



The Dangers of Cold Water Immersion

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**Cold water
is deadlier
than you think**

Protect yourself from the shock of cold water
by always wearing a lifejacket.

coldwaterkills.com

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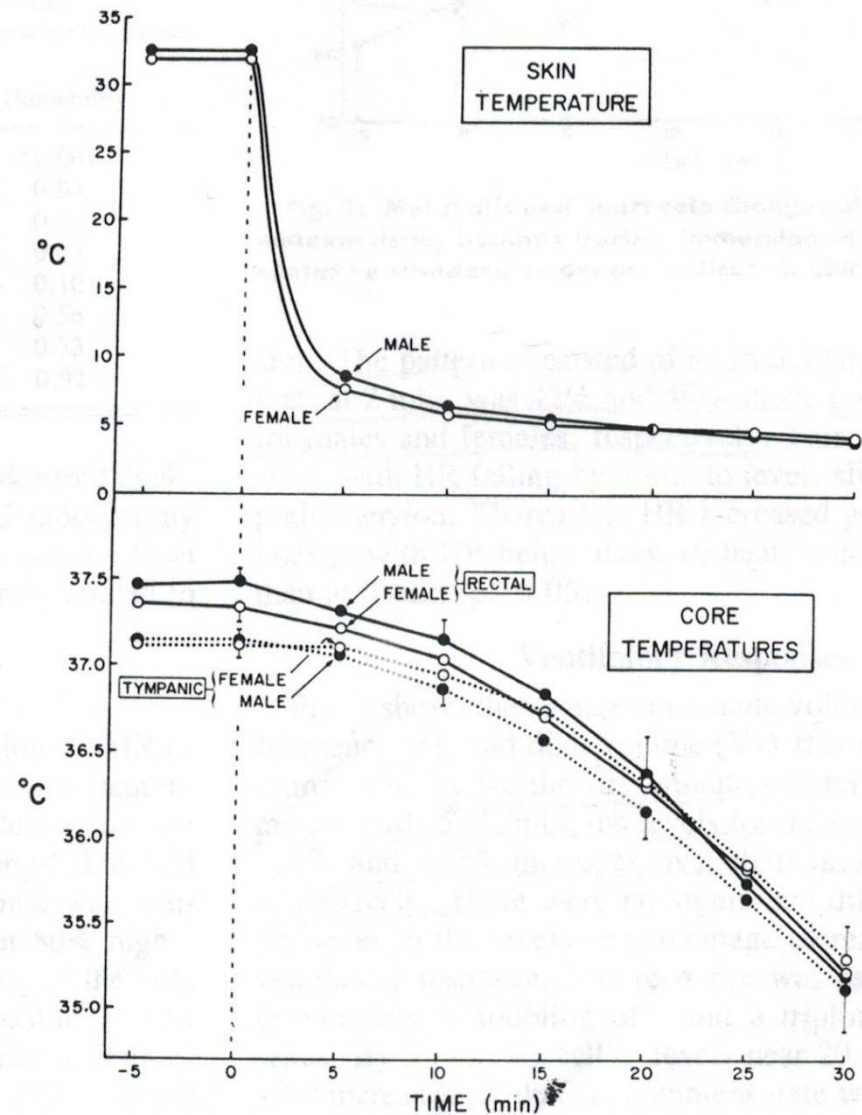
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- Lightly clothed, non-exercising humans in 0°C water.
- After <5 min of immersion skin temp dropped to <10°C.
- Took 30 min for deep body temp to drop below 35.5°C.
- Hypothermia is defined as drop in deep body temperature below 35°C (RCPL, 1966).
- People can die quickly in cold water, less than 10m from shore (Home Office, 1977).



From: Hayward, J.S., and J.D. Eckerson. *Physiological responses and survival time prediction for humans in ice water*. *Aviat. Space Environ. Med.* 1984;55(3):206-12.

4 Stages of Cold Water Immersion

1. Initial immersion (Cold Shock Response).
2. Short term immersion (Swim Failure).
3. Long term immersion (Hypothermia).
4. Circum-rescue collapse (Post-rescue collapse).



