

Author(s): Heidi IgleyReger, 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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CSCS*D, USAW --- Research Fellow, PM&R

Spring 2009

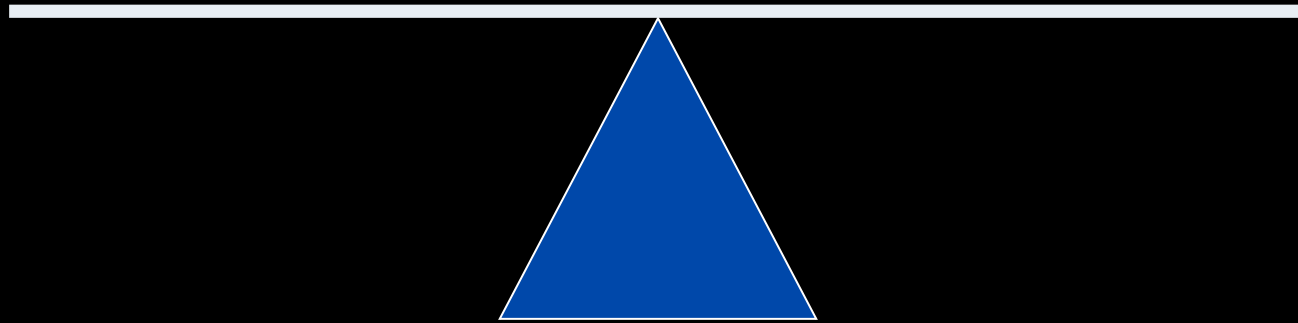
M1 Embryology



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

<u>Classification</u>	<u>BMI</u>	<u>Risk</u>
Underweight	<18.5	High Risk
Normal Range	18.5-24.9	Average
Overweight	≥ 25	Increased
Pre-obese	25-29.9	Slight
Obese class 1	30-34.9	Moderate
Obese class 2	35-39.9	Severe
Obese class 3	≥ 40	Very Severe

Maurice Green



 "Maurice Green" by Jimmy Harris, [Wikimedia Commons](#)

- 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.

Romero-Corral A, Somers VK, Sierra-Johnson J, Korenfeld Y, Boarin S, Korinek J, Jensen MD, Parati G, Lopez-Jimenez F. Normal weight obesity: a risk factor for cardiometabolic dysregulation and cardiovascular mortality. *Eur Heart J*. 2009 Nov 20.

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")

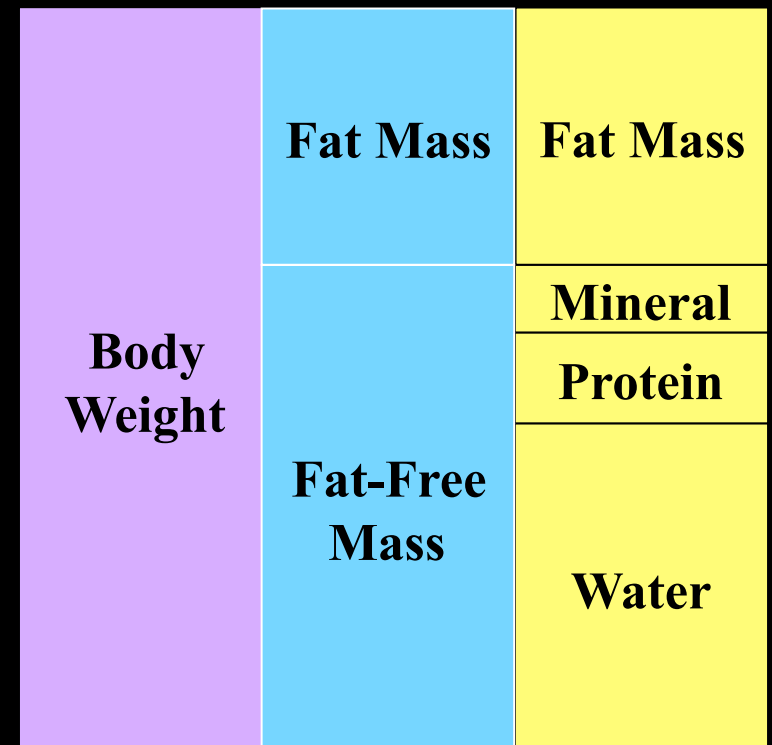
**Must consider Waist Circumference > 100 cm (~39")

Measuring body composition

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

Image of Bod Pod removed

Original image: <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?

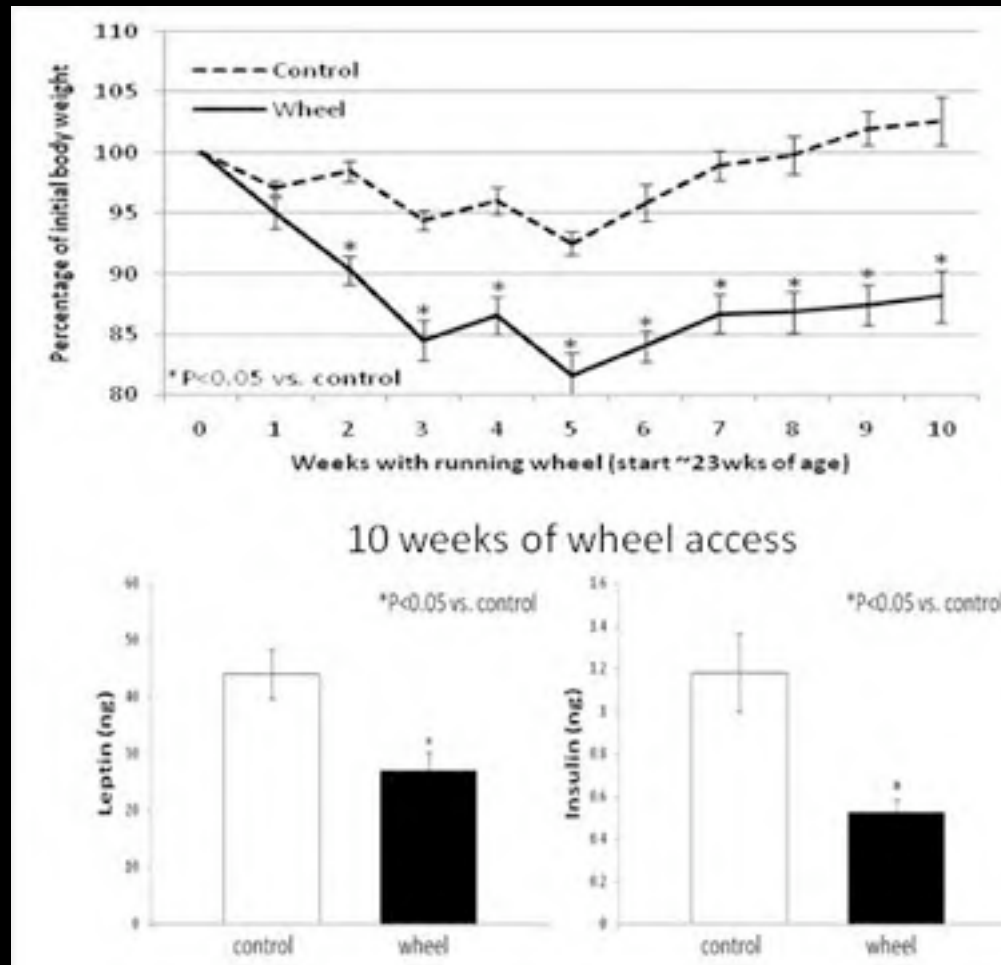


 [University of Michigan Vascular Biology Laboratory](#)



 [University of Michigan Vascular Biology Laboratory](#)

Moderately obese female mice (KK/HIJ): Exercise, insulin, leptin



PD-INEL

Unpublished data from Bodary, IgleyReger et al

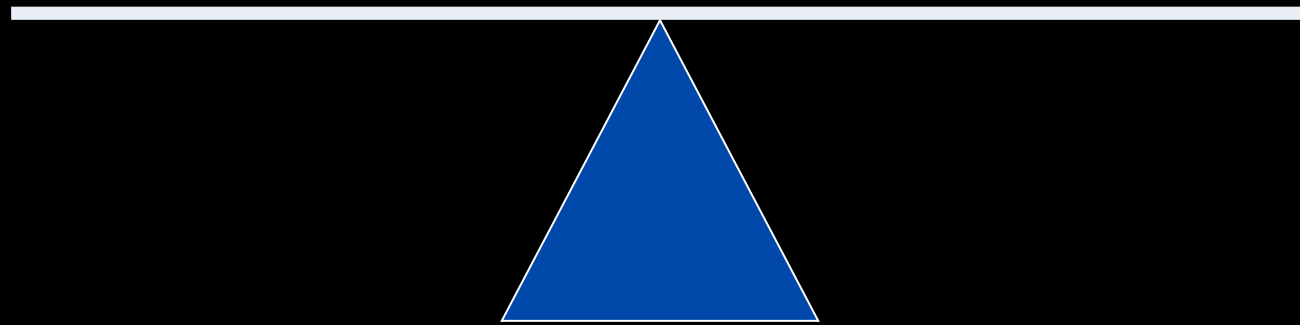
Metabolic Characteristics in Obesity

(compared to non-obese controls)

