Measurement of Energy in Food During Physical Activity

HNF 610: Nutrition & Fitness
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The Calorie

- Calorie
  - One calorie expresses the quantity of heat necessary to raise the temperature of 1 kg (1 L) of water by 1° Celsius.

- Kilocalorie (kCal)
- Kilojoule
- Megajoule
Conversions

- $1 \text{ cal} = 4.186 \text{ J}$
- $1 \text{ kCal} = 1000 \text{ cal} = 4186 \text{ J}$
- $1 \text{ BTU} = 778 \text{ ft. lb.} = 252 \text{ cal} = 1055 \text{ J}$
Temperature Versus Heat

- Temperature reflects a quantitative measure of an object’s hotness or coldness.
- Heat describes energy transfer from one body or system to another.
Bomb Calorimeter

- Measures total energy value of foods
- Type of direct calorimetry
- Sealed chamber charged with oxygen
- Increase in water temperature directly reflects the heat released during a food’s oxidation.
- Heat of combustion
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Heat of Combustion

- Carbohydrates
  - 4.2 kCal

- Lipids
  - 9.4 kCal

- Proteins
  - 5.65 kCal
Net Energy Value

- Actual energy available to the body
- Coefficient of digestibility
  - Affected by dietary fiber
  - Atwater general factors
    - Carbohydrates: 4
    - Lipids: 9
    - Proteins: 4
Direct Calorimetry

- Directly measures energy expenditure
- Human calorimeter
  - Airtight chamber
  - A person lives or works in the chamber for an extended period of time.
- Changes in water temperature relate directly to an individual’s energy metabolism.
Indirect Calorimetry

- Indirect calorimetry infers energy expenditure from measurements of oxygen uptake and carbon dioxide production using:
  - Closed-circuit spirometry
  - Open-circuit spirometry
    - Portable spirometry
    - Bag technique
    - Computerized instrumentation
    - Doubly labeled water technique
Closed- and Open-Circuit Spirometry

- **Closed-circuit**
  - Subject breathes 100% oxygen from a prefilled container.
  - A canister of soda lime absorbs the carbon dioxide in exhaled air.

- **Open-circuit**
  - Subject inhales ambient air with 20.93% oxygen, 0.03% carbon dioxide, and 79.04% nitrogen.
  - Indirectly reflects the ongoing process of energy metabolism.
Portable Spirometry and Bag Technique

- Portable spirometry
  - Ambient air passes through a two-way valve.
  - Expired air travels through a gas meter that measures total expired air.

- Bag technique
  - Ambient air is breathed through one side of a valve.
  - Air is expelled through the other side of the valve.
Computerized Instrumentation

- Computerized instrumentation
  - A computer interfaces with at least three instruments:
    - A system that continuously samples the subject’s expired air
    - A flow-measuring device that records air volume breathed
    - Oxygen and carbon dioxide analyzers that measure the composition of the expired gas mixture
Doubly Labeled Water Technique

- Provides a useful way to estimate total daily energy expenditure in free-living conditions
- Expensive
- Provides an ideal way to assess total energy expenditure of groups over prolonged time periods
The Respiratory Quotient (RQ)

- The ratio of carbon dioxide produced to oxygen consumed
- The RQ provides information about the nutrient mixture catabolized for energy.
- The RQ equals 1.00 for carbohydrate, 0.70 for fat, and 0.82 for protein.
The Respiratory Exchange Ratio

- Ratio of carbon dioxide produced to oxygen consumed
- Computes in exactly the same manner as RQ
- R above 1.00
  - Overbreathing
  - Exhaustive exercise
- R below 0.70
  - Following exhaustive exercise
Energy Expenditure During Rest and Physical Activity

- Three factors determine total daily energy expenditure:
  - Resting metabolic rate
  - Thermogenic influence of food consumed
  - Energy expended during physical activity and recovery
Basal Metabolic Rate

- Minimum energy requirement sustains the body’s functions.
- Regular exercise slows a decrease in metabolism with age.
- Lower in females compared to males
Total Daily Energy Expenditure (TDEE)

- Influenced by:
  - Physical activity
    - Accounts for between 15% and 30% TDEE
  - Dietary-induced thermogenesis
    - Ranges between 10% and 35% of the ingested food energy
  - Climate
  - Pregnancy
The Metabolic Equivalent (MET)

- One MET represents an adult’s average seated, resting oxygen consumption or energy expenditure.
- MET provides a convenient way to rate exercise intensity with respect to a resting baseline.