A lifetime inspired by the ocean:

marine environmental effects on human physiology

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A lifetime inspired by the ocean
BRADYCARDIA, VENTRICULAR PAUSES, SYNCOPE, AND SPORTS

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Summary 16 athletic patients were examined because of syncope, Stokes-Adams attacks, or both. The life-threatening condition required pacemaker implantation in 7 patients. 8 of the 9 other subjects became symptom-free after stopping heavy physical training. 37 top-ranking athletes underwent 24 h Holter monitoring. Pauses longer than 2 s occurred in 19% and resulted from sinus arrest. The longest pause lasted 2.5 s. Second-degree atrioventricular block was noted in 13%.

Introduction

PACEMAKER patients younger than 40 years old are rare. In our institution only 9 of 255 first implantations in 1981, 7 of 244 in 1982, and 6 of 222 in 1983 were done in patients younger than 40. In the past few years we have examined several young, healthy sportsmen and women with bradycardia, ventricular pauses, and syncope. We have compared these “athletic patients” with two out-of-hospital groups of “normal” athletes.
A lifetime inspired by the ocean

“Deckmate on Cast Otter”
“A lifetime inspired by the ocean”

Helmsman Admiral’s Cup, Transatlantic races and Whitbread Round the World Race
“A lifetime inspired by the ocean”
Faculty of Medicine and Health Sciences

Biggest Faculty: 6000 Students and 24 Departments

Department of Movement and Sport Sciences
Research
“Cardiorespiratory and metabolic responses during exercise and microvascular oxygen extraction”

Gasanalysis  Blood flow  Oxygen extraction  Muscle activation

Ergospirometrie  Echo Doppler  NIRS  Electromyography
Research project “Olympic Dinghy Sailing”

(Callewaert et al. 2013)


M. Callewaert, J. Boone, B. Celie, D. De Clercq, J. Bourgois. Indicators of sailing performance in dinghy sailing. *European Journal of Sport Science*. 2014 (Accepted for publication)
Expertise of our research group

(Wilmore, Costill & Kenney, 2008)
Marine exercise physiology

**Professor Mike Tipton**

**Qualifications:** PhD

**Role Title:** Professor of Human & Applied Physiology

**Area:** Environmental and occupational physiology

**Department:** Department of Sport & Exercise Science

**Laboratory:** Extreme Environments Laboratory

**Faculty:** Faculty of Science

**University:** University of Portsmouth (UK)


Human Kinetics ISBN 9780736002158
Marine exercise physiology: a new research line

Beach lifeguarding

Performance of cardiopulmonary resuscitation in beach lifeguards

Marine exercise physiology: a new research area

Safety in watersports

Safety Management (SAM)

Marine exercise physiology: a new research area

Survival at sea: human factors of surviving

1. Minimum occupational fitness requirements for rescue services

2. Minimum occupational fitness standards for offshore industry, pilot boats and research vessels

3. Marine environmental effects on human physiology!
Marine environmental effects on human physiology
“A marine science worker is paid to bring a specific skill to a problem. If that problem lies in warm, tropical water or in a marine park, fine. But more likely, the problem will yield only to prolonged study in an uncomfortable, cold, or dangerous environment.”
Working in extreme environments

Human thermoregulation

→ Heat and humidity

Physiological responses

→ Cold and wind

Health issues

Preventive strategies

“Physiology of cold water immersion”
‘Humans’ belong to a group of animals called ‘homeotherms’ and can be thought of as ‘tropical animals’.