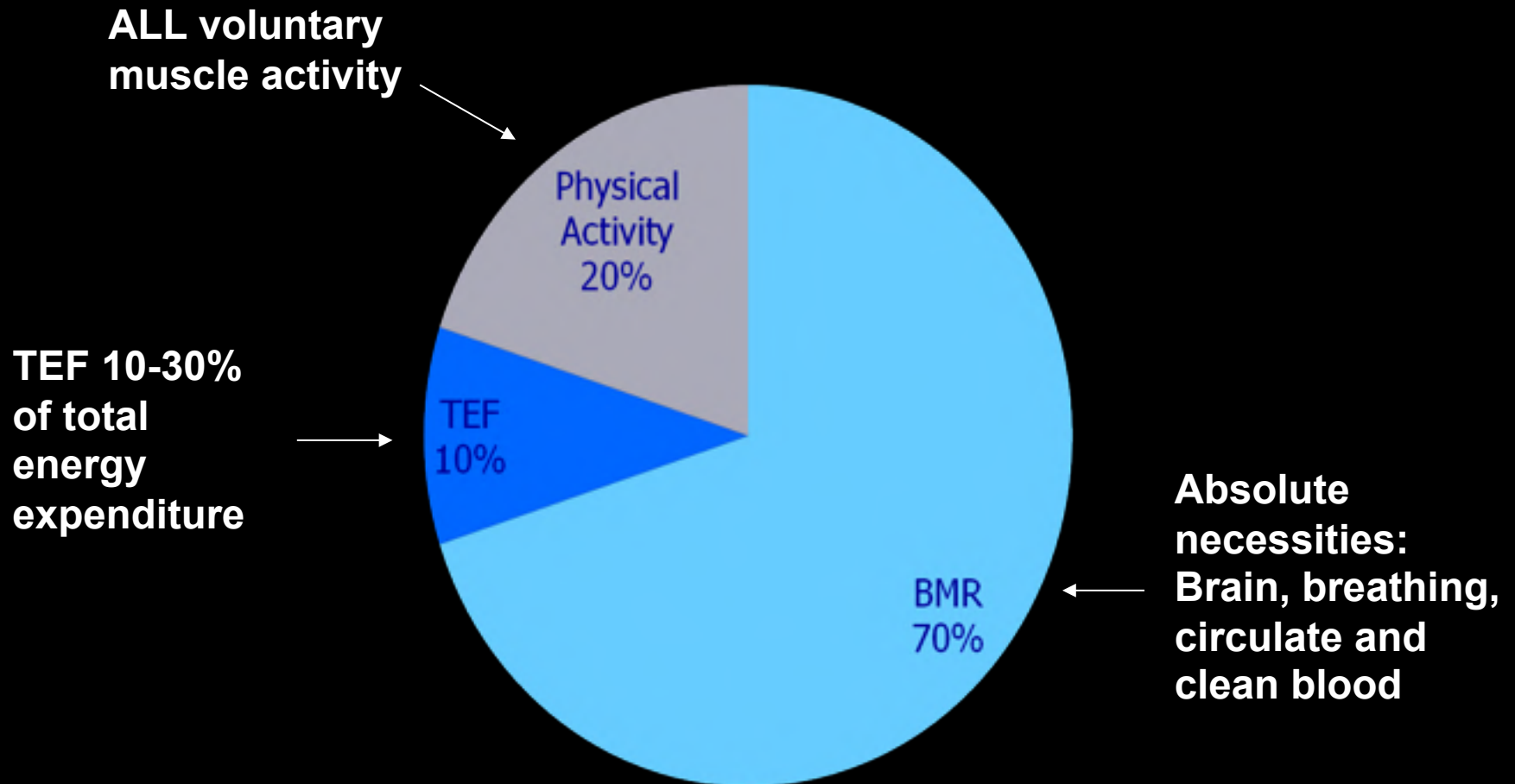
- | | |
|---------------------------|------|
| • Leptin | High |
| • RMR | High |
| • Fat Oxidation | High |
| • Sympathetic NS activity | High |
| • Insulin Sensitivity | Low |

**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)



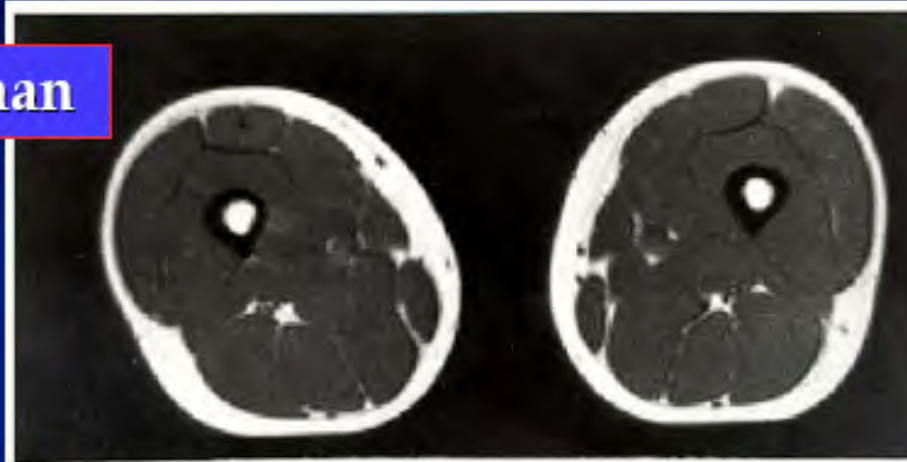
What influences TEE?

Estimate TEE

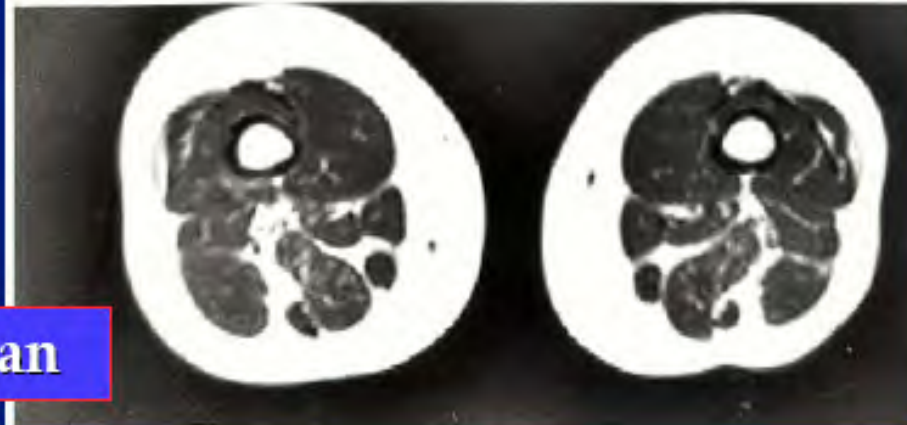
- Calculate your BMR/RMR
- Harris Benedict equation
 - **Women:** $BMR = 655 + (4.35 \times \text{weight in pounds}) + (4.7 \times \text{height in inches}) - (4.7 \times \text{age in years})$
 - **Men:** $BMR = 66 + (6.23 \times \text{weight in pounds}) + (12.7 \times \text{height in inches}) - (6.8 \times \text{age in years})$

Muscle influences BMR

21 year old woman



63 year old woman



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

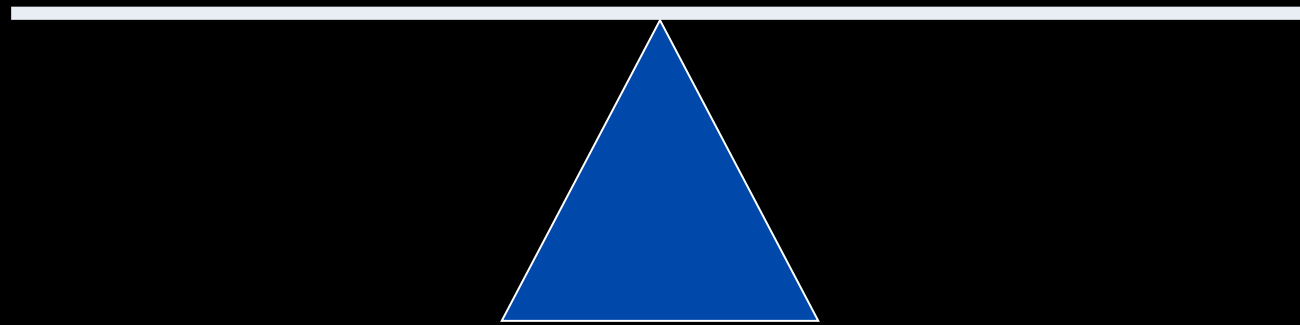
- Extreme examples
 - Tour de France: 6000 calories / day
 - Triathlons: 4500 calories / day
 - Distance Runners: 3500 calories /day
- Energy expenditure from physical activity
= _____ (intensity, duration, frequency)

Physical Activity	MET
Light Intensity Activities	< 3
sleeping	0.9
watching television	1.0
writing, desk work, typing	1.8
walking, less than 2.0 mph (3.2 km/h), level ground, strolling, very slow	2.0
Moderate Intensity Activities	3 to 6
bicycling, stationary, 50 watts, very light effort	3.0
calisthenics, home exercise, light or moderate effort, general	3.5
bicycling, <10 mph (16 km/h), leisure, to work or for pleasure	4.0
bicycling, stationary, 100 watts, light effort	5.5
Vigorous Intensity Activities	> 6
jogging, general	7.0
calisthenics (e.g. pushups, situps, pullups, jumping jacks), heavy, vigorous effort	8.0
running jogging, in place	8.0

Measuring TEE

- BMR in the lab: Calorimetry
 - $\text{Food} + \text{O}_2 = \text{Heat} + \text{O}_2 + \text{H}_2\text{O}$
 - Direct – measure heat
 - Indirect – measure O_2
- 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.

