SAFELY ON THE WATER (recreational kayaking)

proposal V 29 04 2024 E
Translation Dutch /English from Deepl with some changes.

Preparation 9 JUNE 2024 AKKC rescue/self rescue .

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” (Northern Castle). Later the Scheldt and other open air waters became too polluted to swim. 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 remarkable experience being my rescue at the North Sea 3 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 October). During my teenage years (50s/60s) I was not aware of the concept of cold water. 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 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" in connection with "turning upside down" with the kayak is important.

Discussion :

basic / *comprehensive*

- Equipment

    - clothing
    headgear / normal clothing - appropriate clothing - dry suit - wet suit / footwear / under suit - undergarments / *gloves (paddle pogies)*

    - safety equipment
    pfd / *hand torch(s) / whistle / cell phone / vhf radio / PLB (return link) / rope with carabiner / picket / knife / first aid*

    - kayak
    spray deck / paddle (attachment) / pump - sponge / *safety strap (rescue straps) / short loose strap(s) / paddle float(s) / point air bags / safety line / spare paddle*

    - general
    water temperature (cold shock) - *hypothermia / air temperature / sun / wind / night / winter (numb fingers)*

- Paddle

    - paddling technique
    distance between hands / posture / technique / *waves from the back*

    - support
    low brace / high brace / *angle (backward 45°) /*

    - injuries
    shoulder / wrist

- Rescue / Self rescue

    - spray deck
    loop / release techniques / *knee strap / side straps /*

    - PFD

    - *safety line*
    long - short / quick release belt /

- Parts (Oregon Ocean Padling Society) **OOPS certificate**.
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

- empty the kayak

- close spray deck

OOPS CERTIFICATE Part 2

- idem without use splash deck loop

- idem with assisted rescue

Safely on the water.

"Getting on the water safely" 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.

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. So, as a swimmer, it is usually interesting to pick the places with surf 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 (with 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**.

Although one does not have to be able to swim 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 systems that protect us:

"Cold shock" and the "diving reflex," both of which are autonomic 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 heavier the shock and the conflicting signals, the more likely the conflict will result in cardiac arrhythmia's, some of which may be "normal," but they can also become dangerous.
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 ...), old age,.... Also influencing the face and nose sensors by face cream, diving mask, nose clip,... can have an influence.
Practicing both protective systems, the cold shock and the diving reflex, even mildly, can improve effectiveness, and possibly early detection of functional problems, or indicate a functional problem. Getting the face used to cold water occasionally can be done even at home. Practicing breath holding e.g. during light activity (walking e.g.) can also activate parts of the diving reflex. Swimming and some underwater swimming, even in water of 25 / 28 ° C (indoor pool), is already a good exercise. An underwater rollover is then close to a tip over with the kayak. All "cold water" training is very effective and remains effective long after one has stopped training. Practicing tipping the kayak will also reduce stress reactions and thus not interfere with the normal functioning of the autonomic reactions.

We must realize that both systems, the cold shock and the diving reflex, are very individual in their functioning and can be influenced by all kinds of other factors.

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 of going under (dangerous during hyperventilation) by taking support, under the kayak, at the cockpit edge 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 difficult e.g. opening a zipper, opening a hatch, opening a hand torch, opening a watertight container, ... and thus must be provided for (quick action, providing drawing loops, adjusting equipment,...).
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.

Further research and references:

Thanks to:

- Professor Dominique Adriaans, oa 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

Objective:

We limit ourselves to discuss the components of the OOPS (Oregon Ocean Padling Society) "Wet exit certificate" because that seems to us to be the most essential.
https://www.oopskayak.org/resources/Documents/WEC%20Document%2002-13-2024.pdf

Method:

Equipment: kayak, spray deck, PFD, 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

- 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. On 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 underwater with the head

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 dive reflex, consciously breathing in and holding breath, the latter whether by dive reflex or not. Surfacing and exhaling. Hyperventilation and/or "vertigo" (orientation loss) after surfacing is then among the possibilities in cold water.

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" (gasp). If I jump into that same water (feet forward) or dive (head forward) I do not have that inhalation reflex (otherwise I would probably be long drowned).

I also never experienced a pressure to inhale in the first seconds or ten seconds or so after jumping or diving, where in my younger years I would sometimes stay as far underwater as possible. Then sometimes the pressure to exhale did clearly begin 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.

In this last position (partial turning over with high brace) I experienced an immediate "inhalation reflex" 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. 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 overalls of different weight, plain or "thermal" underwear etc). Possibly because of my age, I have become more sensitive to the "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 statement:

- *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 studies whether the "diving reflex" with breath holding (voluntary or by reflex) suppresses or delays the "inhalation reflex" (gasp) from cold shock. So far, research in simulated helicopter crashes (North Sea related) seems to give us some indicative data (5).
Thus, both reflexes are largely opposite and 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 of vigilance to avoid problems afterwards. Especially with salt water, it is watchful.
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. https://blogimages.seniorennet.be/kajak/attach/174568.pdf

(6) 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

References and Notes:

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

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) This study shows why specialists do not tend to rely on the "diving reflex" to suppress the "breathing reflex" caused by "cold shock." They are opposing reflexes, even with regard to breathing, that must do their work correctly and in time or problems will arise.
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.***

Obviously this guideline prevails out of caution but it does not apply to our activity.
The kayaker who turns over must feel the cockpit edge upside down in the water to the loop of the spray deck, then push to release the spray deck, exit the kayak and come to the surface. It is also not unusual for kayakers who can roll to try it a few times before they succeed (or fail), and it can also happen that you, when sailing in a group, stay upside down in the kayak and ask for help by e.g. 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 "cold shock" will be avoided, but there is also a whole variety of suits. Personal health and possibly (cold water) training is also difficult to factor in.

https://journals.sagepub.com/doi/10.1177/00258172211053127 **The experience of drowning**

Here we already have a partial "diving reflex" through voluntary preventive blocking of breathing and possibly anticipation (Prospective Control).

(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.

Summary: 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. 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 as "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

T*he 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.

(6) *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.***

- 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.

- Ziekenhuis St Jansdal
Als noodmaatregel kunt u uw ***handen afsluitend om mond en neus houden en hierin een tijdje in- en uitademen.***

- 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.***

- 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.***

- 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***

- 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.***

- 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.***

- *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.

- *(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)*

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

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.***

- *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.

https://pubmed.ncbi.nlm.nih.gov/8018553/#:~:text=The%20diving%20response%20in%20human,stimulus%20to%20the%20cardiac%20pacemaker.
*"Essentially t**he response is produced by the combination of water touching the face and either voluntary or involuntary (reflex) arrest of breathing."***

- 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)

- 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.***

Paul

AKKC

https://blog.seniorennet.be/kajak/

P M (to study) Chris.Button@otago.ac.nz
https://www.academia.edu/68199497/Behavioural_analysis_of_human_survival_characteristics_following_sudden_water no gasping?

https://onlinelibrary.wiley.com/doi/full/10.1111/j.1600-0838.2005.00440.x