Water, Electrolytes, and thermoregulation Ch. 9 Gatorade Sports Science Institute articles  and other primary research

Outline

Function

Distribution

Mechanisms of heat exchange

Calculating sweat rate

ACSM recommendations

Strategies for fluid consumption

Heat injury

Prevention

Daily water needs are individualized

Water balance

Output

Sensible:

Feces

Urine

Sweat

Insensible:

Ventilation

Non-sweat losses via skin

Input

Beverages & food

~2500 ml/d

Metabolic water

Metabolize 300 g CHO → 1 liter of water

Body water

Total Body Water Distribution

Body water regulation

Euhydration

Hypohydration

Low levels of body water

Dehydration = Process of losing body fluids

Hyperhydration

Mechanism of body water homeostasis

Osmoreceptors:

Fluid follows particles

Where is the water?

Why does this happen?

Hyponatremia

Decrease in plasma sodium ([Na+] <135 mmol/L)

Moderate (< 130 mmol/L)

Severe (<120 mmol/L)

Symptoms:

Mild to moderate

Bloating

Puffiness of hands and feet

Nausea

Vomiting

Headache

Severe

Brain swelling and seizures

Coma

Permanent brain damage

Death

Prevention?

 Mechanisms of Heat Transfer

Conduction

direct physical contact

Convection

movement of air or water over the body

Radiation

radiates from/to the body (from sun or to surroundings)

Evaporation

Body heat used to convert sweat to a vapor.

Lungs help dissipate heat through evaporation.

Leads to countercurrent exchange

Heat exchange mechanisms during exercise

 Influence on body temperature

Normal range: 97-99⁰ F (36.1-37.2⁰ C)

Typical oral temperature: 98.6⁰ F = 37⁰ C

Small rise in T improves performance

Up to 104° F

Heat balance =

RMR ± Work ± Conduction ± Convection ± Radiation – Evaporative heat losses

High risk for hyperthermia

Air temperature

Air movement

Solar radiation

Relative humidity

Sauna vs. steam room?

Heat index and Possible Heat-related Illnesses

Physiological effects of dehydration  (process of losing H2O)

Environmental heat and exercise performance: Possible mechanisms of fatigue

Central neural fatigue caused by ↑ brain temperature

Cardiovascular strain caused by changes in blood circulation

Muscle metabolism changes caused by increased muscle temperature

Hypohydration caused by excessive sweat losses

Factors that influence sweat rate

Environment

Air temperature

Relative humidity

Radiant heat (solar and ground)

Wind

Clothing worn

Individual characteristics

Body weight

Genetic predisposition

Metabolic efficiency

Heat acclimated

Wide individual variability

Calculating Sweat Rate

Sweat rate calculation example:

**Athlete A Athlete B**

  (metric) (English)

A. Body weight before exercise 70.5 kg 180 lbs

B. Body weight after exercise 68.9 kg 174 lbs

C. Change in body weight -1.6 kg - 6 lbs

(1600 g) (96 oz)

D. Drink volume 300 ml 16 oz

E. Urine volume -100 ml 0 oz

F. Sweat loss (c + d – e) 1800 ml 112 oz

G. Exercise time 60 min 90 min

H. Sweat rate (f ÷ g) 30 ml/min 1.25 oz/min

Practice Fluid Intake during Training

Determine sweat rate and practice consuming fluids to minimize weight loss

Use a trial and error approach to see what works

Timing and amounts before exercise

During exercise

CHO concentration

Na+ concentration

Carrying fluids

Experiment with brands used at race

Maughan and Meyer stress the importance of proper hydration during training in order to maintain high training loads and to “train” the intestinal tract to accommodate hydration during competition.

ACSM Fluid Intake Guidelines:  Before Competition and Training

ACSM Fluid Intake Guidelines:  During Competition and Training

ACSM Fluid Intake Guidelines:  After Competition and Training

Gastric emptying

Larger volumes (up to 700 ml) empty faster

Solute concentration

A 6% to 8% solution appears optimal

Lower osmolality may empty faster

Cold beverage

Burdon and colleagues reported increased preference for, greater consumption of, and attenuated dehydration following consumption of cold (0–10ºC) or cool (10–22ºC) beverages compared to warmer beverages.

Moderate-intensity facilitates emptying, whereas high intensity (> 75% VO2max) may decrease emptying

Excessive hypohydration (> 3% body wt) may decrease emptying

Intestinal absorption

Water absorbed rapidly by passive diffusion

Glucose-sodium co-transport

Glucose helps pull water into blood

Adequate sodium in the intestines

Abdominal cramping and diarrhea if Na+ too great in gut – pulls fluid

Multiple carbohydrate receptors

Use variety of monosaccharides and disaccharides

Individual differences

Rowlands and others reported significantly faster fluid absorption following consumption of a hypotonic sports drink compared to isotonic and hypertonic sports drinks and a noncaloric control drink in cyclists consuming these drinks (2 liters: 250 mL each 15 minutes) over a 2-hour period, followed by an incremental test to exhaustion.

Heat syncope: fainting

AKA: *exercise-associated collapse*

Etiology: excessive vasodilation and decreased relative blood volume

Venous return decreases thus cardiac output decreases

Blood flow to brain decreases

Prevention

Cool down after exercise -> venous return from legs

Recovery usually rapid

Heat cramps

Unknown etiology

According to Schwellnus: spinal-mediated hyper-excitability of motor neurons d/t effort above training effort level

May occur at any temperature, but more common in hot, humid conditions

Theories:

Cause still remains a mystery

Fatigue and abnormal spinal control of motor neurons

Salt losses

Oral or IV saline can stop cramping

Prevention

Train at race effort

Consume salt solutions at first sign of muscle twitches

Hot sauce

Heat exhaustion

Causes

Hypohydration

Inadequate salt replacement

Symptoms

Fatigue and weakness

Rapid pulse

Headache, nausea, vomiting, chills

Rectal temperature < 104⁰ F

Generally resolves with rest and fluids

Heat stroke

Caused by interaction of:

Hot environment

Strenuous exercise

Limited ability to cool:

Clothing that limits evaporation

To much body fat

Inadequate heat acclimatization

Lack of fitness

Most dangerous of heat illnesses

Symptoms

Stopped sweating

Pallor

Confusion

Disorientation

Aggressiveness

Convulsions

Rectal temperature > 104⁰ F

May be fatal

Symptoms and treatments of heat illnesses

Heat acclimatization

Exercise in the heat.

intensity and/or duration of training sessions when ambient temperatures increase

Gradually increase the intensity and duration of exercise.

Full acclimitization takes about 10-14 days, but longer in children -> why?

Acclimatization:  Adaptations to Ex in Heat

Takes 4-14 days

Sweat earlier, more profusely and more dilute -> improved evaporation

Adaptations: makes sweat glands more sensitive to signals from the hypothalamus

send signals to sweat glands at lower temps

Increased plasma volume -> adequate blood flow

Increased stroke volume - unknown etiology

Physiological Changes with Heat Acclimatization

Sports Drinks and Other Fluids