Lecture 5:
Physical Activity and Dieting

Critical Analysis of Popular Diets and Supplements

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Body Fat/Composition Measurements

- Underwater weighing: Archimedes principle
- Skinfold measurements / anthropometry
- Bioimpedance (BIA)
- Computerized tomography (CT)
- Magnetic resonance imaging (MRI)
- Dual-energy x-ray accelerography (DEXA)

Pact vs Energy Expenditure

- *Physical activity* (Pact) is measured in watts of work actually performed
- *Energy expenditure* (EE) is the kcal or kJ of energy burned, either in the performance of work, or less efficiently work-productive (shivering, moving ions up energy gradients, etc.)
- Different types of physical activity may affect substrate balance differently for the same amount of work accomplished (sprint 1/10 mi vs walk it)
  - The sprint burns lactate and CHO
  - The walk burns primarily fat
  - The EE of the sprint is > for the same work performed

Measures of P-act : 1

- The mean adult RMR is 3.5ml O2/kg/min
  (or about 1.0 kcal/kg/hr)
- With increasing levels of p-act, rate of O2 consumption / heat produced increases
- Multiples of a person's RMR are called "metabolics" or "mets" and denote intensity of p-act being performed: a short-term measure
- 7 mets would be 7x3.5=24.5ml O2/kg/min; or, for a 70kg adult, a burn rate of 70 kcal/hr above RMR
- 7 mets is about 70% of VO2 max, or a 5mph run
- A slow walk is 2 mets

Measures of P-act : 2

- Physical activity level (PAL) = TEE/RMR
- PAL is a daily average, not a measure of intensity of an activity like mets
- PAL is about 1.4 - 1.5 for sedentary adults
- Extreme athletes or pyramid builders PAL may be 3.5 – 4.5
- DL H_2O can accurately gauge PAL over 14d
  - Also accelerometers, HR recording, logs/scales

Components of EEact

- ADL (walking, stairs, housework, bathing, etc
- Nonproductive activities (fidgeting, shivering)
- NEAT (non-exercise activity thermogenesis)
- Planned exercise
  - Ravussin highlighted the large variability in non-exercise activity between people with a radar study in a closed room with no exercise equip’t:
  - Range of 830- 4180 kJ/d found

Determinants of Level of P-act

- Age: P-act declines in both men and women
  - Data shows worse *relative* declines in P-act over time in young
- Gender: US adult men and women about =
  - Canada, UK men 1.5 – 3x women
  - US boys > girls
- Body comp and BMI: PAL of obese is lower, but, because of cost of wt bearing, EEact may be similar to lean
- Genetics: EEact shows 29-62% heritability in family and twin studies
- Education: US- college grads 2-3x more likely to be active in leisure physical activities
- Seasonal variation: Canada- summer = 2x winter time spent in physical activity

Determinants of E cost of P-act
(work efficiency: work/E-cost)

- What could make work efficiency vary?
  - Energy cost of muscle per twitch
  - Recovery time (oxidative capacity: VO_2 max)
  - Training / technique (eg, swimming)
  - Gender: women are more E efficient (less ms.)
  - BMI: obese in most studies have similar efficiency
- Why is work efficiency important?
  - While of survival value, high efficiency could predispose to weight gain or regain
  - In fact, some studies find increased efficiency in "post-obese" (Geissler, 15% c/w lean)

The post-Exercise Period

- Is there a post-exercise “burn” (excess EE)?
  - *Yes*- there is a period when EE has not yet fallen to pre-exercise levels
  - Varies from minutes to all day (for vigorous, prolonged exercise)
  - Adds up to a modest (3- 15%) increase in TEE of the activity
  - Mechanism is unknown

Effects of Training on RMR

- Significant effect only in vigorous, daily exercisers
- Probably related to increased FFM and "burn"
- Increasing one's VO_2 max in and of itself does not increase RMR, TF, EE_{act}, TEE after adjustments for change in body comp are made

Effects of exercise on substrate oxidation

- How does one study this?
  - Measure RQ by IC during exercise c/w rest
- Findings:
  - During low-intensity P-act (20% VO_{2max}), RQ= 0.8 (62% fat ox'n, 38% CHO and muscle)
    - slow (type I) muscle fibers are used most, and they burn FFAs
  - During high intensity P-act (80% VO2max), RQ= 0.9 (79% CHO and muscle, 21% fat ox'n)
    - fast (type II) muscle fibers are used most, and they burn glycogen
- Does this mean low intensity exercise is best for wt loss?
  - Yes and no: yes by % loss from fat, but no because burn is so slow that a small absolute amount will be lost c/w vigorous ex

