Author(s): Heidi IglayReger, Ph.D., Mark D. Peterson, Ph.D., 2009

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Energy Balance and Obesity: The Role of Physical Activity for Weight Management & Morbidity/Mortality

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Spring 2009
M1 Embryology
After today’s lecture, you should be able to answer the following questions

• What is energy balance?
• How is obesity defined?
  – What is BMI? When is it appropriate?
• What changes with obesity?
  – How is body weight controlled?
• Is energy balance possible?
  – What are the three components of total energy expenditure?
  – How is metabolism calculated? Measured? How are energy balance and obesity associated?
  – What is an optimal program for body weight change?
• Is obesity bad? Why?
What is energy balance?
Defining Obesity: Simple, right…?

- Wikipedia: A condition in which the natural energy reserve, stored in fat exceeds healthy limits.
- WHO: For adults, body mass index (BMI) > 30
  - Calculate your BMI
  - When is this appropriate?
# BMI Standard Classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>BMI</th>
<th>Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>&lt;18.5</td>
<td>High Risk</td>
</tr>
<tr>
<td>Normal Range</td>
<td>18.5-24.9</td>
<td>Average</td>
</tr>
<tr>
<td>Overweight</td>
<td>&gt;25</td>
<td>Increased</td>
</tr>
<tr>
<td>Pre-obese</td>
<td>25-29.9</td>
<td>Slight</td>
</tr>
<tr>
<td>Obese class 1</td>
<td>30-34.9</td>
<td>Moderate</td>
</tr>
<tr>
<td>Obese class 2</td>
<td>35-39.9</td>
<td>Severe</td>
</tr>
<tr>
<td>Obese class 3</td>
<td>&gt;40</td>
<td>Very Severe</td>
</tr>
</tbody>
</table>
Maurice Green

- Former “World’s Fastest Man”
- Overweight
“Normal Weight Obesity” Caveat

• Recent findings demonstrated that so-called "normal weight obesity" (i.e. normal BMI yet high adiposity), among otherwise healthy adults

• Independently associated with metabolic dysregulation and cardiovascular mortality.

Fitness vs Fatness

- Sumo wrestlers lose 10 to 20 life years
  - Due to fat or ETOH or Puffer Fish?
  - Those who lose weight after retiring live longer

- Fat and fit live longer than thin and unfit.
- Predict mortality independently.
Standards of Body Fat Percentages

* Must consider Waist Circumference > 85 cm (~33”)
**Must consider Waist Circumference > 100 cm (~39”)

Measuring body composition

- Anthropometrics
- Hydrostatic Weight
- Whole Body Plethysmography
- Bioelectrical Impedance Analysis (BIA)
- Dual-energy X-ray absorptiometry (DXA)

[Image of Bod Pod removed: http://gizmodo.com/images/2006/05/bodpod.jpg]
Of course adiposity increases with obesity… What else changes?
Leptin

• Adipokine
  – Body fat
  – Appetite

• Is leptin high or low in obese individuals?
Moderately obese female mice (KK/HIJ): Exercise, insulin, leptin

Unpublished data from Bodary, IglayReger et al
Metabolic Characteristics in Obesity
(compared to non-obese controls)

- Leptin: High
- RMR: High
- Fat Oxidation: High
- Sympathetic NS activity: High
- Insulin Sensitivity: Low
OBESITY IS A NORMAL ADAPTATION TO A STATE OF ENERGY IMBALANCE
How much energy is needed to remain in energy balance?
Total Energy Expenditure (TEE)

ALL voluntary muscle activity

TEF 10-30% of total energy expenditure

Physical Activity 20%

BMR 70%

Absolute necessities: Brain, breathing, circulate and clean blood

What influences TEE?
Estimate TEE

- Calculate your BMR/RMR
- Harris Benedict equation
  - **Women**: BMR = 655 + (4.35 x weight in pounds) + (4.7 x height in inches) - (4.7 x age in years)
  - **Men**: BMR = 66 + (6.23 x weight in pounds) + (12.7 x height in inches) - (6.8 x age in years)
Muscle influences BMR

21 year old woman

63 year old woman

Source Undetermined
Estimate TEE (cont)

- TEF + Physical Activity ~ Activity Factor
- Activity factor category definition
  - 1.2 Sedentary: Little or no exercise and desk job
  - 1.375 Lightly Active: Light exercise or sports 1-3 days/wk
  - 1.55 Moderately Active: Moderate exercise or sports 3-5 days/wk
  - 1.725 Very Active: Hard exercise or sports 6-7 days a week
  - 1.9 Extremely Active: Hard daily exercise or sports and physical job
Energy Expenditure

• Extreme examples
  – Tour de France: 6000 calories / day
  – Triathlons: 4500 calories / day
  – Distance Runners: 3500 calories / day

