “safety feature” is activated.

(13) - Ziekenhuis St Jansdal
Als noodmaatregel kunt u uw **handen afsluitend om mond en neus houden en hierin een tijdje in- en uitademen.**
(Deepl translation) As an emergency measure, **you can keep your hands closed around your mouth and nose and breathe in and out in these for a while.**

(14) - https://www.britannica.com/science/drowning#ref214301 **Up to 15 percent of drownings are “dry,” presumably because the breath is held or because a reflex spasm of the larynx seals off the airway inlet at the throat.**

(15) - https://mtbio.weebly.com/uploads/3/7/7/4/37743881/your_inner_fish_-_neil_shubin.pdf
Your Inner Fish – Neil Shubin p 251
A spasm in one or two of the major nerves that control breathing causes these muscles to contract. **This results in a very sharp inspiration of air. Then, about 35 milliseconds later, a flap of tissue in the back of our throat (the glottis) closes the top of our airway.**

(16) - https://eng.lsm.lv/article/society/health/latvia-tops-european-stats-for-drowning-deaths.a369587/#:~:text=Among%20the%20EU%20Member%20States,)%20and%20Romania%20(3.0).

Latvia tops European stats for drowning deaths / Article (lsm.lv)
Based on 2017 data, around 5,100 deaths of European Union (EU) residents were caused by accidental drowning and submersion.

Among the EU Member States, in 2017 the highest rate was recorded in Latvia, with 5.6 deaths per 100,000 inhabitants, followed by Lithuania (4.8 deaths per 100 000 inhabitants), Estonia (3.2) and Romania (3.0). **Belgie 0.7**

(17) - https://www.tandfonline.com/doi/full/10.1080/10407413.2021.1885979 *In a Heartbeat:* **Prospective Control** of Cardiac Responses for Upcoming Action Demands during Biathlon

These findings provide evidence that biathletes anticipate forthcoming events by prospectively adjusting their heart rate upwards and downwards depending on task demands. **Being able to use perceptual predictive information to optimally prepare the body for challenges that lie ahead, may have implications for expert performance in several different sports, as well as in other fields where purposeful regulation of heart rate is important for success.**

(18) - The diving reflex in rabbit, sheep and newborn lamb and its afferent pathways - ScienceDirect

Abstract: Head immersion under general anesthesia was performed in sixteen newborn lambs, ten adult rabbits and eight ewes in water at different temperatures (6 to 40 °C). Apnea or reduction in respiratory frequency, bradycardia and rise in arterial pressure occurred in all animals although free access to air was maintained through a tracheal cannula.

(19) - (PDF) The Mammalian Diving Response: An Enigmatic Reflex to Preserve Life? (researchgate.net)
The AEN (anterior ethmoidal nerve) is considered the “gatekeeper” nerve by us since it is the first to sense noxious gases or water entering the nasal passages. Indeed, transection of the AEN eliminates the bradycardia and attenuates the apnea and ABP changes to nasal stimulation (210)

(20) - https://link.springer.com/article/10.1007/BF02691277 - B.A. Gooden

Mechanism of the human diving response

The diving response in human beings is characterized by breath-holding, slowing of the heart rate (diving bradycardia), reduction of limb blood flow and a gradual rise in the mean arterial blood pressure. The bradycardia results from increased parasympathetic stimulus to the cardiac pacemaker. The reduction in limb blood flow is due to vasoconstriction resulting from increased activity of the sympathetic nerves supplying arteries in the arms and legs. **Essentially the response is produced by the combination of water touching the face and either voluntary or involuntary (reflex) arrest of breathing.**

(21)- https://www.jstage.jst.go.jp/article/jjphysiol/40/5/40_5_701/_pdf Facial cold receptors and the survival reflex "diving bradycardia" in man

Thus "diving bradycardia" is in fact a basic survival response independent of water.

Facial receptors sensitive to cold seem to be vital in the largest responses observed. The fast response to breath-holding with the face in water of neutral temperature was equal to that in air.

(22) - Cold Water Swimming Webinar with Prof Mike Tipton & Dr Heather Massey (Jan 2021) (youtube.com) https://www.youtube.com/watch?v=1axP_prHezY

Cold Water Swimming Webinar with Prof Mike Tipton & Dr Heather Massey (Jan 2021)

24 [20] **SIPE**, aspiration of water, clothing (pursed lips breathing)
1 [01] **Secundary drowning** (British Journal of Anaesthesia 1997 tot 12 u na het ongeval)

(23) - https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8667218/

The Implications of the Diving Response in Reducing Panic Symptoms

As hypothesized, the CFI (Cold Facial Immersion) task exerted demonstrable anxiolytic effects in the clinical group in this study by reducing heart rate significantly and **lessening self-reported symptoms of anxiety and panic. (Kyriakoulis, 2024)**

(Additional information from the author Peter Kyriakoulis: Participants did not immerse their face in water with nose clip)

.. **Studies have demonstrated that 2 weeks of daily apneic (breath-hold) training increased both the DR (Diving Response) and the duration of breath-hold (Konstandinidou, 2017).**

