Exercise and the Environment

High Altitude
Air Pollution

Outline

1. Air pollution and exercise
2. Exercise at high altitude

Exercise in Polluted Air

- Air pollution irritates lungs and decreases oxygen delivery to muscles
  - Ozone, carbon monoxide
- Guidelines to combat air pollution
Worst times of day for ozone and carbon monoxide

<table>
<thead>
<tr>
<th>7 A.M.</th>
<th>8 A.M.</th>
<th>11 A.M.</th>
<th>3 P.M.</th>
<th>5 P.M.</th>
<th>6 P.M.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon Monoxide High in Traffic Areas</td>
<td>Ozone High</td>
<td>Avoid Exertion</td>
<td>Carbon Monoxide High in Traffic Areas</td>
<td>Avoid Exertion</td>
<td></td>
</tr>
</tbody>
</table>

Exercise at Altitude

- Primary problem is decreased oxygen delivery to muscle
  - Lower barometric pressure
- Physiological adjustments
  - Breathing becomes deeper and faster
  - Exercise heart rate rises
  - Body decreases its water content
The effects of altitude on maximal exercise capacity.

Heart rate and ventilation responses to moderate exercise at various altitudes

Effect of altitude on exercise heart rate
Changes in Anaerobic Performance at Altitude
• Comparison of Performances in Short Races in the 1964 and 1968 Olympic Games

<table>
<thead>
<tr>
<th>Olympic games</th>
<th>Short races: Men</th>
<th>Short races: Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>100m 200m 400m 800m</td>
<td>100m 200m 400m 800m</td>
<td></td>
</tr>
<tr>
<td>1964 (Tokyo) 10.0s 20.3s 45.1s 1:45:41</td>
<td>11.4s 23.0s 52.0s 2:01:01</td>
<td></td>
</tr>
<tr>
<td>1968 (M.city) 9.9s 19.8s 43.8s 1:44:03</td>
<td>11.0s 22.5s 52.0s 2:00:09</td>
<td></td>
</tr>
<tr>
<td>% change</td>
<td>+1.0 +2.5 +2.9 +0.8</td>
<td>+3.5 +2.2 0 +0.2</td>
</tr>
</tbody>
</table>

Changes in Aerobic Performance at Altitude
• Comparison of Performances in Long Races in the 1964 and 1968 Olympic Games

<table>
<thead>
<tr>
<th>Olympic games</th>
<th>Long Races: Men</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500m 3000m 5000m 10,000m Marathon</td>
<td></td>
</tr>
<tr>
<td>1964 (Tokyo) 3:38:01 8:30:08 13:48:00 28:24:04 2hrs 12min</td>
<td></td>
</tr>
<tr>
<td>1968 (M.city) 3:34:09 8:51:00 14:05:00 29:27:04 2hrs 20min</td>
<td></td>
</tr>
<tr>
<td>% change</td>
<td>+1.5 -3.9 -1.9 -3.7 -6.2</td>
</tr>
</tbody>
</table>
Performance at Extremes of High Altitude

- At 8,848m (28,800 ft), Mt. Everest represents the most extreme challenge to exercise at high altitude
- The first summit occurred in 1953 with the aid of supplemental oxygen
  - Previous attempts w/o supplemental O₂ were unsuccessful but close (w/in 300m)
  - Later attempts to summit w/o extra O₂ have been successful (1978), but rare

Acclimatization to High-Altitude

- Chronic altitude exposure results in:
  - Increase in red blood cell production
    • Kidneys produce erythropoietin which stimulates RBC production
    • Increased Hct increases the O₂ content of the arterial blood
      \[ CaO₂ = Hb \times \text{saturation} \times 1.39 \]
    • However, since plasma volume remains the same, blood viscosity is increased which increases the TPR, afterload, and venous return, reducing SV
  - Persistent elevation in \( V_E \)
- Complete acclimatization in non-altitude natives in unlikely

“Ergogenic” effect of High-altitude Training

- Due to the observed physiologic adaptations to high altitude exposure, HA is used as a means to improve exercise capacity and performance
- The latest research suggests individuals live at high altitude to elicit changes in RBC mass and,
- Train at a low enough elevation to maintain high training intensity