HEAT GAIN ≈ HEAT LOSS

Adjustments to hot environments
≈ ‘Physiological’ thermoregulation

Adjustments to cold environments
≈ ‘Behavioral’ thermoregulation
Heat and humidity

Heat stress can be defined as any environmental condition that causes gain of body heat that threatens homeostasis.
Hyperthermia

1. Increased blood and internal temperature

2. Increased temperature is sensed by the hypothalamus

3. Vasodilation occurs in skin blood vessels so more heat is lost from the skin.

4. Sweat glands become active, increasing evaporative heat loss.

5. Body temperature decreases.

(Wilmore, Costill & Kenney, 2008)
Warning signs:
- Nausea
- Chills, goose bumps
- Headache
- Fatigue
- Excessive thirst
- Profuse sweating
- Painful large muscle cramps

Heat illness:
- Heat cramps
- Heat exhaustion
- Heatstroke

Increasing severity

(Wilmore, Costill & Kenney, 2008)
Recommendations for Counteracting Heat and Humidity

→ Consult weather reports: air temperature and humidity.

→ Limit duration and severity of exposures to heat and humidity.

→ Wear lightweight clothing, loose-fitting and porous to allow skin cooling via evaporation of sweat and dry heat loss (radiation and convection).

→ Look for sun protection (porous cap, sun glasses, high quality protection cream, ...)

→ Prevent water depletion and salt depletion:
  - check hydration status: body weight and urine color*** (morning after waking);
  - select foods and beverages for NaCl replacement.

→ Avoid alcohol.

→ Recognize warning signals of heat illnesses and look for appropriate treatment.
Recommendations for Counteacting Heat and Humidity

The Urine Color Chart shown here will assess your hydration status (level of dehydration) in extreme environments. To use this chart, match the color of your urine sample to a color on the chart. If the urine sample matches #1, #2, or #3 on the chart, you are well hydrated. If your urine color is #7 or darker, you are dehydrated and should consume fluids. See Chapter 2 for details.

The scientific validation of this color chart may be found in the International Journal of Sport Nutrition, Volume 4, 1994, pages 265-279 and Volume 8, 1998, pages 345-355.

(Armstrong, 2000)
Cold and wind

Cold stress can be defined as any environmental condition that causes loss of body heat that threatens homeostasis.
Hypothermia

1. Decreased blood and/or skin temperature

2. Decreased blood sensed by the hypothalamus.

3. Vasoconstriction occurs in skin blood vessels so less heat is lost to the environment.

4. Skeletal muscles are activated, causing shivering, which increases metabolism and generates heat.

5. Body temperature increases.

(Wilmore, Costill & Kenney, 2008)
Vasoconstriction in the hand: manual function and sensitivity?

\[ T = 9 ^ \circ C \]

Infrared image \( \rightarrow \) Peripheral temperature
Cold induced vasodilatation (CIVD) of finger vessels causes rises in tissue temperature

→ Mechanisms of CIVD?
   - Axon reflex?
   - Vasodilatory substances in the blood?
   - Control via norepinephrine?
   - Direct effect of cold on cutaneous vasculature (AVA’s)?

→ Trainability of CIVD?
   - No.

→ Requirement CIVD?
   - Maintaining deep body $T^\circ$.

(Cheung, 2010)
Cold injury: hypothermia

Golden & Tipton, 2002
Cold-Dry injuries (especially extremities)

Frostnip
- Outer layer of the skin is frozen.

Frostbite
- Continued cooling and freezing of cells, leading to tissue death.

Causes of frostnip and frostbite:
- low air T° & windchill;
- exposed skin, moisture on skin;
- poor insulation, moisture in clothing, tight clothing;
- direct contact with supercooled metal or liquid...

Source: www.mounteverest.net
Source: www.theadventuremedic.com
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**Very low**
Freezing is possible, but unlikely

**Likely**
Freezing is likely > 30 min

**High**
Freezing risk < 30 min

**Severe**
Freezing risk < 10 min

**Extreme**
Freezing risk < 3 min

(Wilmore, Costill & Kenney, 2008)
Cold-Wet injuries (especially extremities)

Chilbain
Damage to superficial blood vessels.  
Local edema and inflammation.
Source: www.homeopathyworldcommunity.com

Pernio
Continuation chilblain.  
Initiation of skin necrosis.
Source: dermis.multimedica.de

Trench/Immersion foot
Severe damage to local vasculature and likely nerves.
Source: adenosinetriesphosphate.tumblr.com

Causes of chilblain, pernio and trenchfoot:  
- prolonged immersion in cold water;  
- trenchfoot: exposure (>12h) of wet feet to T° 0,5 – 10°C.
Recommendations for Counteracting Cold and Wind

→ Consult weather reports: air temperature and windchill.