(24) - https://pubmed.ncbi.nlm.nih.gov/636078/ Effects of varying thermal and apneic conditions on the human diving reflex. D F Speck, D S Bruce 1978

pdf : https://membership.uhms.org/nl-be/uhm-search/undersea-biomedical-research-volume-5/number-1-march-1978/chapter-2-effects-of-varying-thermal-and-apneic-conditions-on-the-human-diving-reflex-pdf.html

Experiments: - control period

- Simple breath-hold
- snorkel control
- Submersion with facial covering (face mask) and nonapnea (snorkel)
- Submersion with facial covering (face mask)
- Nonapneic immersion (snorkel, some with and some without nose clip)
- Apneic immersion
- Ice-bag application with nonapnea
- Ice-bag application with apnea

NOTE*: This study investigates the effect of different applications on some of the aspects of the diving reflex. From recent experiments we know that the ambient temperature is also of importance for the results (difference between air temperature and water temperature), so are the "perceptual predictive information" effects. But we can reasonably assume that the ambient temperature during this experiments was the same, this way the evolution of the data is still valid although the data itself can change with different room temperatures (different skin temperatures).*

We also have to consider the fact that the facial position of the participants during the experiments prevented water entering in the nose, while in other experiments this is not the case (for example the simulating helicopter crashes where participants are upside down in the water). Often kayakers who are turning upside down in the water are mentioning unpleasant "water in the nose" experience, something they don't experience when swimming. The "water in the nose" experience seems to have no effect on the breath holding (apnea), there is also no indication whatsoever that water enters the lungs. We also don't know the effects of the different aspects of a nose clip, it covers parts of the outside of the nose wings (surface also depending on the model), at the same time prevents water entering the nose and also exerts some mechanical pressure on the nose vestibule. What we can conclude from this experiment is that covering parts of the face has measurable significant effects on the resulting diving reflex (the cardio vascular system) and the more facial surfaces we cover the less are the registered effects. We also can notice that the "ice pack" used for facial cooling has a noticeable effect but far less than face immersion in water of 5°C and, in this experiment, can be compared with facial immersion in water of 25 °C (ambient temperature assumed constant).

(25) - https://pubmed.ncbi.nlm.nih.gov/11981669/ Intranasal chemosensory function of the trigeminal nerve and aspects of its relation to olfaction - Thomas Hummel 1, Andrew Livermore

.. The primary function of the intranasal trigeminal system is to act as a sentinel of the airways where they reflexively stop inspiration to prevent inhalation of potentially life-threatening substances.

.. Overall, this indicates that the trigeminal chemoreceptive system exhibits an age-related functional decrease, aspects of which appear to be similar to those of the olfactory system

(26) https://www.academia.edu/74380831/Acute_anxiety_predicts_components_of_the_cold_shock_response_on_cold_water_immersion_before_and_after_repeated_immersion_implications_for_control_of_ventilation?email_work_card=title Acute anxiety predicts components of the cold shock response on cold water immersion before and after repeated immersion: implications for control of ventilation

Moreover, familiarity with the immersion scenario, thereby reducing the associated anxiety with immersion also has a beneficial effect. We showed that repeatedly experiencing the immersion sequence (i.e., repeated thermoneutral water immersion; 35 ◦ C) in the absence of a repeated cold-water stimulus leads to a small but significant reduction in respiratory tidal volume on subsequent CWI (Barwood et al., 2014). Accordingly, we concluded that repeated immersion in thermoneutral water induces a perceptual habituation of the threat posed by imminent immersion and this confers some benefit even when the water temperature is cold.

(27) https://www.gastrojournal.org/article/S0016-5085(11)00349-0/fulltext Protective Role of Aerodigestive Reflexes Against Aspiration: Study on Subjects With Impaired and Preserved Reflexes

Pharyngoglottal Closure reflex; PGCR, Pharyngo-UES Contractile reflex; PUCR, and Reflexive Pharyngeal Swallow; RPS were studied in 15 healthy non-smokers (24.2 ± 3.3 SD y, 7 males) and 15 healthy chronic smokers (27.3 ± 8.1, 7 males).

In summary, this study has shown the direct role of pharyngeal aerodigestive reflexes in protecting the airways. Defective pharyngeal sensory mechanisms resulting in absent RPS seen in the majority of chronic cigarette smokers predispose them to risks of aspiration.

(28) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4160881/#:~:text=Acute%20systemic%20alcohol%20exposure%20inhibits,the%20elicitation%20of%20these%20reflexes. Effect of Systemic Alcohol and Nicotine on Airway Protective Reflexes

Acute systemic alcohol exposure inhibits the elicitation PUCR and RPS.

In this study, we have shown that systemic alcohol exposure to a BAC of 0.1% has an adverse effect on the elicitation of PGCR, PUCR, and RPS. This level is within the legal driving limits of the state where the study was carried out and hence, at this level, we did not expect any major changes in the cognitive, motor, or sensory functions in the individual.

