

Introduction to Exercise Physiology and Metabolism

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1 Exercise physiology

- Three pathways for metabolism: CP (creatine phosphate, anaerobic), glycolysis (anaerobic), oxidative (aerobic)
 - CP: creatine supplements, first mode of energy generation, very fast ATP production
 - * Resynthesis is oxygen-dependent, total repletion after an hour
 - Anaerobic glycolysis: glucose and glycogen
 - * Up to 40 seconds of work, half the peak yield of CP
 - * Generates lactic acid (part contributor to soreness), buffered by bicarbonate, produces CO₂, need to exhale
 - * One glucose gives you 2 ATP + lactic acid
 - * "Hitting the wall" – running out of glycogen

- * Eating carbohydrate immediately after exercise is a good idea; not mediated by insulin (usual way to get sugar into tissue); also helps with recovery
 - Oxidative metabolism: glucose, fats, protein; first need to convert to glucose
 - * Much more efficient: 1 glucose: 38 ATP
- Type II muscle fibers tend to work anaerobically, Type I tend to work aerobically; both can work for both
- One of the best recovery items: chocolate milk
- Fatigue:
 - Central (nervous system is not allowing full energy usage) vs. peripheral (muscles cannot generate as much energy)
 - Twitch check: stimulate at maximum force
- Blood sugar drop is a issue for brain, not muscle (muscle stores its own glycogen)
 - Recent research: some glycogen stored in the brain
- First indication of hunger is blood sugar dropping
- Central nervous system can detect when muscle glycogen is running low ("glycostat"), then central fatigue kicks in
 - Impending available of glycogen may increase central drive

2 Metabolism (measuring fitness)

- $\text{VO}_{2,\text{max}}$: maximum rate of oxygen consumption
 - L/min: normalize to body mass
 - Usually tested on bike or treadmill: treadmill will usually be higher
 - Cardiac output times oxygen difference between arteries and veins
 - Measured using metabolic cart
- Max heart rate is mostly genetic, except it decreases with age

- Maximal heart rate $\sim 220 - \text{age}$
- Sports players have to be very anaerobically fit
- Anaerobic threshold (AT) (also goes by other names): point at which venous lactate increases
 - Measures ventilation/CO₂ vs. oxygen/work
 - Work starts to feel difficult, begin recruiting Type II muscles
- Respiratory compensation threshold (RCT), second threshold:
 - Most of the way up to max exertion
 - Increase in lactic acid exceeds ability to buffer it (uncompensated metabolic acidosis)
- Respiratory exchange ratio (RER)
 - Ratio of CO₂ expired to O₂ consumed
 - $< 0.7 \Rightarrow$ almost all 100% fat
 - > 1.0 : almost 100% carbohydrate, feel uncomfortable
 - Maximum test: want to see $\text{RER} > 1.2$
- Want to train around AT for aerobic, around RCT for anaerobic, interval training above RCT

3 Nutrition

- Carbs (4C/g), proteins (4C/g), fats (9C/g)
- 100 calories a day excess \rightarrow 10 lb of fat in a year
- Hard to lose weight during the competitive season, because we need energy, food
- Fats and protein are necessary: difficult
 - Necessary and slow digestion
 - Keep blood sugar more level: don't cause sugar spike/plummet
- Exercise doesn't burn as many calories as one may expect, but it has many other health benefits

- Exercise tends not to aid weight loss in women
 - Body fat too low -> cessation of menstruation
- Other health benefits of exercise:
 - Weight management
 - People who exercise tend to be more aware of what they are eating
 - Good for chronic disease ("exercise is medicine")
 - * Swedish golf paper
- Caloric restriction (~25%) leads to longer lifespan
 - Exercise makes you healthier until you die, but it is controversial whether it extends life span
- Consequences of high obesity levels:
 - Metabolic syndrome
 - *
 - Diabetes
 - * I (used to be called childhood diabetes): autoimmune condition
 - * II (used to be called adult-onset): obesity
 - Seen now in children
 - * Exercise improves insulin sensitivity
 - * Symptoms:
 - Vulnerable to infection
 - Neuropathies
 - Blindness
 - Kidney/liver failure
 - Uncontrolled blood sugar (ketoacidosis)

4 Ergogenic aids

- Sports drinks
 - Water with sugar, salt
 - Salt makes you drink more

- High-enough concentration of carbohydrate to be effective, but low enough to be easily-absorbed
 - * 6% carbohydrate so that it is equiosmolar to blood
 - * Water is fine for low intensity and short duration
 - * "Diet sports drink" is an oxymoron
 - * Can fake out the brain by swishing carbohydrate water in the mouth (doesn't work with placebo sweetened drink)
- Dehydration
 - Increased heart rate: headaches, dizziness, decreased skin turgor, thirsty
 - Increased temperature
 - Increased ratings of perceived exertion
 - Decreased performance (esp. aerobic)
 - Usually concomitant with heat stroke
 - Raise feet to return fluid to the heart, only need IV if unconscious
- Heatstroke
 - Very serious, ice bath
 - Confusion, mental status changes
- Hyponatremia
 - Low sodium, when you drink too much water or sweat too much
 - Very dangerous
- Cramping
 - Not caused by dehydration
 - Mostly caused by fatigue
 - Related to electrolyte concentration
 - "Salty sweater"
- DSHEA: Dietary Supplement Health and Education Act (1994)
 - Allowed for drug advertisements to the public

- Defined dietary supplement as something separate from drugs and food; not regulated by the FDA (no approval, clinical trials, must be proved unsafe to get off the market)
- Ergogenic aid: something used to enhance performance
 - Mechanical: shoes
 - Psychological: hypnosis
 - Physiologic: blood doping
 - Nutritional: vitamins
 - Pharmacologic: anabolic steroids
- Carb loading
 - Little evidence but may help for long duration events that lead to near exhaustion
 - Not just one meal, carb loading for almost a week
- Caffeine
 - Stimulant: decrease use of glycogen at beginning of exercise
 - Risk of dehydration, hypertension, arrhythmia
- Ephedra: stimulant proven to be harmful; weight loss and enhancement
 - More extreme effects when mixed with caffeine: even more dangerous
- Anabolic steroids: synthetic testosterone
 - Not corticosteroids; used for inflammation or asthma
 - Increases protein synthesis; enhances effect of the workout
 - Causes reversal of secondary gender characteristics; "roid rage"; weight gain; tendon injuries; liver toxicity
- Erythropoietin: stimulates red blood cell production, replaced blood doping (Lance Armstrong)
 - Hypertension and hyperviscosity of blood (clots)
- Other ergogenics:
 - Sodium bicarbonate

- Live high, train low (legit doping)
- Creatine
- Human growth hormone
 - * Also greatly increases the risk for cancer

5 Misc.

- "The Hacker's diet": eat less, exercise more, and why it is difficult to do
 - No one estimates their intake well without writing everything down
- Orthopedists love golf ... ?
- Humans are evolved for long distance running
 - We dissipate heat by sweating rather than panting
 - Big brain development
- Colorado is very active
- Michael Pollan: wise words about food
- Homeopathic medicine: "like cures likes" (like vaccines but not vaccines); "homeopathy is water"