• Energy expenditure from physical activity
  = ____ (intensity, duration, frequency)
<table>
<thead>
<tr>
<th>Physical Activity</th>
<th>MET</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Light Intensity Activities</strong></td>
<td></td>
</tr>
<tr>
<td>sleeping</td>
<td>0.9</td>
</tr>
<tr>
<td>watching television</td>
<td>1.0</td>
</tr>
<tr>
<td>writing, desk work, typing</td>
<td>1.8</td>
</tr>
<tr>
<td>walking, less than 2.0 mph (3.2 km/h), level ground, strolling, very slow</td>
<td>2.0</td>
</tr>
<tr>
<td><strong>Moderate Intensity Activities</strong></td>
<td></td>
</tr>
<tr>
<td>bicycling, stationary, 50 watts, very light effort</td>
<td>3.0</td>
</tr>
<tr>
<td>calisthenics, home exercise, light or moderate effort, general</td>
<td>3.5</td>
</tr>
<tr>
<td>bicycling, &lt;10 mph (16 km/h), leisure, to work or for pleasure</td>
<td>4.0</td>
</tr>
<tr>
<td>bicycling, stationary, 100 watts, light effort</td>
<td>5.5</td>
</tr>
<tr>
<td><strong>Vigorous Intensity Activities</strong></td>
<td></td>
</tr>
<tr>
<td>jogging, general</td>
<td>7.0</td>
</tr>
<tr>
<td>calisthenics (e.g. pushups, situps, pullups, jumping jacks), heavy, vigorous effort</td>
<td>8.0</td>
</tr>
<tr>
<td>running jogging, in place</td>
<td>8.0</td>
</tr>
</tbody>
</table>

Ainsworth et al., 2000.
Measuring TEE

• BMR in the lab: Calorimetry
  - Food + O₂ = Heat + O₂ + H₂O
    • Direct – measure heat
    • Indirect – measure O₂
• Doubly labeled water
• Free living:
  - Measurement: Accelerometer, sensewear, pedometer, double labeled water
  - Recall, diary
What causes a change in body weight?

How best to lose fat?
Caloric Restriction and Weight Loss

- Small controlled / physiologic trials
- Large Randomized Controlled Trials
- Very large historical events / disasters
  - Somalia
  - Holocaust
  - Irish Potato Famine
Is caloric restriction alone the best answer?

What are common problems / limitations?
National Weight Registry

- Recruitment for the Registry is ongoing. If you are at least 18 years of age and have maintained at least a 30 pound weight loss for one year or longer you may be eligible to join our research study.

- 80% of persons in the registry are women and 20% are men.
  - The "average" woman is 45 years of age and currently weights 145 lbs, while the "average" man is 49 years of age and currently weights 190 lbs.
  - Registry members have lost an average of 66 lbs and kept it off for 5.5 years.

- These averages, however, hide a lot of diversity:
  - Weight losses have ranged from 30 to 300 lbs.
  - Duration of successful weight loss has ranged from 1 year to 66 years!
  - Some have lost the weight rapidly, while others have lost weight very slowly--over as many as 14 years.

http://www.nwcr.ws/default.htm
National Weight Registry

• 45% of registry participants lost the weight on their own and the other 55% lost weight with the help of some type of program.

• 98% of Registry participants report that they modified their food intake in some way to lose weight.

• 94% increased their physical activity, with the most frequently reported form of activity being walking.

• There is variety in how NWCR members keep the weight off. Most report continuing to maintain a low calorie, low fat diet and doing high levels of activity.
  
  – 78% eat breakfast every day.
  – 75% weigh themselves at least once a week.
  – 62% watch less than 10 hours of TV per week.
  – 90% exercise, on average, about 1 hour per day.

http://www.nwcr.ws/default.htm
What makes it easier to decrease weight?

• Physical: Exercise, medication, surgery
• Mental: Resolve non-hunger issues
• Workable plan: Easy tracking, change environment, support
  – How to track intake?

• How to lose 1 lb of fat…
Healthy People 2010 Objectives

“Physicians and other health care providers should counsel their patients to be physically active as part of routine health care visits “

U.S. Preventive Services Task Force 2000
But I… hate to exercise, don’t have time, fill-in the excuse
Total Energy Expenditure

- ALL voluntary muscle activity
- TEF 10-30% of total energy expenditure
- Physical Activity 20%
- TEF 10%
- BMR 70%

What influences TEE?

Absolute necessities: Brain, breathing, circulate and clean blood

Source Undetermined
Prevalence of Inactivity

CDC: Adults participating in NO leisure-time physical activity
Current average = 40%
Energy Expenditure and All-Cause Mortality
Harvard Alumni Study

Relative Risk vs. Kcal per week:
- < 500: 1.0
- 500-999: 0.9
- 1000-1499: 0.8
- 1500-1999: 0.7
- 2000-2499: 0.6
- 2500-2999: 0.5
- 3000-3499: 0.4
- > 3500: 0.3
Mortality Risk per 10,000 person years among individuals with a BMI > 25

Fitness Category

Low
Medium
High

Age-Adjusted Death Rates per 10,000 Person Years of Follow-Up: Cooper Clinic Men and Women

