Cold Water Immersion – Beyond Hypothermia

USCG Auxiliary Paddlecraft Safety Division

Why Worry About Cold Water Immersion?

- Leads to an increased, but preventable, risk of rapid drowning
- Relatively well understood in medical literature but ….
- Few boaters are aware of the full extent of the problem
- Proper preparation is the key to managing the problem

Overview

- Popular beliefs vs. reality
- Defining cold water
- Four types of cold water immersion problems
- Methods to mitigate each type of problem
- Implications for individual boaters and boating programs

Risk Management Approach

- Anticipate problems
- Take steps to prevent problems
- Manage problems while they happen
- Mitigate the outcome after problems happen
- Learn from the problems
  - It's good to learn from your mistakes – but it's better to learn from someone else's mistakes

Popular (But False) Beliefs

- Hypothermia is the major risk in cold water
- You'll die of hypothermia in a few minutes if you fall into cold water
- You don't need a wetsuit or drysuit unless the combined air and water temperatures are 120 F or less
- Cold water is really cold

Reality

- There are several major cold water immersion problems
- Most cold water deaths are likely not due to hypothermia – they're due to drowning
- Even in ice water, loss of consciousness or death due to hypothermia takes time
- The "120" rule makes no sense
- "Cold" water is not very cold

How Cold Is Cold Water?

- Olympic pools are 78-82 F
- Cold water defined as 70 F or less
- Temperature decreases, risk increases
- Cold water can be immediately life threatening - unless you're prepared

Swiftwater rescue training – swimming in cold water

Cold Water Immersion Syndromes

- Adverse affects to the body upon exposure to cold water
  - Cold shock response
  - Cold incapacitation
  - Hypothermia
  - Circum-rescue collapse

Cold Shock Response (Cold Shock, Cold Water Shock)

- Immediate, reflexive response
- Typically lasts one to five minutes
- Colder water = higher risk of occurring
- Rapidly reaches maximum effect

Cold Shock Response (Cold Shock, Cold Water Shock)

- Sudden gasping - breathing rate could increase 10x and breath holding time could decrease 4x or more
- Elevated pulse and blood pressure
- Panic
- Pain
- Loss of coordinated motion – difficulty swimming

Cold Incapacitation

- Extremities cool and lose function; subjects lose fine muscle coordination at first and then lose gross muscle coordination
- Swim failure can happen in as little as ten minutes; fine motor skills are lost more quickly
- Without flotation, drowning then results from swim failure

Hypothermia

- Core body temperature 95 F or less
- Mild – shivering, decreased physical ability, decreased mental ability including worsening judgment
- Moderate – shivering stops, subjects become lethargic or unconscious
- Severe – subjects are unconscious, vital signs reduced or absent, subject to spontaneous heart dysrhythmias and death

Circum-rescue Collapse

- Collapse around the time of rescue
- Ranges from fainting to cardiac arrest
- May be associated with loss of hydrostatic pressure supporting the subject's blood pressure
- Important to be prepared for loss of consciousness
- Gently remove subject from the water, keeping them horizontal; avoid rough treatment
- Warm based on current medical guidelines

What happens when you fall in to cold water? What do you do about it?

- Cold shock response
  - Get to the surface quickly and keep your head above the surface
  - Regain control of breathing and reduce panic
  - Stay Afloat! – *Dramatically easier with a lifejacket! Generally recommended to try and float on your back*

What happens when you fall in to cold water? What do you do about it?

- Take critical survival steps as soon as possible and self rescue to the extent possible
- Avoid thrashing; move purposefully
- Each situation is different – secure PFD, swim for safety if very close by, activate PLB, call for help, climb onto debris, secure your survival suit…

What happens when you fall in to cold water? What do you do about it?

- As you lose coordination and strength, cold incapacitation develops
- Conserve heat – HELP & HUDDLE
  - Try these postures after you've done everything else and can't do anything else - now you're depending on someone else for rescue

HELP – Heat Escape Lessening Posture

HUDDLE

What happens when you fall in to cold water? What do you do about it?