Cold Shock Response (CSR)

- Sudden death in cold water not due to hypothermia.
- Series of physiological responses termed the CSR believed to cause the majority of *drowning* deaths (Tipton 1989).
- Triggered by a rapid fall in skin temperature (Keatinge and Nadel, 1965; Goode et al., 1975; Cooper et al., 1976)

CSR Responses

- 4 responses to sudden cold water immersion (Tipton, 1989):
 - A large involuntary gasp.
 - Hyperventilation.
 - Significant increase in heart rate.
 - Constricting of blood vessels.
- First two responses are greatest threat to survival.

- Large involuntary gasp can be as much as 3L over 1.2 seconds (Goode et al., 1975).
- Hyperventilation can be 5x resting values (Hayward and Eckerson, 1984).
- Make it hard to hold your breath in water – increased risk of drowning.
- Cardiovascular components may be fatal with pre-existing heart conditions (Tipton, 1989).

Causes of CSR

- Rapid cooling of the skin – causes thermoreceptors to fire (Goode et al, 1975).
- Superficially located; body fat does not reduce response.
- Greatest CSR is seen when the torso is cooled (Burke and Mekjavic, 1991).

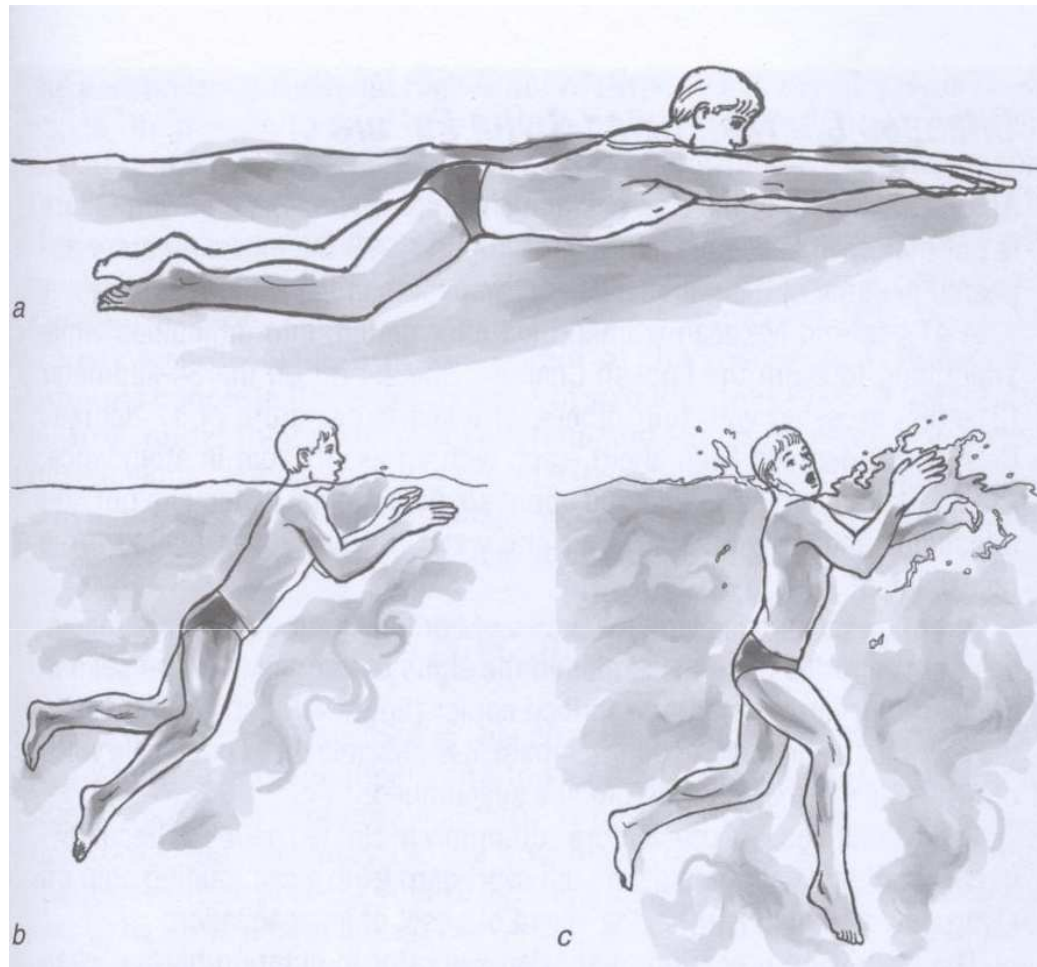
Cold Shock Response Video



Short Term Immersion (Swim Failure)

