Chapter 17

Environmental Physiology

Heat

Exercise And Thermal Stress

Dehydration - decrease in total body water. Occurs at a faster rate during exercise in hot and/or humid environments

for example,

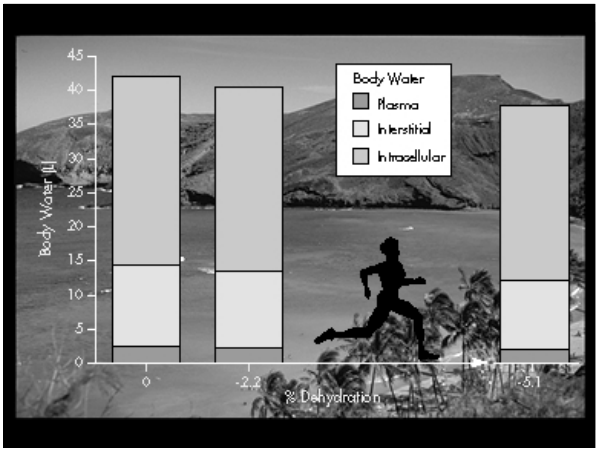
sweat rates can increase to 2-3 L/Hr

Deleterious effects of dehydration on exercise occur with as little as fluid loss equal to 2% body weight.

For a 70 kg male; 70 x 0.02 = 1.4 kg ~ 1.4 L

This could occur with as little as 30 min of exercise!!!!

Hyperthermia - increased body temperature resulting from body heat storage



Dealing with Dehydration

- Athletes (and others!) lose water through perspiration during exercise
- The hotter the temperature, the greater the sweat rate as body tries to maintain homeostatic core temperature (37 deg. C)
- High humidity compounds the problem

- The normal thirst mechanism does not cause a person to drink enough water to replace that lost, esp. in hot/humid cond.
- Even if person forces themselves to drink more water than they really thirst for, they often do not maintain hydration
- Drinking too much water can be a problem, but you would have to really overdo it

- Athletes should be weighed when conditions suggest heat problems
  - Some trainers weigh athletes before and after workouts
  - Others weigh each day before workouts
  - Either method will allow the tracking of body weight over time.
  - Almost all change seen from day to day is water loss, thus indicating hydration level
  - If athlete does not rehydrate to previous day's weight (or reasonably close to it) they are not allowed to participate until they correct this

- What is the problem with not rehydrating?

"Heat Illness!"

- Heat cramps
- Heat exhaustion
- Heat stroke

Heat kills! Take appropriate precautions

Heat Illness, Heat Exhaustion and Heat Stroke

These conditions are more severe clinical manifestations of heat exposure.

Heat Exhaustion - the decreased cardiovascular function that accompanies dehydration and mild hyperthermia

Heat Stroke - when heat stress continues, or is worsened beyond that of heat exhaustion (core temp > 39.5 °C), physiological symptoms progress to CNS dysfunction - *disorientation, confusion, psychoses*

Heat exhaustion and heat stroke are both **heat illnesses**. However, heat stroke can be potentially lethal due potential organ damage and failure.

Preventing Heat Illness

- Make water available to athletes
  - Cold water helps with temperature as well as hydration
  - GatorAde, Sport Ade, etc. better during recovery than during activity (thirst quenchers!) but fine if you have the money
  - Encourage athlete to drink more water than they really desire

- Encourage athletes to "tank up" before exercise (drink a pint or so of water during the half-hour prior to beginning exercise)
- Be aware of the dangers of heat—check the heat index and follow ACSM guidelines for practices
  - Avoid hottest time of day—practice early morning or late afternoon
  - Shorten practices as appropriate
  - Take rest/water breaks & get out of the sun!
  - Encourage athletes to drink, drink, drink

- After exercise encourage athletes to consume lots of fluids to rehydrate before next practice or performance session

Evaluating Environmental Conditions For Risk of Heat Injury

An index has been developed that incorporates all contributors to thermal heat stress - **Wet Bulb Globe Index** (WBGI)

Dry bulb temperature - measure of air temperature

Black bulb temperature - measure of the potential for radiative heat gain

Wet bulb temperature - measure of the potential for evaporative cooling

WBGI = (0.7 x Tw) + (0.2 x Tb) + (0.1 x Td)

The relative risks for heat injury at different ranges of the WBGI

WGBI	*Physiological Benefit*
23-28	**High risk for heat injury: red flag** Make runners aware that heat injury is possible, especially for those with a history of susceptibility to heat illness
18-23	**Moderate risk for heat injury: amber flag** Make runners aware that the risk for heat injury will increase during the race
< 18	**Low risk for heat injury: green flag** Make runners aware that although the risk is low, there is still a possibility for heat injury to occur
< 10	**Possible risk for hypothermia: white flag** Make runners aware that conditions may cause excessive heat loss from the body, especially for individuals who will have slow race times and when conditions are wet and windy

- WHAT ABOUT SALT?
  - Salt (NaCl and other electrolytes including K+ and Ca++) is present in sweat
  - However, heat acclimated athletes sweat more water and less electrolyte than unacclimated
  - Except in extreme heat conditions, the normal diet includes more than enough salt
  - Other electrolytes may be a problem (bananas?)
  - DO NOT ADMINISTER SALT TABLETS!!!
  - Sport drinks (or just add a very small amount of salt to drinking water) work okay for really hot times.

- Some "experts" have recommended salting food more to supply the extra NaCl—not a good idea because of problems with salt intake and CVD/hypertension

Why is heat/humidity a problem—physiology!

- 4 ways to gain or lose heat
  - Conduction
  - Convection
  - Radiation
  - Evaporation
- During high heat/high humidity exercise in the sun, heat may be gained from first three!
- Only evaporation remains for cooling the skin to remove the heat produced (and absorbed)

- Sweat is only effective for cooling if it evaporates!
- Humidity prevents evaporation
- Person sweats more and more but with little benefit to cooling body
- Dehydration decreases blood volume and affects HR, Qc, and numerous other parameters
- Exercise in heat more difficult, even when hydrated—blood flow to the skin increased

Physiological changes during dehydration

- ↑ Core temperature
- ↓ Plasma volume
- ↓ Venous return
- ↓ Stroke volume
- ↑ Heart rate
- ↓ Cardiac output
- ↑ a-v O_2 Diff
- ↓ Skin blood flow

- ↑ Catecholamines
- ↑ Blood lactate
- ↑ VO_2
- CNS dysfunction
- ↓ Exercise tolerance
- ↓ Sweat rate
- ↓ Evaporative cooling

Improving Exercise Tolerance During Heat Exposure

- Fluid intake (pre-during and post-exercise)
- Do not rely on thirst mechanism
- Complete heat acclimation or acclimatization

Acclimation - chronic adaptations induced by exposure to artificial environmental conditions
(eg. environmental chambers, sauna, exercise)

Acclimatization - chronic adaptations induced by exposure to foreign a foreign climate
(eg. geographical relocation)

Chronic adaptations to exercise and exercise in a hot environment that improve acclimation to exercise in the heat

Acclimation/Adaptation	*Physiological Benefit*
Plasma Volume	↑ Blood Volume ↑ Venous return ↑ Cardiac output ↓ Submaximal heart rate Sustained sweat response ↑ Capacity for evaporative cooling
Earlier onset of sweating	Improved evaporative cooling
Osmolality of sweat	Electrolyte conservation (mainly Na^+)
Muscle glycogenolysis	↓ Likelihood for muscle fatigue