- Ultimately, hypothermia, unconsciousness and death
- Before unconsciousness, loss of muscle control will make aspiration more likely, particularly if there are any waves
- Flotation and thermal protection are critical

What we don't know…

Research vs. Real World – what if you're already cold and wet?

- Poor judgment – probably more likely to swim
- Early aspects of cold incapacitation – probably more likely to swim
- Probably faster onset of cold incapacitation after immersion
- Almost certainly less self rescue ability
- Already on the way to hypothermia

What we do know – reality is worse…

- Cold Shock vs. Laryngospasm
  - Cold Shock makes you gasp
  - Laryngospasm happens when you gasp in water and, in response, the airway spasms shut
  - Research into Cold Shock tries to keep the research subject's head above water
  - In reality, that gasp could occur underwater

What we do know – reality is worse…

- Cold Shock vs. Mammalian Diving Reflex
  - Cold Shock seems to be induced by suddenly exposing the torso to cold water
  - Mammalian Diving Reflex is a phenomenon that leads to decreases in pulse and respiratory rate. It appears to be induced by exposing the face to cold water while breath holding; impact on adults varies
  - One mechanism increases pulse and breathing rate, the other decreases it – the conflict may lead to heart attack or stroke

What we do know – reality is worse…

- Flush drowning
  - Drowning occurring to a subject wearing a life jacket and not entrapped or otherwise held underwater
  - Term is not medically recognized but is widely used by paddlers
  - Believed to be due to repeated aspiration of small amounts of water
  - Cold incapacitation likely increases the risk due to decreased airway control

How Can We Prevent The Problems?

- Don't go in the water – take steps to avoid capsize and falls overboard
  - Pay attention to weather and water conditions
  - Boat under control and choose calmer venues to avoid spray, waves and unexpected entry to the water
  - If you're cold, put on more clothes before you get in the water

How Can We Prevent The Problems?

- Pay attention when people swim
  - The first capsize or fall overboard might not be the problem – but it might lead to a second and third event, ultimately creating a victim
- Dress to swim
  - Wear your lifejacket
  - Wear proper clothing for water temperature – test your gear before you need it, in venue
  - Consider the situation, bring appropriate rescue and communication equipment

Dressing to Swim

- Wear your lifejacket – consider how it will fit over more warm clothes
- Wear proper clothing
- Consider how to add layers or warmth without taking off what you have on
- Conditions matter – an offshore sea kayaker typically has to be prepared for longer immersion than a whitewater paddler

Clothing Options

Drysuit

Strengths and limitations

- Waterproof and windproof
- Vary layers of insulation, allowing use over wide temperature ranges
- Perfect for frequent immersion
- More fragile than wetsuits
- Expensive

Clothing Options

Wetsuit

Strengths and limitations

- Varying weights
- Varying coverage (full, farmer john, shorty, …)
- Provides padding, flotation and impact protection
- Less protection from convective heat loss

Clothing Options

Splash Gear

Strengths and limitations

- Lightweight foul weather gear; not watertight
- Vary amount of underlying insulation based on conditions
- Not as warm as other options
- Only appropriate for milder conditions

Hand protection

- Options include pogies (see next slide), gloves and mittens
- For mittens and gloves, neoprene is a good choice
- Thicker material provides more protection
- Thicker material makes it harder to hold a paddle

Hand protection

- Pogies are mittens that wrap around a paddle shaft, allowing bare skin contact with the paddle
- Many paddlers find these the warmest and most comfortable option while paddling
- Unfortunately, they provide no protection if you let go of the paddle
- Consider wearing or carrying thin neoprene gloves in addition to pogies

Head protection

Footwear

Rendering Aid for Yourself and Others

- Can you get back aboard or to some other safe (and warm) place?
- Can you get someone else back aboard and/or to a safe, warm place?
- Can you manage the vessel without their help?
- Can you signal for help?
- Can you provide appropriate first aid?
- Are you carrying appropriate survival equipment?