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 them self at least once a week.
 - 62% watch less than 10 hours of TV per week.
 - 90% exercise, on average, about 1 hour per day.

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...

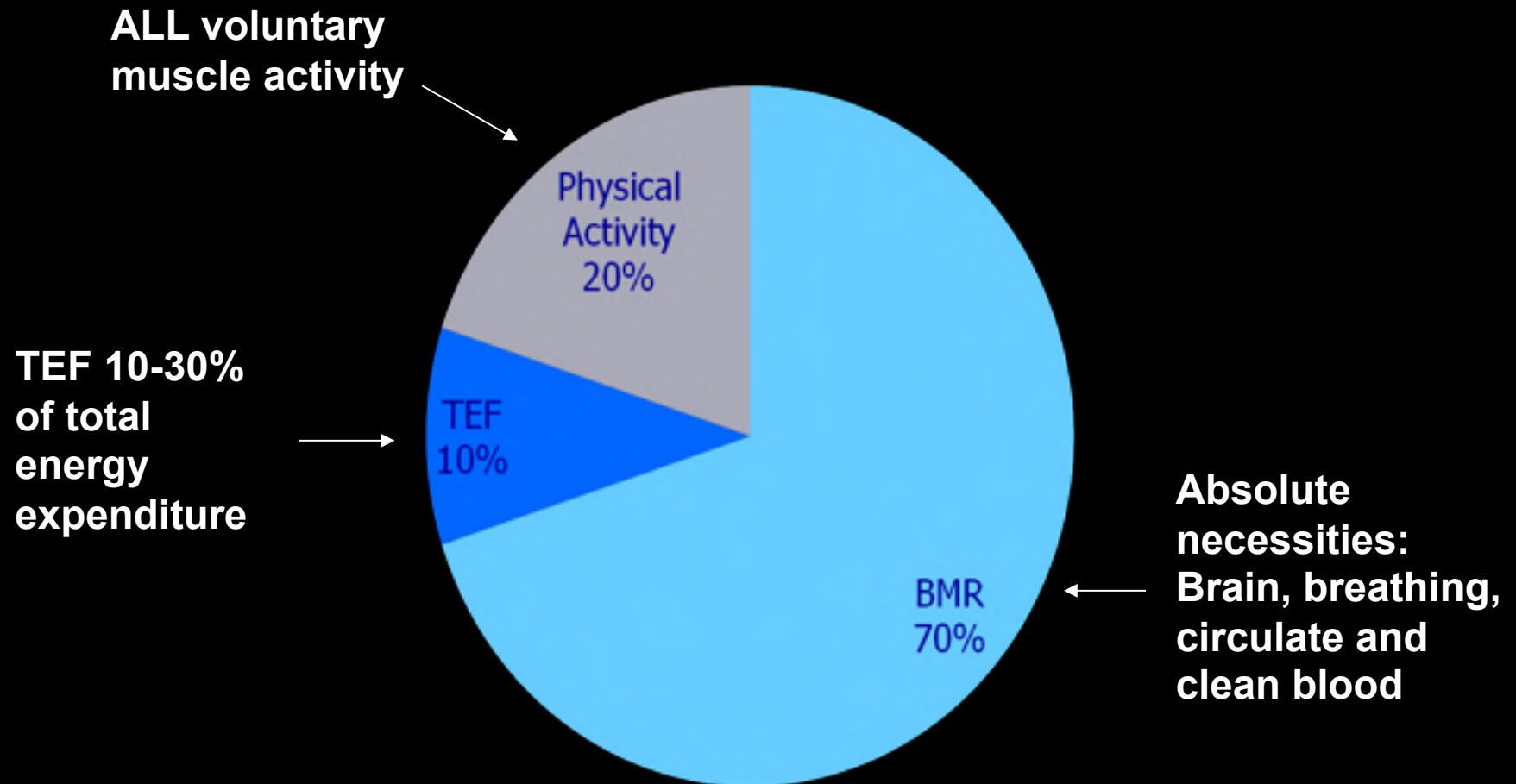
Healthy People 2010 Objectives

“ 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

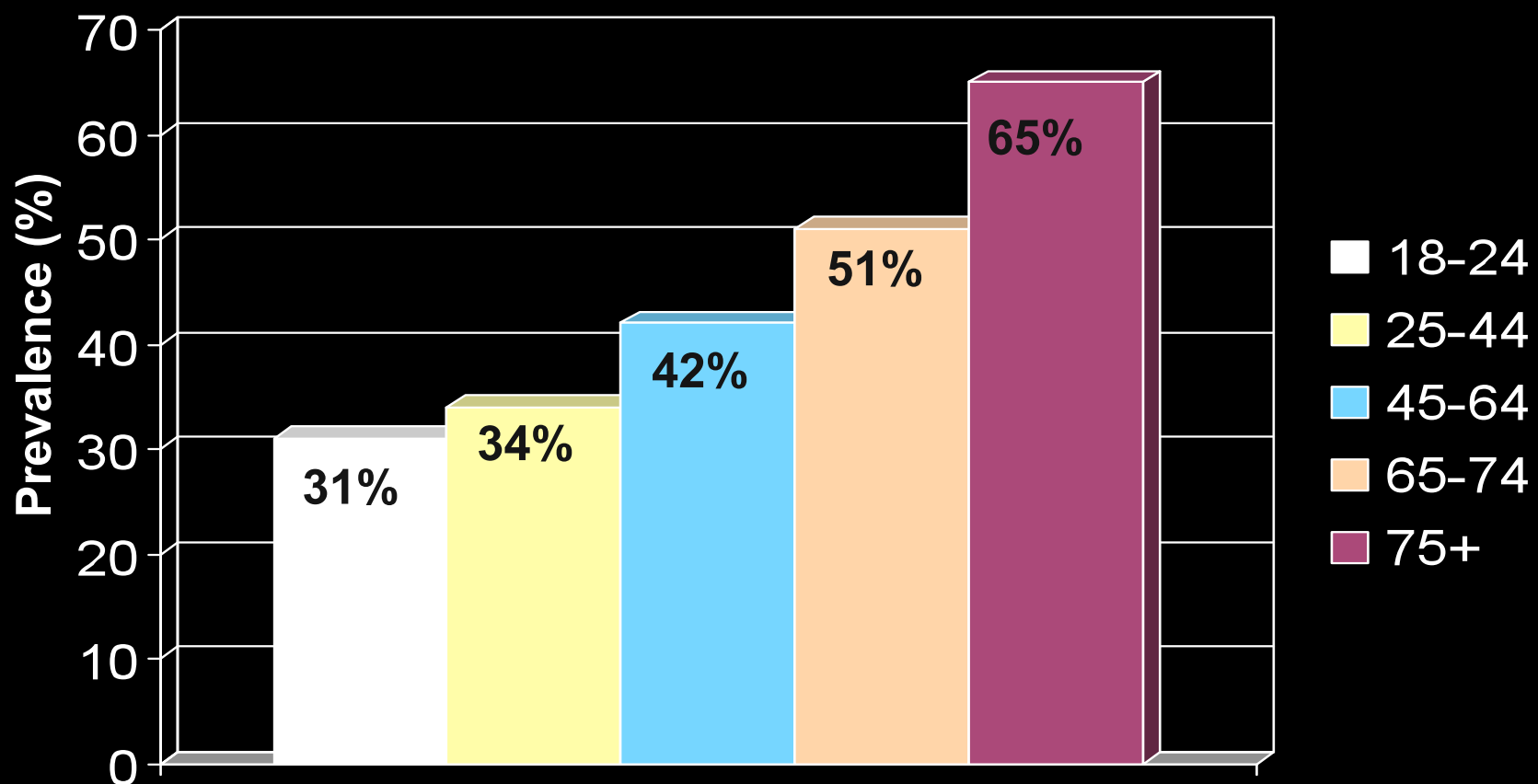
But I... hate to exercise, don't have
time, fill-in the excuse

Total Energy Expenditure



What influences TEE?

