The Effect of Water Temperature on Aquatic Exercise
June M. Chewning, MA
june@FitnessLearningSystems.com

Water has many affects on the human body:
- Submersion (hydrostatic pressure, buoyancy, and gravity all acting on the body)
- Cardiovascular responses
- Renal responses
- Oxygen consumption
- Endocrine responses
- Psychological responses
- Recovery
- Decreased body mass
- Pulmonary responses
- Immersion in Water
  - Human dive response (face in) has an oxygen-conserving effect on the body.
  - Increases cardiac output for a given oxygen consumption.
  - Preload of atrium, stroke volume increases.
  - Total peripheral resistance drops causing improved venous return.
- Immersion in Water continued…
  - Increased perfusion and absorption of O2 in the lungs.
  - Decrease in heart rate at a given oxygen consumption.
    - Individual
    - Dependant on depth of immersion

Cold Responses
- Peripheral vasoconstriction (except head)
- Increase of flux in deep veins
- Lower blood pressure
- Shivering
- Eventual impairment of function
- Death
- Cold responses are moderated by factors that influence heat production and heat loss: (Stocks et al)
  - Severity of cold
  - Duration of exposure
  - Accompanying exercise
  - Magnitude of metabolic response
  - Body composition
  - Age
  - Gender

Cold Responses in the Aquatic Environment
- Same basic physiological responses to cold in water as in air.
- Typically we exercise in water that is lower than thermo neutral. Due to convection, water cools the body faster than air- accelerates the process.
- Higher heat loss in cold water when body is actively, and especially passively pre heated. (Scot et al)
- Cold water temperature stimulated post exercise energy intake.
  - 33 C / 91 F (neutral) and 20 C / 68 F (cold).
  - Submersed cycle ergometer.
  - Water temperature is a factor in aquatic exercise programs for weight loss. (White et al)

Heat Responses
- Increase in heart rate/ cardiac load
- Loss of heat and fluid through evaporation. (release of ADH to increase water reabsorption)
- Dehydration
- Loss of heat through radiation
- Eventual rise in core temperature
- Death
Heat Responses in the Aquatic Environment

- Evaporation from the head and shoulders may be impaired by higher humidity.
- Bathing caps will impair heat loss.
- Heat loss primarily through conduction and convection.
  - Conductivity of water 4-20 times faster than air, depending on water temperature.
- Recovery is slower in warmer water.
- In maximal efforts, (swimmers) increase in anaerobic metabolism, lactic acid and accelerated muscle fatigue.
  - (highest at 33C/91F and lowest at 17C/63F)
- May not have as much of an affect, if any, in submaximal effort.
- Heart rate increase not as high as on land because of heart rate lowering affect of water.
- Thermo Neutrals
  - Air
    - 21-22 degrees C
    - 70-72 degrees F
  - Water
    - 34-35 degrees C
    - 93-95 degrees F

Nakamitsu et al.
- 80% increase in cardiac work above thermo neutral.
- 32 C/ 90 F degrees - only a 40% increase in cardiac work.
- Reduction in total peripheral resistance.

Choukroun et al.
- Gas exchange measured in 25 C/ 77 F, 34 C/ 93 F, and 40 C/ 104 F water temperatures while immersed to the chest.
- O₂ transport during immersion is affected by two main factors: hydrostatic pressure and temperature.
  - Nonsignificant fall in VO₂ in thermo neutral.
  - Hot bath similar to thermo neutral.
  - Marked rise in metabolic rate during cold immersion.
- Immersion in thermo neutral temperature
  - Cardiac output increased significantly.
  - Heart Rate fell significantly.
- Immersion in cold temperature
  - Cardiac output increased significantly.
  - Heart rate fell (not as much as recorded in a previous experiment.
- Immersion in warm temperature
- Pulmonary volumes and capacities in different water temperatures.
  - 25 C/ 77 F, 34 C/ 93 F, and 40 C/ 104 F
  - Decrease in vital capacity as water temperature decreased.
  - Maximum breathing capacity decreased as water temperature decreased.
  - Increase in tidal volume in cold or hot compared to thermo neutral.
- “Beside variations in the metabolic state, the variations of the pulmonary volumes as a function of Tw are estimated to be mainly due to alterations in respiratory muscles functioning.”
- Muscles affected 2 ways: internal variation in muscle temperature and an extrinsic mechanism acting on the control system of the muscle contraction.

Pendergast 1988
- Effect of Body Cooling on O2 Transport
  - Body cooling results in an increase in resting metabolism proportional to the decrease in core temperature.
  - Oxygen supply to meet cost of activity is decreased due to respiratory effectiveness, cardiac function, muscle blood flow.
  - Exercise in vasoconstriction environment/ core temperature too low- affects oxygen transport to muscles.
- SUGGESTED that water temperature may affect VO2.
- A water temperature around 29 C/ 84 F was recommended to optimize oxygen consumption.
Yazigi

- Pools above 32 C/ 90 F are more favorable to the increase in lactate concentration and consequent installation of fatigue than in cooler water.
  - Higher effect in maximal effort than in submaximal effort.
- Submitting a non-athlete to exercise in higher water temperatures may cause unwanted physiological consequences.
  - Beware with special populations and health concerns.

Cider et al.

- Acute cardiorespiratory reaction to warm water immersion of elderly patients with chronic heart failure during rest and exercise in a sitting position.
  - (33-34 C / 91-93 F)
  - No significant differences in control or test group for land or water for carbon dioxide production, total ventilation, respiratory frequency, RER, HR, or BP.
  - Significant difference found in oxygen consumption, at rest, land vs water, between 2 groups for CHF patients as compared to healthy people. (-0.2 vs +0.3)
  - Oxygen kinetics increased significantly in both groups during exercise in water.