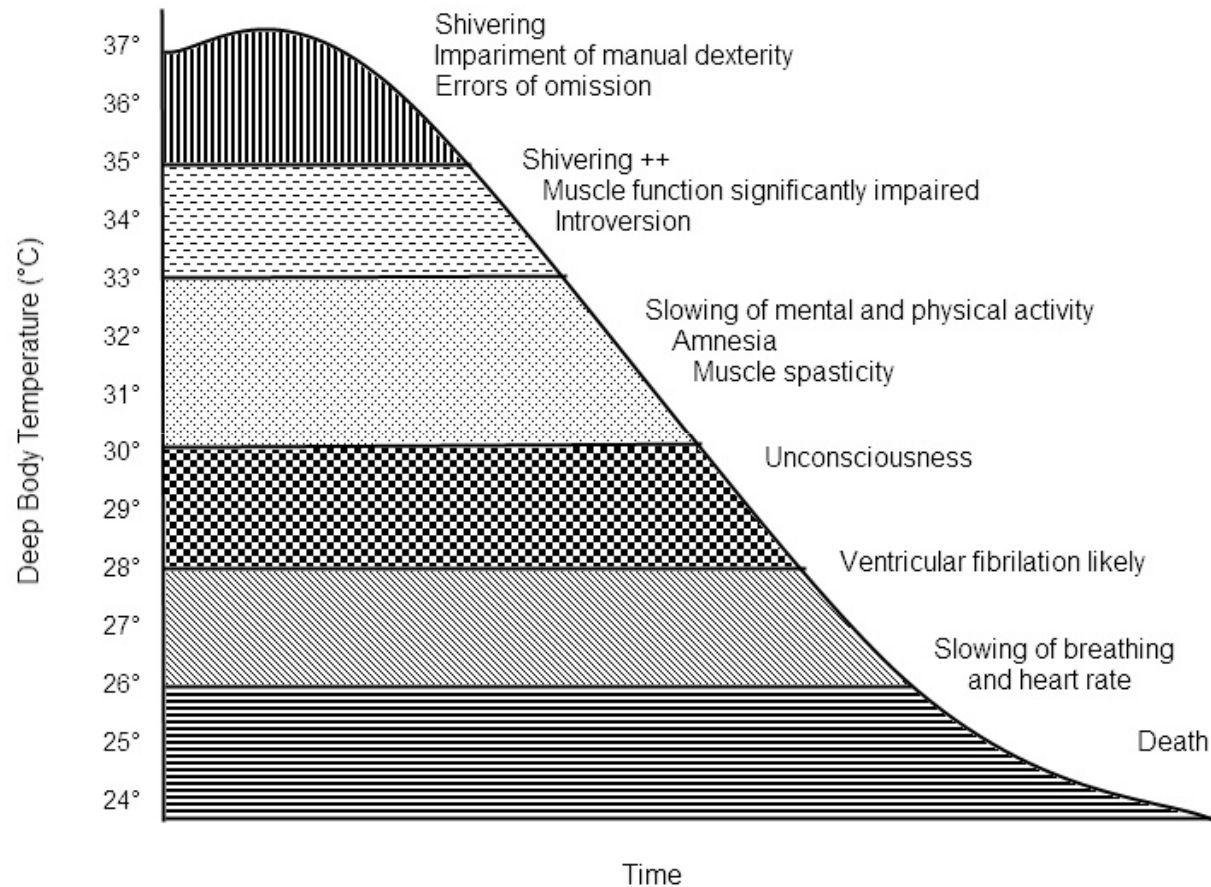
- As skin temp falls, so does muscle, joints, and nerve temps.
- Minimum criteria: 15°C for local skin temperature, nerve temperature of 20°C, and a muscle temperature of 28°C (Heus et al. 1995).
- Exposure of either forearms or hands to cold found to significantly reduce maximum grip strength within 2 minutes (Tipton and Vincent 1988) – MV *Estonia* incident.