Take Home Messages

- "Cold water" is defined as 70 F or less. The colder the water, the more likely a problem will occur
- Cold Shock occurs in the first few minutes of cold water exposure, causing gasping and panic
- Cold Incapacitation occurs as extremities cool, leading to inability to use extremities
- Hypothermia eventually happens, but it can take hours to lead to unconsciousness

Take Home Messages

- Circum-rescue collapse can make things worse – don't rescue the subject just to make them worse off
- Remember that subjects can suffer from one, two, three, or all four conditions
- You don't have to go in the water to suffer from cold related illnesses – so take steps early (e.g., add more clothing, get off the water, or change the paddling venue) to keep from getting colder

Take Home Messages

- Prevent the problems – because they can happen to any of us
  - Don't capsize or fall overboard – but be prepared for it to happen
  - Dress to swim in the water conditions
  - Remember that thermal protection and flotation do no good if not worn
- Know how to respond to the problems

Helpful Websites

- https://awls.org/wilderness-medicine-case-studies/surviving-cold-water-immersion/
- Cold Water Boot Camp

  http://www.coldwaterbootcamp.com/pages/home.html
- Beyond Cold Water Boot Camp https://beyondcoldwaterbootcamp.com/
- Four phases of cold water response (including circum-rescue collapse) https://www.youtube.com/watch?v=8nH3i7Fv5IU (presentation by Dr. Gordon Giesbrecht, one of the world's leading experts on the topic)

Helpful Videos

Illustration and discussion of CSR can be found in a number of videos

- https://www.youtube.com/watch?v=_96YEPAdA2Y (shows the response in 10 C water)
- https://www.youtube.com/watch?v=0gd6QC2Emrc (quick overview)
- https://vimeo.com/427683058 (more in-depth discussion by one of the world's experts)
- https://www.youtube.com/watch?v=8nH3i7Fv5IU (another in-depth discussion by another world expert)

Questions?

Research

- **Barwood M, Corbett J, Massey H, McMorris T, Tipton M and Wagstaff C** (2018) *Acute anxiety predicts components of the cold shock response on cold water immersion: Toward an integrative psychophysiological model of acute cold water survival.* Frontiers in Psychology. v. 9 pp 510. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5904285/
- **Bowes H, Eglin C, Tipton M, and Barwood M** (2016) Swim performance and thermoregulatory effects of wearing clothing in a simulated cold water survival situation. *European Journal of Applied Physiology* v. 116, pp. 759-767. https://link.springer.com/article/10.1007/s00421-015-3306-6
- **Cheung S, Montie D, White M and Behm D** (2003) Changes in manual dexterity following short term hand and forearm immersion in 10 degrees C water. *Aviation, Space and Environmental Medicine* v. 74(9) pp. 990-993. https://pubmed.ncbi.nlm.nih.gov/14503680/
- **Datta A and Tipton M** (2006) Respiratory responses to cold water immersion: neural pathways, interactions, and clinical consequences, awake and asleep. *Journal of Applied Physiology* v. 100 pp 2057-2064. https://journals.physiology.org/doi/pdf/10.1152/japplphysiol.01201.2005

Research

- **Ducharme MB and Lounsbury DS** (2007) Self-rescue swimming in cold water: the latest advice. *Applied Physiology Nutrition and Metabolism* v. 32(4), pp. 799-807. http://www.nrcresearchpress.com/doi/full/10.1139/H07-042
- **Farstad, DJ and Dunn, JA** (2019) Cold water immersion syndrome and whitewater recreation fatalities. Wilderness and Environmental Medicine v. 30(3), pp. 321-327. https://www.wemjournal.org/article/S1080-6032(19)30058-4/fulltext
- **Ferrero F** (2006) Whitewater Safety and Rescue 2nd ed. Pesada Press. 298 pages.
- **Franks CM, Golden FS, Hampton IF** and **Tipton MJ** (1997) The effects of blood alcohol on the initial responses to cold water immersion in humans. European Journal of Applied Physiology and Occupational Physiology v. 75(3) pp. 279-281. https://www.ncbi.nlm.nih.gov/pubmed/9088850