Watson et al.

- Prolonged exercise in temperate (T) vs. warm (W) conditions.
  - T = 30 min seated submersion in water 35 C/ 95 F followed by 60 minutes cycle exercise at 60% peak O2 in a room at 18.3 C/ 64 F.
  - W = 30 min seated submersion in water 39 C/ 102 F followed by 60 minutes cycle exercise at 60% peak O2 in a room at 35 C/ 95 F.
  - Blood-brain permeability may be altered, core temperature reached higher elevation, heart rate higher, blood lactate higher, blood glucose higher, RPE higher.

Wakabayashi 2006

- Thermal swim suit effects on body temperature and thermal insulation of prepubescent children during moderate intensity exercise.
  - 23 C, peddled bike for 30 minutes.
  - Rectal temperature was maintained slightly higher with the TSS.
  - Total insulation was significantly higher with TSS.
  - Wearing TSS reduced heat loss from subject’s skin to the water.
  - Especially advantageous for subjects with low body fat.

Application

- Research on water temperature is all over the place.
- We know that water temperature has physiological consequences:
  - At rest
  - Submaximal exercise
  - Maximal exercise
  - Water too cold = unwanted physiological consequences
  - Water too warm = unwanted physiological consequences
  - We are warm blooded creatures.

Other Players

- We know there are other players:
  - Depth of immersion
  - Hydrostatic pressure

Ideal Water Temperature

- Ideal water temperature is dependent upon:
  - Type of class/ level of activity
  - Fitness level of participants
  - Age of participants
  - Gender of participants
  - Body composition of participants
  - Duration of class /exposure
  - Some things we do kind of know:
- Regardless of water temperature, we will see immersion effects:
  - Effects of hydrostatic pressure acting on several systems of the body.
o Lower heart rate at same oxygen consumption.
o Pulmonary responses.
o Reduced body mass.
o Increased resistance / drag.

- Decrease in vital capacity as water temperature decreased.
- Maximum breathing capacity decreased as water temperature decreased.

- Increase in tidal volume in cold or hot compared to thermo neutral.
  - O₂ transport during immersion is affected by two main factors: hydrostatic pressure and temperature.
  - VO₂ or metabolism rises in temperatures below thermo neutral.
  - We know if the water is too cold, blood is sent to the core away from the working muscles.

- Colder water may cause additional post exercise food intake.
- Air temperature and humidity will affect evaporation from the head and shoulders and affect the body’s ability to cool itself.

**Ideal Water Temperature: The pool would have a thermostat so we could instantly change the water temperature dependant on the population and activity!**

**Recommended Water Temperatures**

**AEA Standards and Guidelines**

**Typical Cardiorespiratory Format**

- 83-86 degrees Fahrenheit (28-30 degrees Celsius)
- Body reacts and responds normally to the onset of exercise and the accompanying increase in body temperature.
- Cooling benefits are still felt- little risk of overheating.

**Program Modifications**

- Know the water temperature and modify the program accordingly:
  - population
  - program format

- **Below the recommended range- COLD**
  - Warm up should be large, lower impact, rhythmic movements that gradually elevate core temperature of the body and should last for at least 9-15 minutes.
  - Main segment must be of adequate intensity to maintain proper body temperature and prevent injury. Specialized clothing to maintain body heat.
  - Cool down and post-stretch adjusted- length and activity, according to environmental conditions.
  - Use additional clothing to keep the body warm. It does help elevate core temperature.

- **Above the recommended range- HOT**
  - Intensity and length of the main segment should be adjusted to prevent overheating.
  - Encourage proper hydration and apparel.
  - Extended cool down with emphasis on stretching and relaxation is appropriate.

**Additional AEA Standards and Guidelines Water Temperature Recommendations**

<table>
<thead>
<tr>
<th>Category</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance Training</td>
<td>83 – 86 F/ 28 – 30 C (minimum range)</td>
</tr>
<tr>
<td>Therapy &amp; Rehab</td>
<td>91 – 95 F/ 33 – 35 C</td>
</tr>
<tr>
<td>Multiple Sclerosis</td>
<td>80 – 84 F/ 26.5 – 29 C</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>78 – 84 F/ 25.5 – 29 C (avoid pools 85 or higher)</td>
</tr>
<tr>
<td>Arthritis</td>
<td>84 – 88 F/ 29 – 31 C (minimum, Arth Found)</td>
</tr>
<tr>
<td></td>
<td>86 – 90 F/ 28 – 32 C (low function program, ATRI)</td>
</tr>
<tr>
<td>Fibromyalgia</td>
<td>86 – 96 F/ 30 – 35.5 C</td>
</tr>
<tr>
<td></td>
<td>84 – 88 F/ 29 – 31 C (aerobic activity, Arth Found)</td>
</tr>
<tr>
<td>Older Adults</td>
<td>83 – 86 F/ 28 – 30 C (mod-high intensity)</td>
</tr>
<tr>
<td>Older Adults</td>
<td>86 – 88 F/ 30 – 31 C (low intensity)</td>
</tr>
<tr>
<td>Children, fitness</td>
<td>83 – 86 F/ 28 – 30 C</td>
</tr>
<tr>
<td>Children, swim lessons</td>
<td>82+ F/ 27.5+ C (varies with age, class length)</td>
</tr>
<tr>
<td>Obese</td>
<td>80 – 86 F/ 26.5 – 30 C</td>
</tr>
</tbody>
</table>