(29) https://www.academia.edu/29461649/Voluntary_Respiratory_Control_and_Cerebral_Blood_Flow_Velocity_upon_Ice_Water_Immersion?

In conclusion, the results of this study indicate that it is possible to attenuate the respiratory component of the cold shock response with beneficial consequences for blood flow to the brain. This experiment was a simple case-control study, and warrants further investigation. Habituation to cold-water immersion and protective clothing are first-choice safety measures. However, it is safe to conclude that education about the effects of sudden cold-water immersion, and especially about respiratory control, should be taught to personnel and people in general who are at risk of accidental cold-water immersion.

(30) https://pubmed.ncbi.nlm.nih.gov/12457045/ Pharyngoglottal closure reflex: characterization in healthy young, elderly and dysphagic patients with predeglutitive aspiration

Conclusions: Pharyngeal stimulation by water induces vocal cord adduction in humans; the pharyngoglottal closure reflex. Although preserved, a significantly larger volume of water is required to stimulate this reflex by rapid pulse injection in the elderly, suggesting some deterioration in this age group. …

(31) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3796769/#R22 Physiology and Pathophysiology of Glottic Reflexes and Pulmonary Aspiration: From Neonates to Adults

Pharyngoglottal Closure Reflex (PGCR) Injection of small amounts of water into the pharynx induces brief vocal cord closure. Slow introduction of graded amounts of fluid into the pharynx causes partial adduction of the vocal cords, whereas rapid injection results in complete closure of the cords.12,22 The threshold volume to stimulate the PGCR reflex appears to be smaller than that required to provoke an irrepressive pharyngeal swallow but similar to that required to induce an increase in resting tone in the UES. Significantly larger fluid volumes are required to trigger the pharyngoglottal closure reflex in elderly versus younger subjects as well as in smokers versus nonsmokers

(32)
https://www.academia.edu/121965563/SPECIFICS_OF_REACTION_OF_HUMAN_CARDIOVASCULAR_SYSTEM_TO_IMMERSION_IN_COLD_WATER

Earlier studies present a detailed description of the types determination method [16]; based on these indicators, we distinguished four types of response: highly reactive, reactive, areactive, and paradoxical (Figure 1). cold-hypoxia test

Thus, adaptation to cold-hypoxia effects decreases reactivity of the cardiovascular system somewhat. However, there were participants whose reactivity did not change after the course; the possible reasons behind this are their individual characteristics, including genetic ones

Conclusion: ...In our opinion, cold hypoxia test (CHT) carried out with ECG recorded and blood pressure controlled, can be very informative for identifying people facing higher risks on the part of the cardiovascular system.

Expanding the field of research

During the course of the research, some surprising aspects came to light which, at first sight, are not directly relevant to our application, but which nevertheless seem interesting enough for further study.

These are mainly specific aspects of the 'inhalation reflex', 'hyperventilation' and 'auto- or self-resuscitation'.

(33) https://www.sciencedirect.com/science/article/abs/pii/S0300957207002055

In the present study, we tested the hypothesis that gasps also increase Carotid blood flow (CBF) during untreated cardiac arrest.

Conclusions: spontaneous gasps produce significant increases in CBF during untreated cardiac arrest. The present study therefore confirmed beneficial effects of gasping during cardiac arrest.

Gasping promotes entry of the air into the lungs, securing greater oxygen and CO2 exchange.

(34) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2951081/

Gasping, also referred to as agonal breathing, often follows cardiac arrest. It is a well investigated phenomenon, having been observed in all mammals.

Gasping is an abnormal ventilatory activity considered to be an “auto-resuscitative” phenomenon. Gasping probably occurs as a response of poor perfusion and/or hypoxia of the brain.

(35) https://www.semanticscholar.org/paper/Gasping-as-a-predictor-of-short-and-long-term-in-a-Guo-Xu/9f17a1091c32a817aa5cb8457eb1b302b7e616ca

https://oss.signavitae.com/mre-signavitae/article/20210223-294/pdf/SV2020102201.pdf

Gasping as a predictor of short- and long-term outcomes in patients with cardiac arrest: a systematic review and meta-analysis

Conclusions: The presence of agonal respirations is positively associated with ROSC (Return of Spontaneous Circulation) , achieving a shockable cardiac rhythm, increasing survival rate to discharge,

and a neurologically favorable 1-year survival. Gasping may play an important role in cardiopulmonary resuscitation (CPR) training.

(36) https://journal.chestnet.org/article/S0012-3692(16)31194-1/abstract
Self-Administered Hyperventilation Cardiopulmonary Resuscitation for 100 s of Cardiac Arrest during Holter Monitoring

An 80-year-old man remained conscious due to vigorous deep breathing during 100 s of ventricular arrest which was recorded on a Holter ECC. Arterial blood flow is considered to have been maintained by changes in intrathoracic pressure produced by deep respiratory movements. This case may represent a pure model of the “thoracic pump” mechanism.
(Chest 1991; 99:1310-12)

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