Effects of Exercise on Substrate Oxidation- 2

- Both exercise *intensity* and *duration* affect fuel burned
- *Protein* ox'n is normally <10% of fuel during all but long-duration exercise
  - At 100 % VO_{2max}, (e.g., sprint run) *anerobic* use of muscle glycogen predominates, and lactic acidosis, soreness and fatigue ensue (later, fat ox'n occurs to recover)
  - At submax effort (75+% VO_{2max}), *mix* of aerobic and anerobic source (CHO and fat)
  - As intensity decreases further, *aerobic* source becomes 100% and % fat ox'n increases

Whence Comes the Fuel Burned During Exercise?

- Free fatty acids (FFA) are released from both adipose tissue and intra-muscle fat stores
- CHO are derived from glycogenolysis in both muscle and liver
- Intramuscular fuel is used first; after 30 min of ex, circulating nutrients (glucose and then FFA) used
- The circulating glucose derives first from liver glycogenolysis, later liver gluconeogenesis, too
- Circulating FFA derives from lipolysis in adipose tissue

Exerciser Characteristics: Training Status (I)

- VO_{2max} is a measure of aerobic work capacity or fitness
- As noted, training does not change E cost of Pact
- It does alter fuel source: use fat at a higher intensity of exercise when trained because at any given workload, intensity is effectively lower
- It also increases the proportion of slow, fat ox'g, type I muscle fibers

Exerciser characteristics: Age, gender and BMI

- One study suggests ability to ox fat may decrease with aging
- Some but not all studies find women:
  - Oxidize proportionately more fat, esp. during luteal phase vs follicular phase
  - Protein ox is probably lower during exercise
- Obese: mixed findings
  - One study found they ox less fat during exercise
  - Another found no diff in RQ bet lean and obese exercising at equivalent workloads

Role of P-act in obesity etiology

- Decreasing P-act will lead to wt gain unless EI is decreased by the same amount
- Increasing P-act will cause wt loss unless EI is increased to compensate
  - Degree of compensation is highest in young males, lowest in obese middle-aged females
- P-act also influences fat stores
  - CHO and protein stores are limited and tightly regulated, so changes in EE_{act} tend to be reflected in fat stores

Is Low EE a Risk Factor for Obesity?

- Few historical records of activity levels, but in UK, EI ↓ by 500 kcal/d 1970-1990, but BMI ↑ by 1.0 kg/m2; thus P-act must have ↓ by >500 kcal/d, but there are no data
- In USA: inverse correlation between self-reported P-act and BMI
  - True for men, women, AA, Latino, white, etc.
  - Confirmed by DLH_2O studies and 2/3 longitudinal studies (2-10y duration) showing BMI/P-act at f/u

Obesity and Types of P-act

- Moderate intensity exercise burns more fat than high, but high intensity exercisers have the lowest BMIs
- Both aerobic and resistance exercise are helpful in weight control
- Short bouts of exercise (3x10min) are as effective for wt loss as long (1x30min) if total EE_{act} is equal (Jakicic)

How Much Exercise is Needed for Weight Control?

- Most guidelines have called for 20-30 min of moderate-intensity exercise most, preferably all days
- Recent IOM guideline finds that 60 min daily exercise may be needed just to *maintain* weight
- Reduction in time at sedentary activities can also increase EEact and TEE
- At least 2 studies have found that kids who watch a lot of TV are more likely to be obese
- “Lifestyle” activities (taking stairs, parking farther away, etc) can add up to same EEact as formal exercise

EEact and Body Fat Distribution

- Evidence from 2 large clinical trials:
  - 1 found a negative relationship between P-act and waist circumference (EFDS)
  - 1 same (WHR) in white and AA men and AA women (but not white women) (CARDIA)
- Why does P-act affect fat distribution?
  - Unclear- perhaps all weight loss preferentially reduces visceral adipose tissue
  - Clear- there are gender, age, hereditary diffs: e.g., men tend to lose more VAT, young esp.