Exercise and the Environment

High Temperature/Humidity
Low Temperature/Wind

Outline
1. Types of heat loss
2. Combined effect of temperature and humidity
3. List guidelines for exercising in the heat
4. Heat injuries
5. Heat acclimatization
6. Effects of cold and wind
7. Exercise in cold environments

Temperature Homeostasis

Temperature Homeostasis
Balance in heat gain and heat loss

Heat gain
Heat loss
Heat Production

- Basal metabolism or basal metabolic rate
- Additional heat production:
  - Voluntary = Exercise – 70-80% of energy released as heat
  - Involuntary
    - Digestion (“thermic effect of food”)
    - Shivering
    - Uncoupling proteins (non-shivering thermogenesis) e.g., brown fat
    - Action of hormones such as T3/T4 and catecholamines on cellular metabolism

Exercise in the Heat

- Maximizing heat loss is essential
  - Evaporation
- Guidelines for exercising
- Optimizing clothing when exercising in the heat
- Heat acclimatization
- Heat injury

Heat Exchange During Exercise
Environmental temperature extremes (examples)
Effects of alteration in body temperature

<table>
<thead>
<tr>
<th>Environmental Temperature (°C)</th>
<th>Body Temperature (°F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very hot env. 35°C</td>
<td>95°F</td>
</tr>
<tr>
<td>Snow temp., Seattle 17°F</td>
<td>63°F</td>
</tr>
<tr>
<td>Coffee off-the-cuff 19°C</td>
<td>66°F</td>
</tr>
<tr>
<td>Hot bath, 104°F</td>
<td>40°F</td>
</tr>
<tr>
<td>Cold bath, 38°F</td>
<td>10°F</td>
</tr>
<tr>
<td>Mean Jan temp., New York City 33°F</td>
<td>91°F</td>
</tr>
<tr>
<td>Mean Jan temp., Caracas, Adler 6°C</td>
<td>43°F</td>
</tr>
<tr>
<td>Mean Jul temp., South Pole -60°F</td>
<td>7°F</td>
</tr>
<tr>
<td>Mean July temp., South Pole -78°F</td>
<td>1°F</td>
</tr>
</tbody>
</table>

Note: Body temp does NOT level off (curves are misleading)

The concept of “heat index” or “effective” temperature.

<table>
<thead>
<tr>
<th>Category</th>
<th>Heat Index</th>
<th>General Effect or Heat Index when engaged in higher work intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>104°F or higher</td>
<td>Extremely hot</td>
<td>Heatstroke, heat cramps, heat exhaustion, and heat stroke in individuals with preexisting medical conditions.</td>
</tr>
<tr>
<td>101°–103°F</td>
<td>Very hot</td>
<td>Heat stress, heat cramps, and heat exhaustion.</td>
</tr>
<tr>
<td>90°–101°F</td>
<td>Slightly hot</td>
<td>Fatigue, heat cramps, heat exhaustion, and heat-related illness in healthy individuals.</td>
</tr>
<tr>
<td>80°–90°F</td>
<td>Normal</td>
<td>No significant effects on heat-related illness.</td>
</tr>
</tbody>
</table>
Heart rate during prolonged exercise in various temperature/humidity environments.

Core Temperature and Sweat Rate During Exercise in Heat/Humidity

Consequences of Hyperthermia

- High heart rate
- Redistribution of blood flow to skin, respiratory system
- Higher lactate production
- Impaired performance
- Possibly heat exhaustion or heat stroke
Heat Acclimatization

- Doesn’t happen overnight – requires a few days
- Increased plasma volume
- Earlier onset of sweating (threshold)
- Higher sweat rate (gain or slope)
- Reduced sodium chloride loss in sweat
- Reduced skin blood flow
- Increased synthesis of heat shock proteins

Hydration is the key to exercise in heat

- Dehydration leads to shorter endurance time in the heat
- Hyperhydration leads to improved endurance time in the heat
- Eu- or hyperhydration will help prevent reduction in stroke volume
- If severe, dehydration can lead to cessation of sweating and heat shock

Dehydration

- 0.5% weight loss – Thirst
- 2% weight loss – More thirst, discomfort, appetite loss
- 5% weight loss – Difficulty concentrating
- 8% weight loss – Dizziness, labored breathing in exercise, confusion
- 10% weight loss – Decreased blood volume, possible kidney failure
Exercise in the Cold

- Maintaining body temperature is essential
- Proper clothing is critical
- Wind decreases the "effective" temperature (wind chill effect)

Heat Production

<table>
<thead>
<tr>
<th>Heat Production</th>
<th>Voluntary</th>
<th>Involuntary</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exercise</td>
<td>Shivering</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-shivering thermogenesis</td>
</tr>
</tbody>
</table>

The “wind-chill” index.

<table>
<thead>
<tr>
<th>Ambient Temperature, °F</th>
<th>40</th>
<th>35</th>
<th>30</th>
<th>25</th>
<th>20</th>
<th>15</th>
<th>10</th>
<th>5</th>
<th>0</th>
<th>-5</th>
<th>-10</th>
<th>-15</th>
<th>-20</th>
<th>-25</th>
<th>-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed, mph</td>
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</tbody>
</table>

- Cold (0.001°F/mph): Cold decreases heat loss at wind speeds above 40 mph have little additional effect on body cooling.
Summary

- Evaporation is the primary means of heat loss during exercise.
- Guidelines for exercise in the heat should be heeded.
- Heat acclimatization reduces the chance of heat injury.
- Short-term exercise in the cold doesn’t pose a serious threat to heat balance.