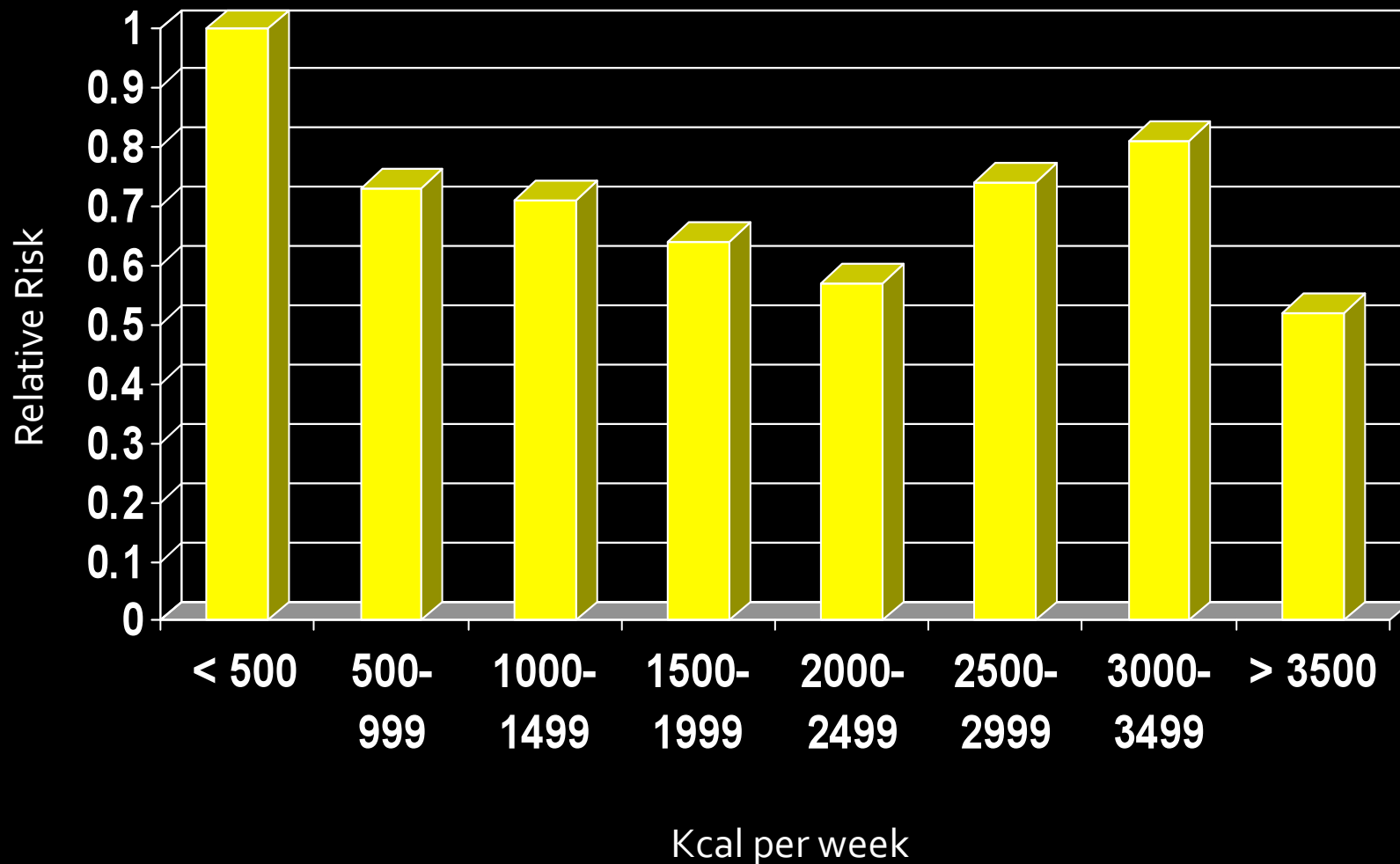
Prevalence of Inactivity



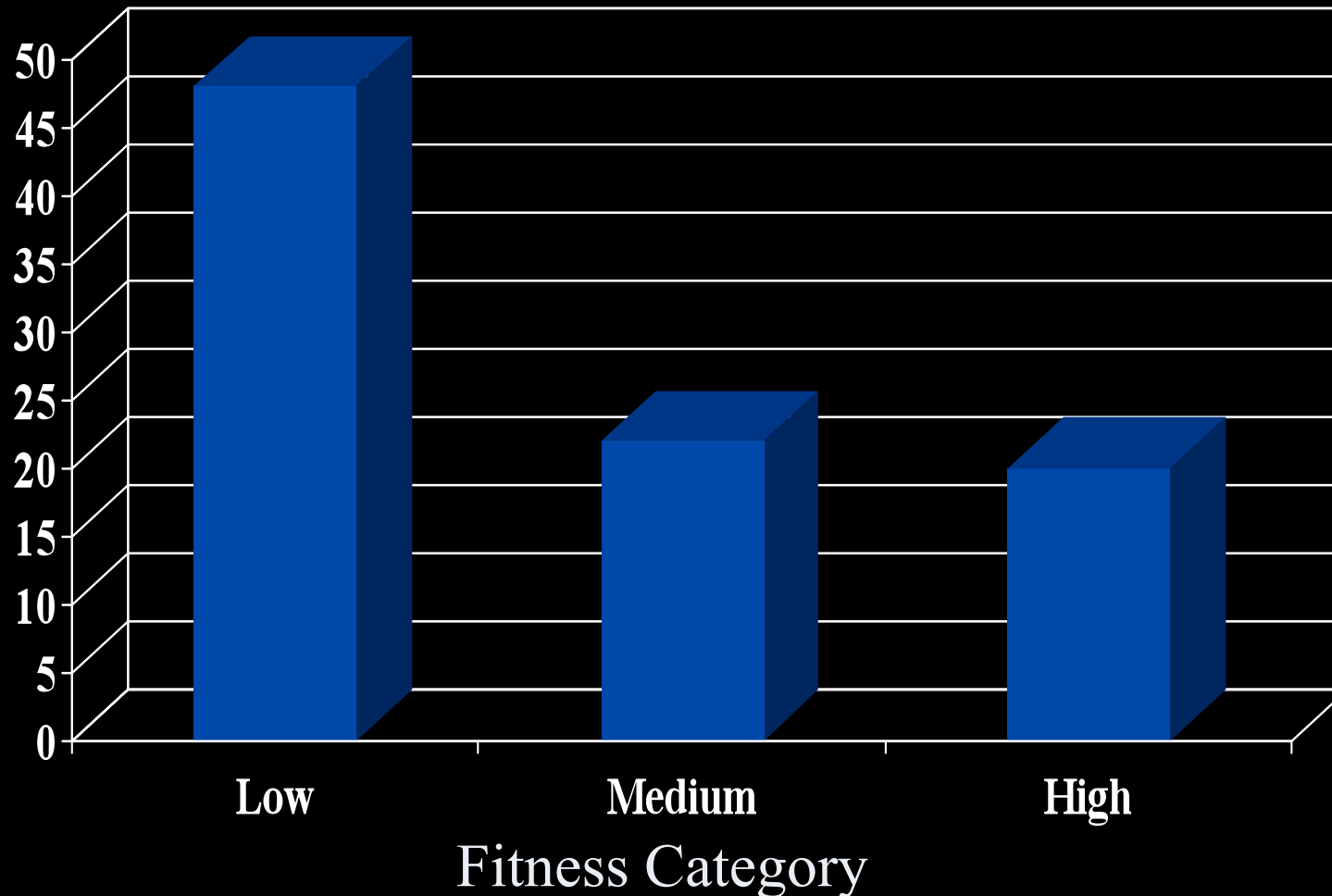
CDC: Adults participating in NO leisure-time physical activity
Current average = 40%