Research

- **Giesbrecht GG** and **Steinman AM**. Immersion into cold water. In: Auerbach PS, editor, Wilderness Medicine 6th ed. (2012) Elsevier. pages 143–170.
- **Giesbrecht GG** and **Hayward JS** (2006) Problems and complications with cold-water rescue. *Wilderness and Environmental Medicine* v. 17, pp. 26-30. https://beyondcoldwaterbootcamp.com/images/stories/downloads/ProblemsWithColdRescueWEMJ.pdf
- **Giesbrecht GG** and **Wilkerson JA** (2006) Hypothermia, Frostbite and Other Cold Related Injuries 2nd ed. Mountaineers Books. 160 pages.
- **Golden F and Tipton M** (2002) Essentials of Sea Survival. Human Kinetics. 320 pages.
- **Golden F**, **Hervey G** and **Tipton M** (1991) Circum-Rescue Collapse: Collapse, sometimes fatal, associated with rescue of immersion victims. *Journal of the Royal Navy Medical Services* v. 77, pp. 139-149.

Research

- **Gueritee J, Redortier B, House JR** and **Tipton MJ** (2015) Thermal comfort following immersion. *Physiology and Behavior* v. 139 pp. 474-481 https://www.sciencedirect.com/science/article/abs/pii/S0031938414006192
- **Gueritee J, Redortier B, House JR** and **Tipton MJ** (2015) The determinants of thermal comfort in cold water. Scandinavian Journal of Medicine and Science in Sport v.25 issue 5 pp. E459 - e471. https://onlinelibrary.wiley.com/doi/10.1111/sms.12360
- **Hayward J, Eckerson J and Collis M** (1975) Effect of behavioral variables on cooling rate of man in cold water. *Journal of Applied Physiology* v. 38(6) pp. 1073-1077. https://pubmed.ncbi.nlm.nih.gov/1141120/
- **Joost JL, Bierens M, Lunetta P, Tipton M** and **Warner DS** (2016) Physiology of Drowning: A Review. *Physiology* v. 31, pp. 147-166. https://www.physiology.org/doi/10.1152/physiol.00002.2015

Research

- **Panneton WM** (2013) The Mammalian Diving Reflex: An Enigmatic Reflex to Preserve Life? *Physiology* v. 28(5), pp. 284-297. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3768097/
- **Research and Technology Organization**, North Atlantic Treaty Organization (2007) Survival at Sea for Mariners, Aviators and Search and Rescue Personnel. 178 pages. http://www.dtic.mil/dtic/tr/fulltext/u2/a485550.pdf.
- **Saycell J, Lomax M, Massey H** and **Tipton M** (2018) Scientific rationale for changing lower water temperature limits for triathalon racing to 12C with wetsuits and 16C without wetsuits. *British Journal of Sports Medicine* v. 52(11), pp. 702-708. https://bjsm.bmj.com/content/52/11/702.full
- **Schimelpfenig T** and **Padgett J** (2012) NOLS Wilderness Medicine Field Guide 5th ed. National Outdoor Leadership School. 83 pages.
- **Schnitzler C, Button C, Seifert C, Armbrust C and Croft J** (2017) Does water temperature influence the performance of key survival skills? *Scandinavian Journal of Medicine and Science in Sports.* v. 28(3) pp. 928-938. https://onlinelibrary.wiley.com/doi/abs/10.1111/sms.12997