![Bar chart showing age-adjusted death rates per 10,000 person years of follow-up for men and women at different fitness levels (low, moderate, high). The chart indicates higher death rates for men compared to women at all fitness levels.](chart.png)

- **Low Fitness Level**
  - Men: High death rate
  - Women: Moderate death rate

- **Moderate Fitness Level**
  - Men: Moderate death rate
  - Women: Low death rate

- **High Fitness Level**
  - Men: Low death rate
  - Women: Very low death rate

Referenced from JAMA 282:2397, 1980.
Mortality Rates from Five Population-based Studies on Physical Activity or Physical Fitness

![Graph showing comparative mortality rates across different levels of activity or fitness. The graph includes lines for LRC, ACLS, Harvard, MRFIT, and Civil Servants, with mortality rates on a logarithmic scale.]
Exercise recommendations
# Aerobic Activity

(Chronic Disease Protection)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>≥ 5 d/wk for moderate intensity, or ≥ 3 d/wk for vigorous intensity</td>
</tr>
<tr>
<td>Intensity</td>
<td>Moderate intensity between 3.0 and 6.0 METS; vigorous intensity above 6.0 METS</td>
</tr>
<tr>
<td>Duration</td>
<td>≥ 30 min/d of moderate-intensity activity, in bouts of at least 10 min each; continuous vigorous activity ≥ 20 min/d</td>
</tr>
</tbody>
</table>

ACSM/AHA Guidelines for Physical Activity in Healthy Adults
Source: Haskell et al. *Medicine & Science in Sports & Exercise, July, 2007*
## Weight Gain & Weight Loss

<table>
<thead>
<tr>
<th>Category</th>
<th>Dose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevent unhealthy weight gain</td>
<td>60 minutes of moderate to vigorous intensity on most days of the week</td>
</tr>
<tr>
<td>Sustain weight loss</td>
<td>60-90 minutes of moderate intensity activity daily</td>
</tr>
</tbody>
</table>

ACSM/AHA Guidelines for Physical Activity in Healthy Adults
## Muscle Strengthening Activity

<table>
<thead>
<tr>
<th>Variable</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Frequency</td>
<td>&gt; 2 d/wk</td>
</tr>
<tr>
<td>- Exercises</td>
<td>8 -10 involving the major muscle groups</td>
</tr>
<tr>
<td>- Sets &amp; Repetitions</td>
<td>&gt; 1 set of 8-12 repetitions</td>
</tr>
</tbody>
</table>

ACSM/AHA Guidelines for Physical Activity in Healthy Adults  
Scare tactics: Some figures that should SCARE you and your [future] patients
Obesity Trends* Among U.S. Adults
(*BMI ≥30, or about 30 lbs. overweight for 5’4” person)
Age-Adjusted Standardized Prevalence of Overweight (BMI 25–29.9) and Obesity (BMI ≥ 30)

CDC/NCHS, United States, 1960-94, ages 20-74 years
Prevalence of Diabetes Among U.S. Adults, BRFSS, 1990


Prevalence of Diabetes Among U.S. Adults, BRFSS, 1997-2000

Is obesity bad? Is it limited to adults?
Childhood Obesity: Gut Check Time for Parents
Changes in the Prevalence of Obesity (BMI > 95th Percentile) Among U.S. White and Black Female Children Ages 6-11 years

Source Undetermined
Tracking BMI-for-Age from Birth to 18 Years with Percent of Overweight Children who Are Obese at Age 25

Whitaker et al. NEJM: 1997;337:869-873
CVD Risks in Youth

• % of children, aged 5-10 with…
  – 1 or more adverse CVD, risk factor level: 27.1%
  – 2 or more adverse CVD risk factor levels: 6.9%

• % of OVERWEIGHT children, aged 5-10 with…
  – 1 or more adverse CVD, risk factor level: 60.6%
  – 2 or more adverse CVD, risk factor levels: 26.5%

Can you answer the following questions?

• What is energy balance?
• How is obesity defined?
  – What is BMI? When is it appropriate?
• What changes with obesity?
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Slide 8: “Maurice Green” by Jimmy Harris, Wikimedia Commons
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Slide 12: Modified from Life Measurements Inc; Original image: http://gizmodo.com/images/2006/05/bodpod.jpg


Slide 15: Unpublished data from Bodary, IglayReger et al

Slide 19: Source Undetermined

Slide 21: Source Undetermined

Slide 34: Source Undetermined

Slide 35: CDC

Slide 36: Harvard Alumni Study


Slide 38: JAMA 282:2397, 1980

Slide 39: Source Undetermined

Slide 45: Source Undetermined

Slide 46: CDC/NCHS, United States, 1960-94, ages 20-74 years

Slide 47: CDC

Slide 48: CDC

Slide 49: CDC

Slide 50: CDC

Slide 51: CDC

Slide 52: Oster et al, Am. J. Managed Care, 2000

Slide 55: Source Undetermined

Slide 56: Whitaker et al. NEJM: 1997;337:869-873