Energy Expenditure and All-Cause Mortality

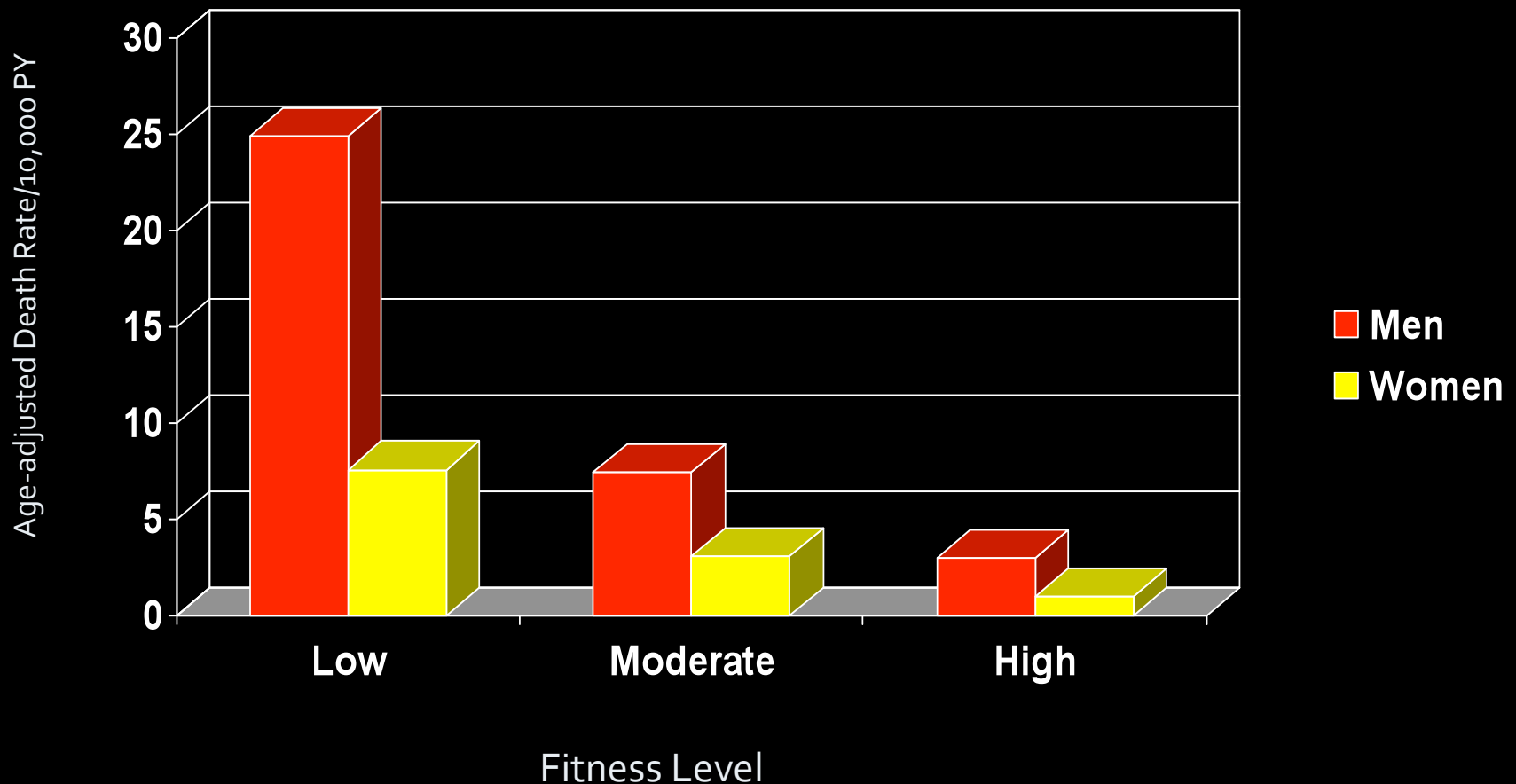
Harvard Alumni Study



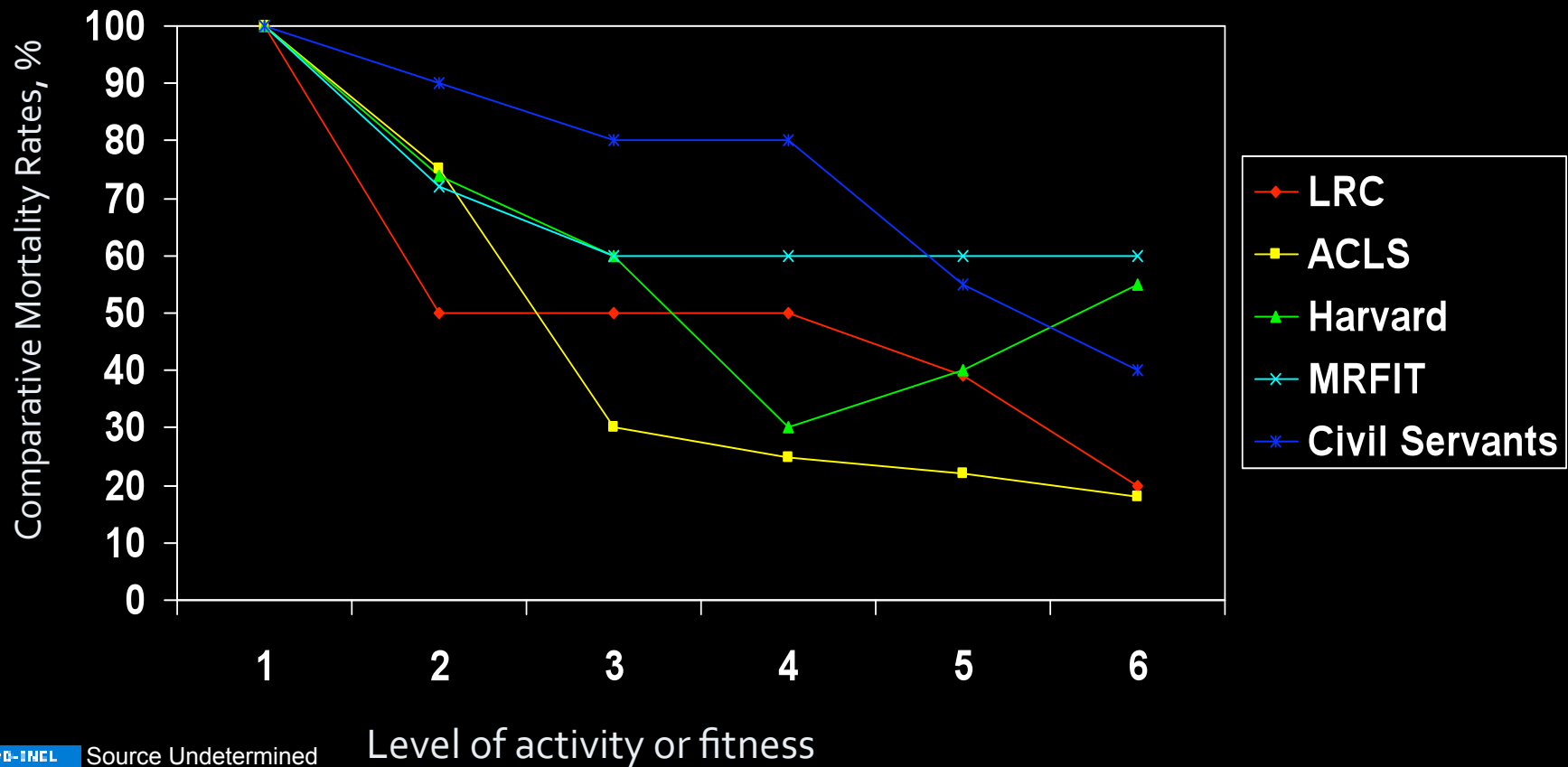
Mortality Risk per 10,000 person years among individuals with a BMI > 25



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



Mortality Rates from Five Population-based Studies on Physical Activity or Physical Fitness



Exercise recommendations

Aerobic Activity (Chronic Disease Protection)

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

ACSM/AHA Guidelines for Physical Activity in Healthy Adults

Source: Haskell et al. *Medicine & Science in Sports & Exercise*, July, 2007

Weight Gain & Weight Loss

Category	Dose
Prevent unhealthy weight gain	60 minutes of moderate to vigorous intensity on most days of the week
Sustain weight loss	60-90 minutes of moderate intensity activity daily

ACSM/AHA Guidelines for Physical Activity in Healthy Adults

Source: Haskell et al. *Medicine & Science in Sports & Exercise*, July, 2007

Muscle Strengthening Activity

Variable	Recommendation
- Frequency	≥ 2 d/wk
- Exercises	8 -10 involving the major muscle groups
- Sets & Repetitions	≥ 1 set of 8-12 repetitions

ACSM/AHA Guidelines for Physical Activity in Healthy Adults

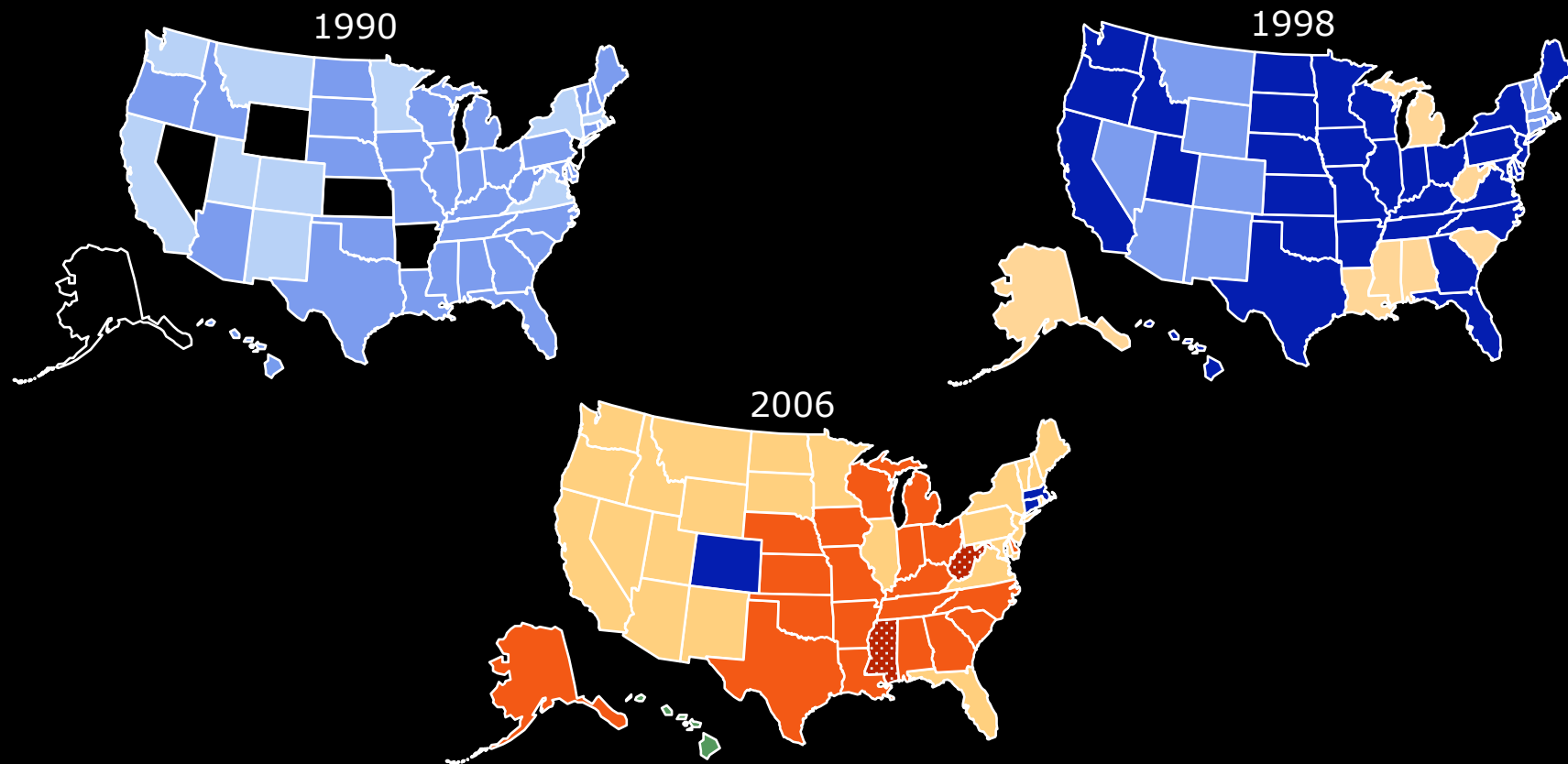
Source: Haskell et al. *Medicine & Science in Sports & Exercise*, July, 2007