→ Limit the duration and severity of exposures to cold air.

→ Wear multiple layers of light, loose-fitting and breathable clothing:***
  - that insulates the skin with trapped air;
  - that provides protection from wind and rain.

→ Oil-based lotions (i.e. vaseline,...) can protect face, hands and ears from exposure. Don’t use water-based lotions (wet the skin and increasing likelihood of cold injuries).

→ Proper hydration and carbohydrate rich diet.

→ Avoid alcohol.

→ Recognize cold injuries and look for appropriate treatment.
- Polyester/Polypropyleen
- Merino wool
- Fleece – Wool
- – Polyester
- GORE-TEX®
Cold water immersion

Source: www.lifesaving.us
Did you ever fall into cold water?

Source: coldwaterbootcampusa.org

Source: kayakdave.com
Get out of the water before you die!!!
“Public Knowledge Regarding Cold Water Immersion”

Questions

1. “If you fall into ice water, with regular winter clothing on, how long do you think it would take to become hypothermic?”

2. “How long until cold water immersion is life threatening?”

(Giesbrecht & Pretorius, 2008)
Survival time: hypothermia

(Hayward, 1975)
Think you’re a good swimmer? It may not matter if you suddenly and unexpectedly end up in the frigid coastal and inland waters. Every year, dozens of swimmers and boaters drown in lakes, rivers and coastal waters.

But it may surprise you that many victims don’t die as a result of poor swimming skills or the effects of hypothermia, but from the immediate effects of cold water immersion, or cold water shock.

(Coast Guard News, 2007)
Physiological considerations: humans are homeotherms

→ **Thermoneutral water temperature** (naked person): 35 – 35.5 °C
  = environmental temperature at which the body can simply maintain normal deep body temperature

→ **Thermal conductivity:**
  = individuals cool 4 – 5 times faster in water compared to air at the same temperature.

→ **High density of water:**
  = head-out immersion in thermoneutral water can produce profound physiological alterations in the circulation, heart, lungs (respiration), and the gut.
Cold water immersion/submersion

- **Initial responses: 3 - 5 minutes**
  Skin cooling

- **Short term responses: 5 - 30 minutes**
  Superficial nerve and muscle cooling

- **Long term responses: > 30 minutes**
  Deep tissue cooling

- **Post immersion:**
  Deep tissue cooling

(Golden & Hervey, 1981; Golden & Tipton, 1981 & 2002; Tipton et al., 1999; Tipton & Golden, 2006; Mantoni et al., 2007; Shattock & Tipton, 2012)
Recommendations for Surviving Cold Water Immersion

→ Cold shock protection:
  - protective clothing;
  - auto-inflating lifejacket;
  - habituation (physiological & psychological [anxiety]);
  - aerobic fitness.

→ Prevent swimming failure:
  - make your decision to swim or not early during immersion, directly after cessation of the cold shock responses.

→ Decrease the rate of heat loss*** to prevent hypothermia by:
  - heat escape lessing position (HEAT);
  - huddling in small group(s).

→ Avoid rescue collapse during rescue and transportation***.
Recommendations for Surviving Cold Water Immersion

Decrease the rate of heat loss!

Avoid rescue collapse during rescue and transportation!

“HELP”

“HUDDLE”

Source: www.hunter-ed.com
Working in extreme environments

Thermoregulation

Sleep                        Seasickness
A lifetime inspired by the ocean:
marine environmental effects on human physiology

Thank you!