Research

- **Shattock MJ** and **Tipton M** (2012) "Autonomic conflict": a different way to die during cold water immersion? *Journal of Physiology* v. 14, pp. 3219-3320. https://physoc.onlinelibrary.wiley.com/doi/10.1113/jphysiol.2012.229864
- **Tipton M** (1989) The initial response to cold water immersion in man. Clinical Science v. 77 pp. 581-588. https://pubmed.ncbi.nlm.nih.gov/2691172/
- **Tipton M** (2003) Cold water immersion: sudden death and prolonged survival. *The Lancet* v. 362 pp. S12-S13 https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(03)15057-X/fulltext
- **Tipton M** and **Bradford C** (2014) Moving in extreme environments: open water swimming in cold and warm water. *Extreme Physiology and Medicine* v. 3(12). https://extremephysiolmed.biomedcentral.com/articles/10.1186/2046-7648-3-12.

Research

- **Tipton MJ**, **Collier N**, **Massey H**, **Corbett J and Harper M** (2017) Cold water immersion: kill or cure? *Experimental Physiology* v. 102(11) pp. 1335-1355. https://physoc.onlinelibrary.wiley.com/doi/full/10.1113/EP086283
- **Tipton MJ**, **Eglin C**, **Gennser M** and **Golden F** (1999) Immersion deaths and deterioration in swimming performance in cold water. *Lancet* v. 354(9179) pp. 626-629. https://www.ncbi.nlm.nih.gov/pubmed/10466663
- **Tipton MJ**, **Eglin C** and **Golden FC** (1998) Habituation of the initial responses to cold water immersion in humans: a central or peripheral mechanism? *Journal of Physiology*. v. 512(2) pp. 621-628. https://physoc.onlinelibrary.wiley.com/doi/full/10.1111/j.1469-7793.1998.621be.x

Research

- **Tipton MJ**, **Mekjavic IB** and **Eglin CM** (2000) Permanence of the habituation of the initial responses to cold-water immersion in humans. *European Journal of Applied Physiology* v. 83(1) pp. 17-21. https://link.springer.com/article/10.1007%2Fs004210000255
- **Tipton MJ** and **Vincent MJ** (1989) Protection provided against the initial responses to cold immersion by a partial coverage wet suit. *Aviation, Space and Environmental Medicine*. v. 60(8), pp. 769-773. https://www.ncbi.nlm.nih.gov/pubmed/2775133
- **Transport Canada** (2003) Survival in Cold Waters. http://www.tc.gc.ca/eng/marinesafety/tp-tp13822-menu-610.htm
- **Vincent MJ** and **Tipton MJ** (1988) The effects of cold immersion and hand protection on grip strength. *Aviation, Space and Environmental Medicine* v. 59(8) pp. 738-741. https://www.ncbi.nlm.nih.gov/pubmed/3178622

Research

- **Vybiral S, Lesna I, Jansky L** and **Zeman V** (2004) Thermoregulation in winter swimmers and physiological significance of human catecholamine thermogenesis. *Experimental Physiology* v. 85(3), pp. 321-326. https://physoc.onlinelibrary.wiley.com/doi/10.1111/j.1469-445X.2000.01909.x
- **Zafren K** *et al.,* (2014) Wilderness Medical Society Practice Guidelines for the Out-of-Hospital Evaluation and Treatment of Accidental Hypothermia: 2014 Update. *Wilderness and Environmental Medicine*, volume 25, pp. S66–S85. https://www.wemjournal.org/article/S1080-6032(14)00283-X/fulltext
- **Zafren K** and **Giesbrecht G**. (2014) State of Alaska Cold Injuries Guidelines. Juneau, AK: State of Alaska.

Research

- http://www.beyondcoldwaterbootcamp.com/
- http://www.coldwaterbootcamp.com/pages/home.html
- http://www.seagrant.umn.edu/coastal_communities/hypothermia
- https://awls.org/wilderness-medicine-case-studies/surviving-cold-water-immersion/