Scare tactics: Some figures that should
SCARE you and your [future] patients

Obesity Trends* Among U.S. Adults

BRFSS, 1990, 1998, 2006

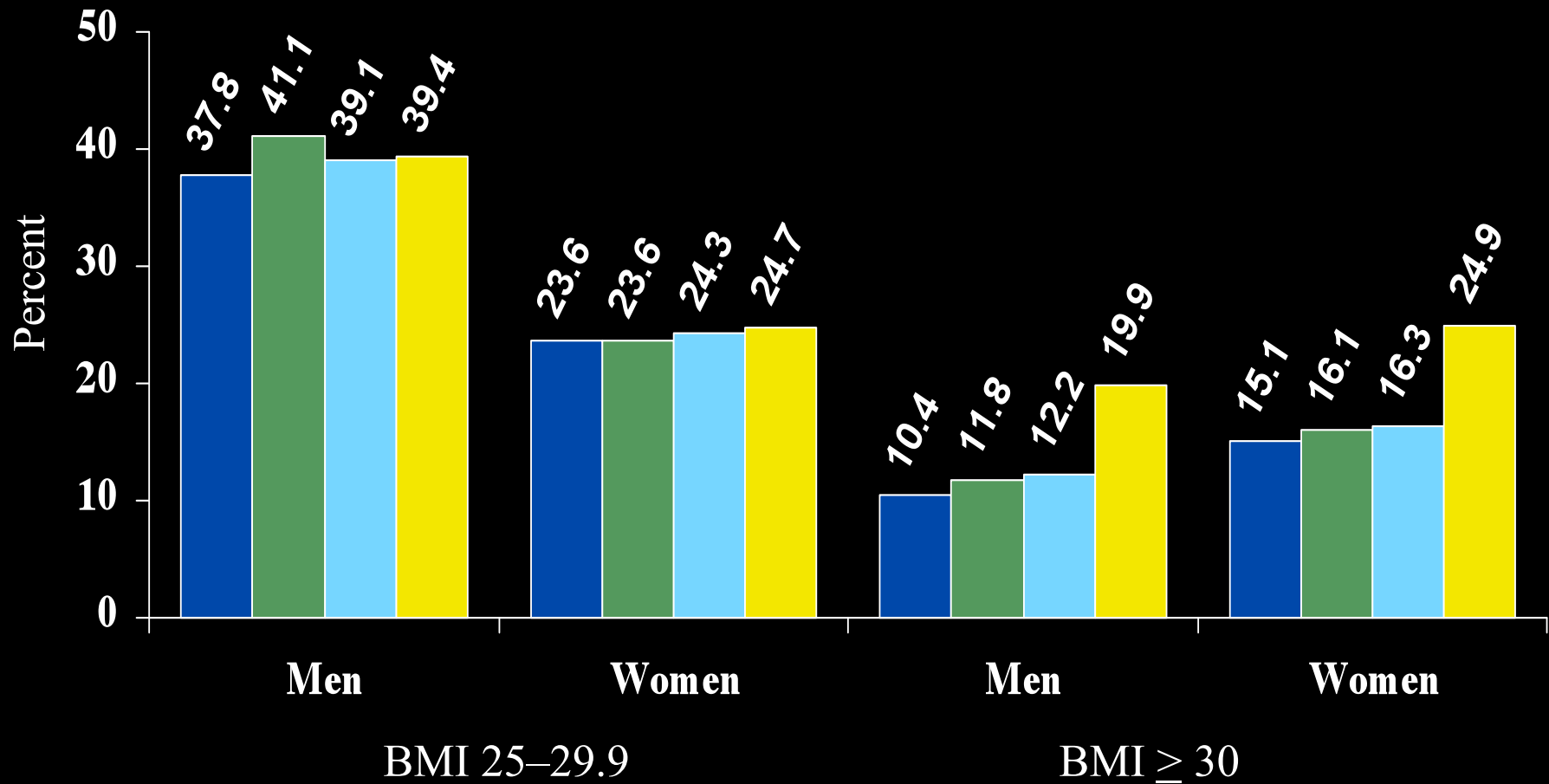
(*BMI ≥ 30 , or about 30 lbs. overweight for 5'4" person)



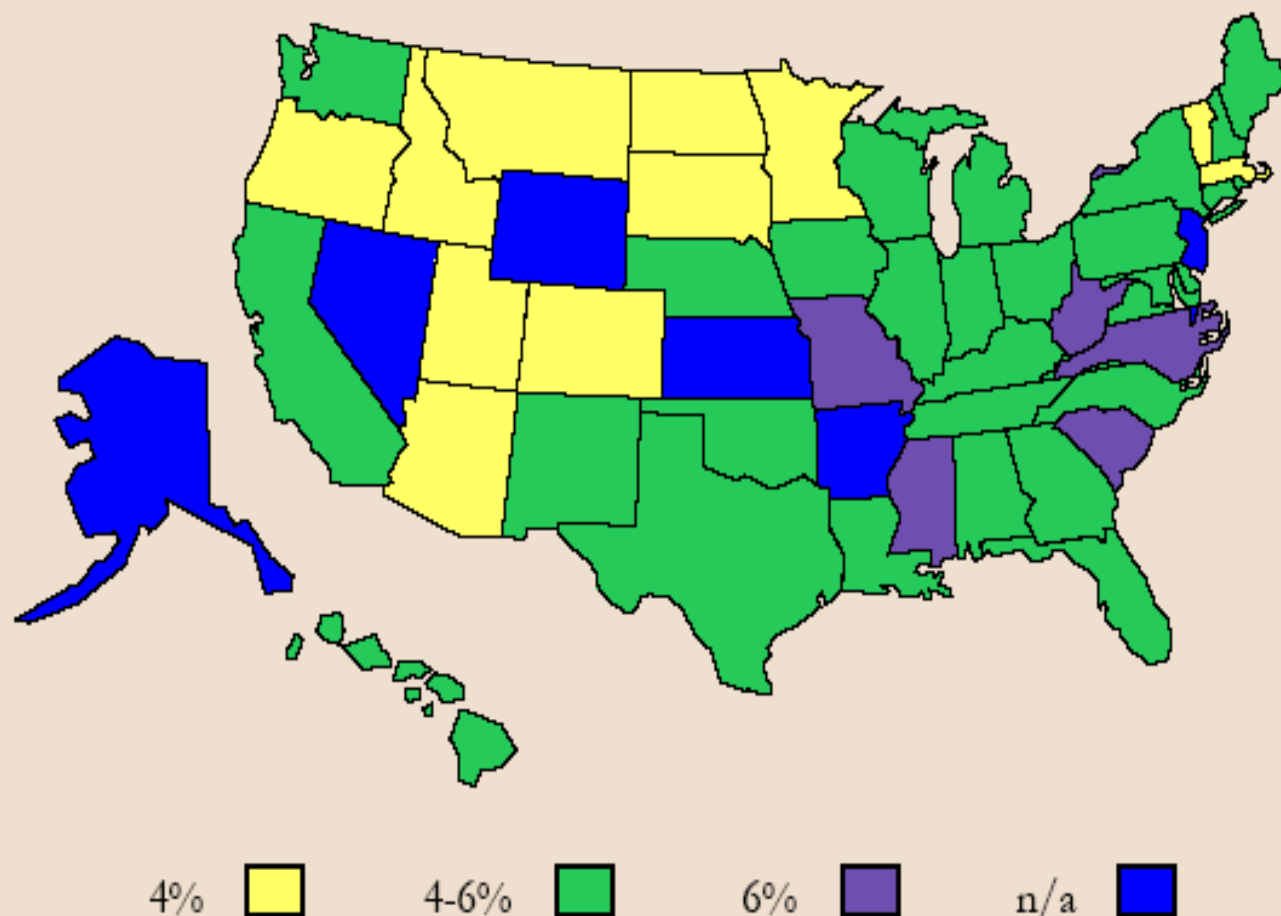
No Data <10% 10%–14% 15%–19% 20%–24% 25%–29% $\geq 30\%$

Age-Adjusted Standardized Prevalence of Overweight (BMI 25–29.9) and Obesity (BMI ≥ 30)