- CSR makes coordinating breathing with swimming motions.
 - More upright posture and inefficient swimming.
- Shivering occurs concurrently with swimming motions.
 - Constriction of blood vessels deprives muscles of blood.
 - Numbing effects reduces coordination.
- Even “good” swimmers will experience swim failure in 10°C water (Tipton et al., 1999).
- When around cold water, even close to shore, always wear a lifejacket or PFD.**



Adapted from: Golden, F.St.C., and M.J Tipton. *Essentials of Sea Survival*. Windsor, ON, Canada: Human Kinetics. 2002.

Hypothermia



Adapted from F.S.C. Golden, and M.J. Tipton, *Essentials of Sea Survival*. 2002.

Post Rescue Collapse

- Not a completely understood phenomenon.
- Thought that 20% of immersion deaths happen just before, during, or after rescue.
- Long believed to be due to *after drop* but disproven by Golden and Hervery (1981).
- Likely due to changes in blood volume and stress placed on the cardiac system.
- If recovering someone from the water, best to take them out in a horizontal position.

CSR Reduction

- Max CSR is observed in 10°C water.
 - Lower temps do not produce increased CSR; just feel colder.
- Can habituate to CSR – 6, 3 min immersions in 15°C water (Tipton et al., 1998).
 - Significantly lower CSR in follow up 10°C immersions.
 - Lasts up to 6 months.
- Possibly explains why some people can swim in cold water without severe effects (e.g. English channel swimmers; Polar Bear club.)

Exercise and Staying Warm

- Has been recommended not to exercise in water.
 - Reduced peripheral insulation due to blood perfusion.
- Recent work by Farevik et al. (2010) shows that moderate leg exercise *in insulated immersion dry suits* can increase deep body temperature during immersions.
- People performed leg cycling motions; deep body temp increased over 3h immersion.
- Had a positive effect on subjective perception of thermal comfort.

Manual Dexterity

- Manual dexterity can be lost quickly in cold water (“Lobster Claw”).
- Recent work by MacKinnon and Mallam (2011) showed that still able to perform the required survival tasks in under 2 min, after a 2 min barehanded immersion.
- Prolonged exposure can make it extremely difficult to help in your own rescue (e.g. can’t grab a rope thrown to you).
- Instead of gripping the rope, roll both hands over the rope in the water to tangle it over your arms.
- Then, put your hands together (as if praying), and move both hands in a circular motion so that the rope wraps around your wrists.

Undergarments

- Immersion suits are tested with a defined clothing ensemble.
 - Underwear (short sleeved, short legged).
 - Shirt (long sleeved).
 - Trousers (not woolen).
 - Wool socks.
- Immersion suit`s insulation level (clo value) measured with this ensemble.
- Altering the underclothing will increase or decrease insulation level.

- Specific conditions for human test subjects:

“Each subject shall have had a normal night’s sleep the night before the test, a well-balanced meal 1 to 5 h before the test, and no alcoholic beverages 24h prior to the test” (CAN-CGSB 65.16-2005 section 6.22.2.1.1).

- Low blood sugar and alcohol can decrease the intensity of the shivering response – faster rate of fall in deep body temp (Golden and Tipton, 2002).
- Important to eat normally, be well rested, and abstain from alcohol.

Summary

- CSR thought to be responsible for deaths upon sudden immersion in cold water.
- Swim failure will occur – important to wear lifejackets around open water.
- Can take at least 30min for hypothermia to develop.
- Pre-exposure to cold water can lessen CSR.
- Exercising in insulated, immersion dry suits can help maintain a stable deep body temperature.
- Wearing warmer, layered clothing than what the suit was tested in will provide more thermal protection.

Recommended Further Reading and Watching

Dr. Frank Golden and Professor Michael Tipton—
Essentials of Sea Survival.

Dr. Christopher Brooks —
Survival in Cold Waters: Staying Alive.

<http://www.tc.gc.ca/publications/app/en/corral.asp?itemid=48469&tpnumber=13822&language=US&source=istore>

Dr. Gordon Giesbrecht -
Cold Water Boot Camp.

<http://www.coldwaterbootcamp.com>



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Discussion

Thank-you



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