■ NHES I ■ NHANES I ■ NHANES II ■ NHANES III



Prevalence of Diabetes Among U.S. Adults, BRFSS, 1990

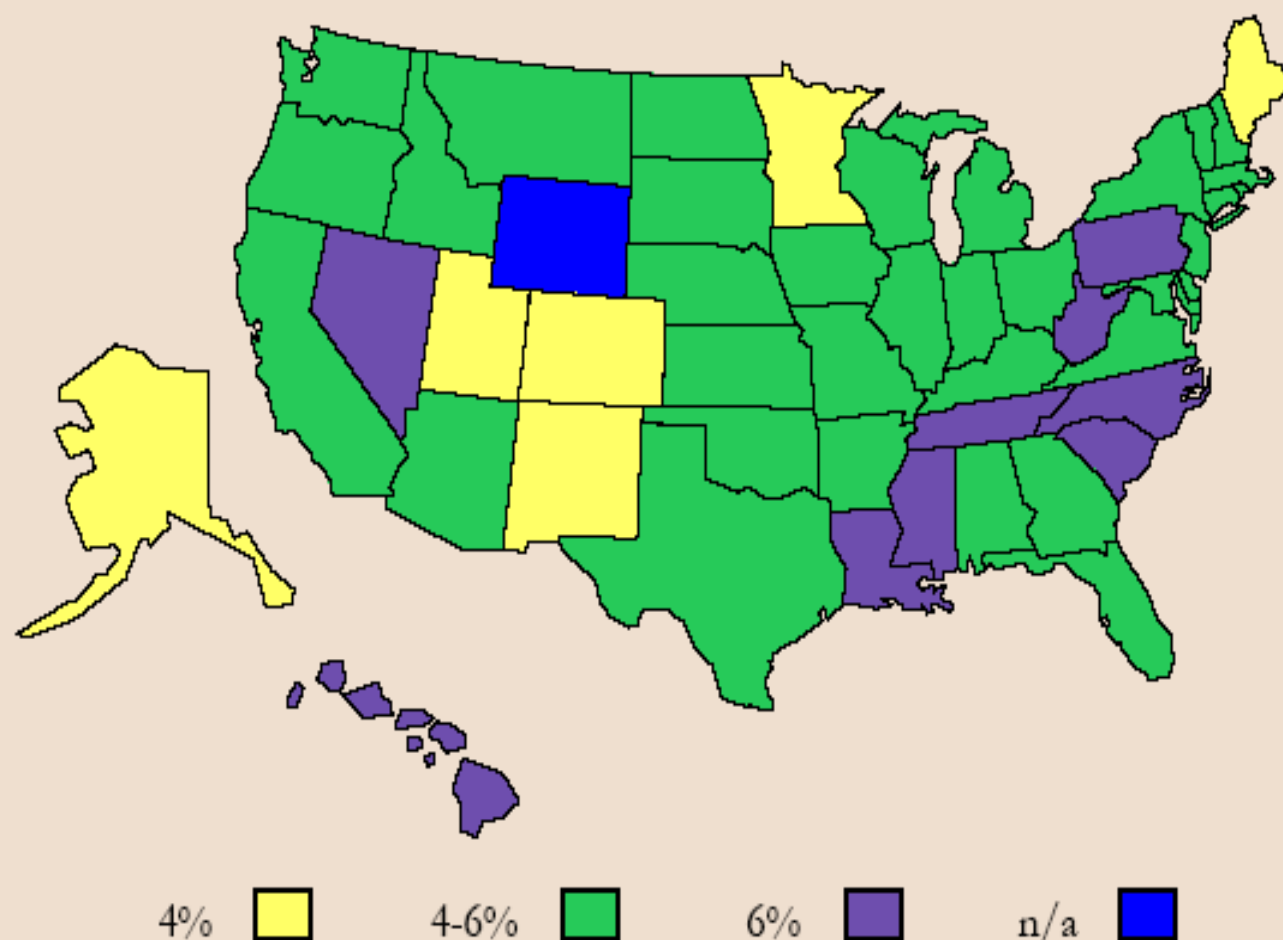


 PD-GOV CDC

Source: Mokdad, A H, et al. Diabetes Care 2000;23:1278-83



Prevalence of Diabetes Among U.S. Adults, BRFSS, 1991-1992

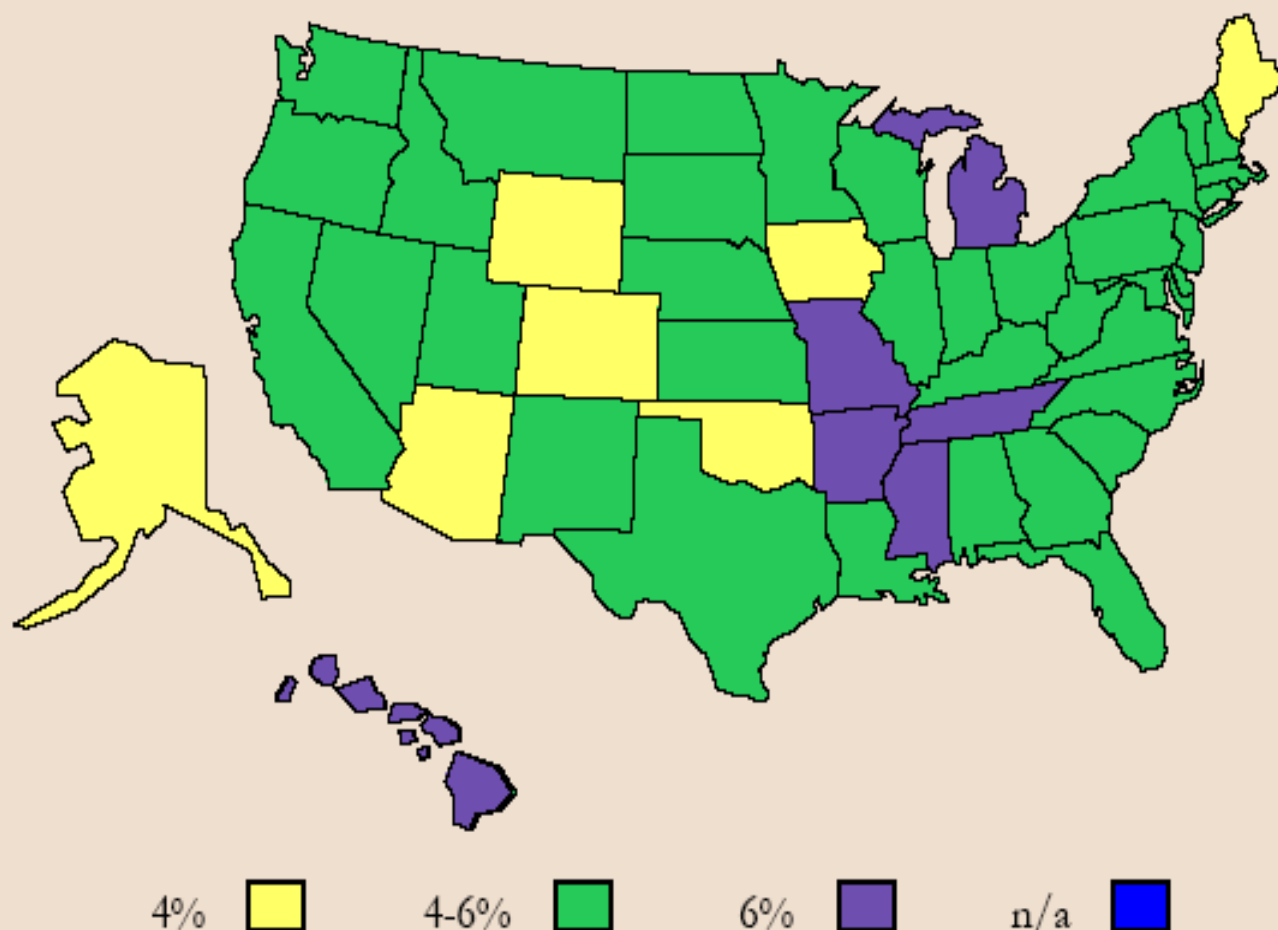


 CDC

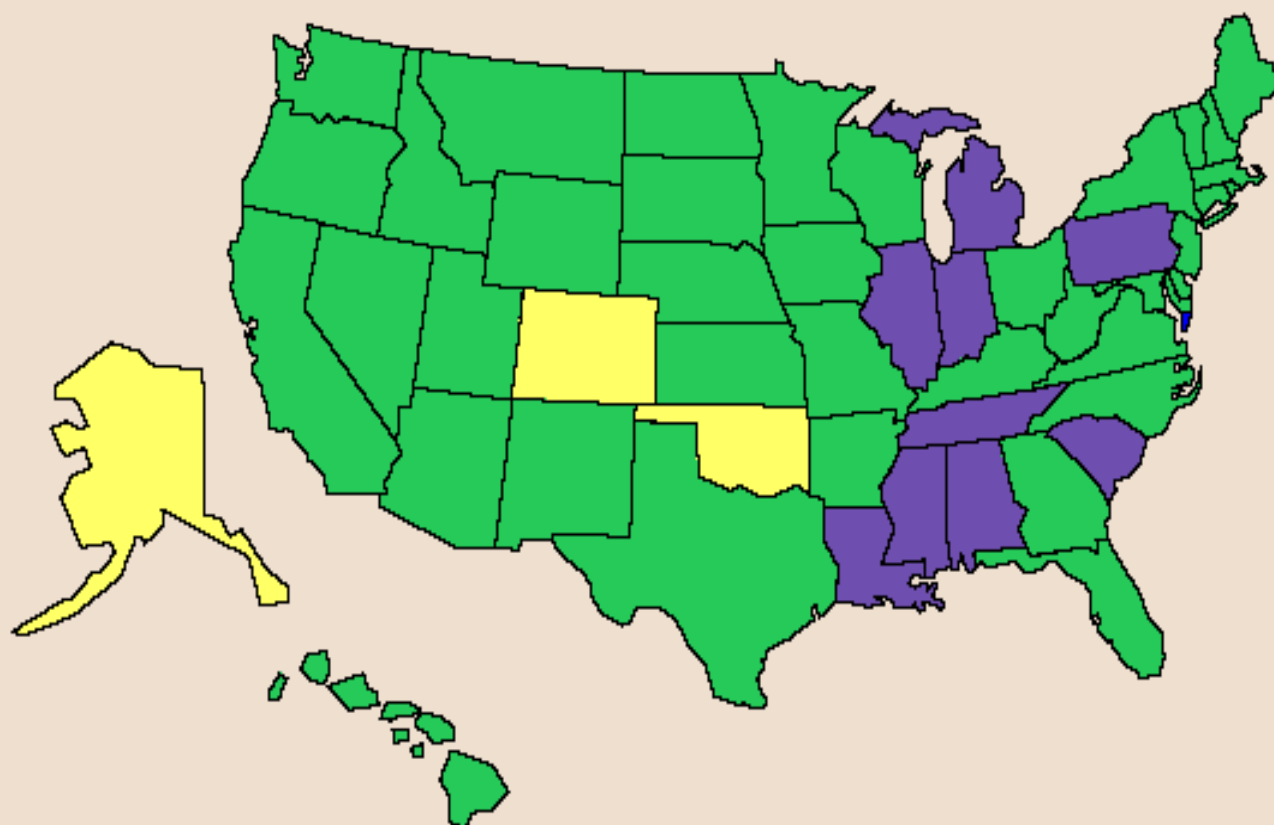
Source: Mokdad, A H, et al. Diabetes Care 2000;23:1278-83



Prevalence of Diabetes Among U.S. Adults, BRFSS, 1993-1994



Prevalence of Diabetes Among U.S. Adults, BRFSS, 1995-1996



4%



4-6%



6%



n/a

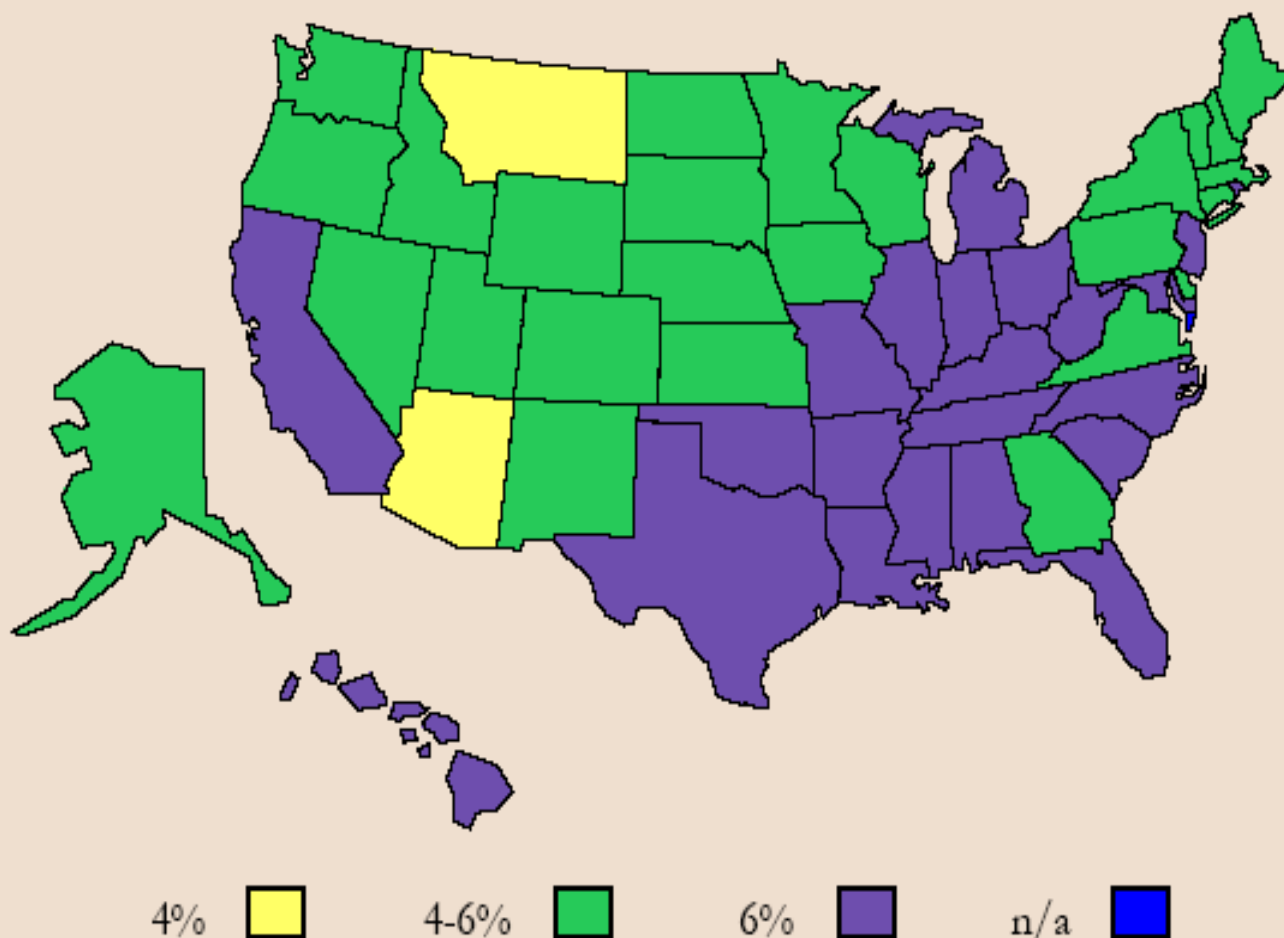


PD-GOV CDC

Source: Mokdad, A H, et al. Diabetes Care 2000;23:1278-83



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

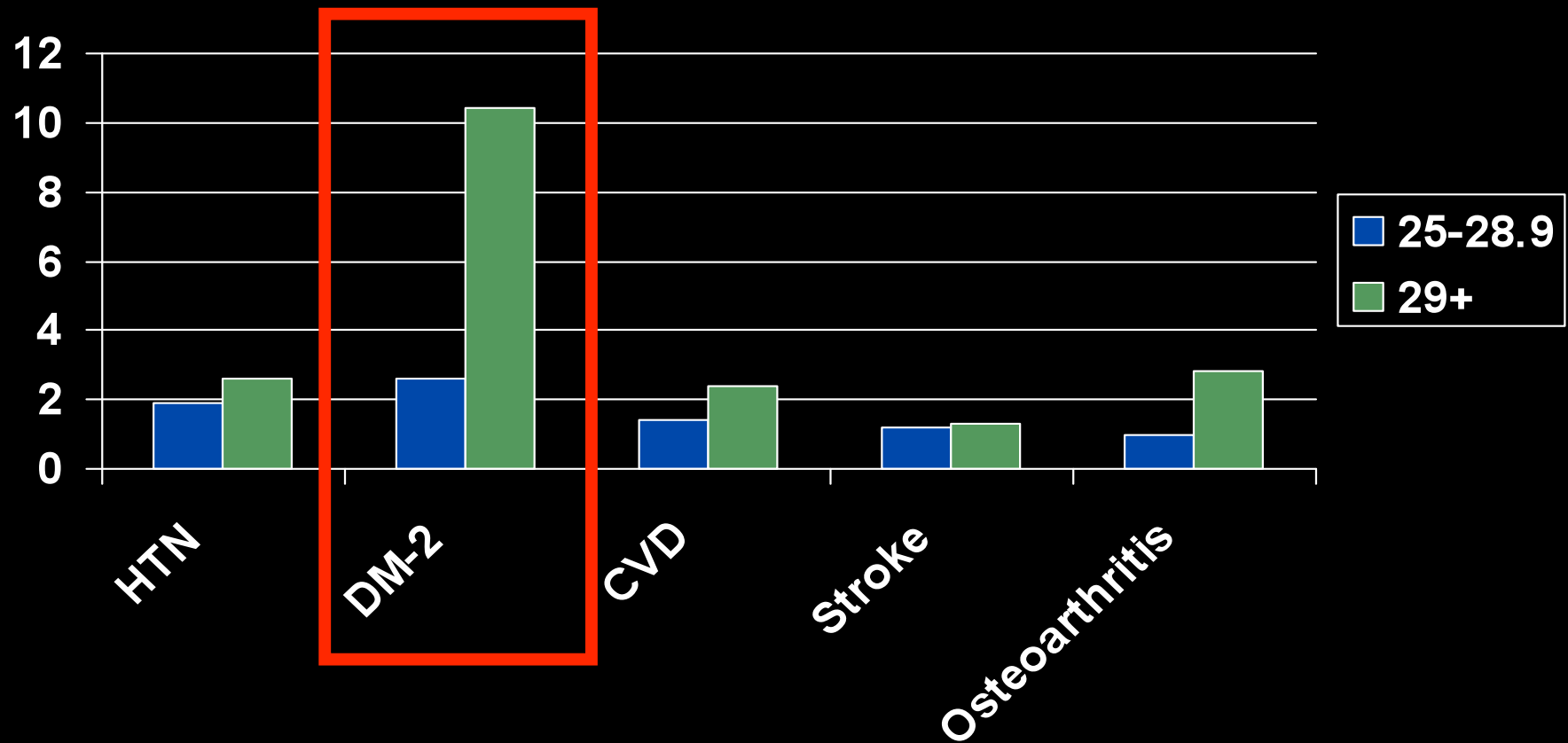


 CDC

Source: Mokdad, A H, et al. Diabetes Care 2000;23:1278-83



Relative Risks of Obesity-Related Diseases by BMI for Men

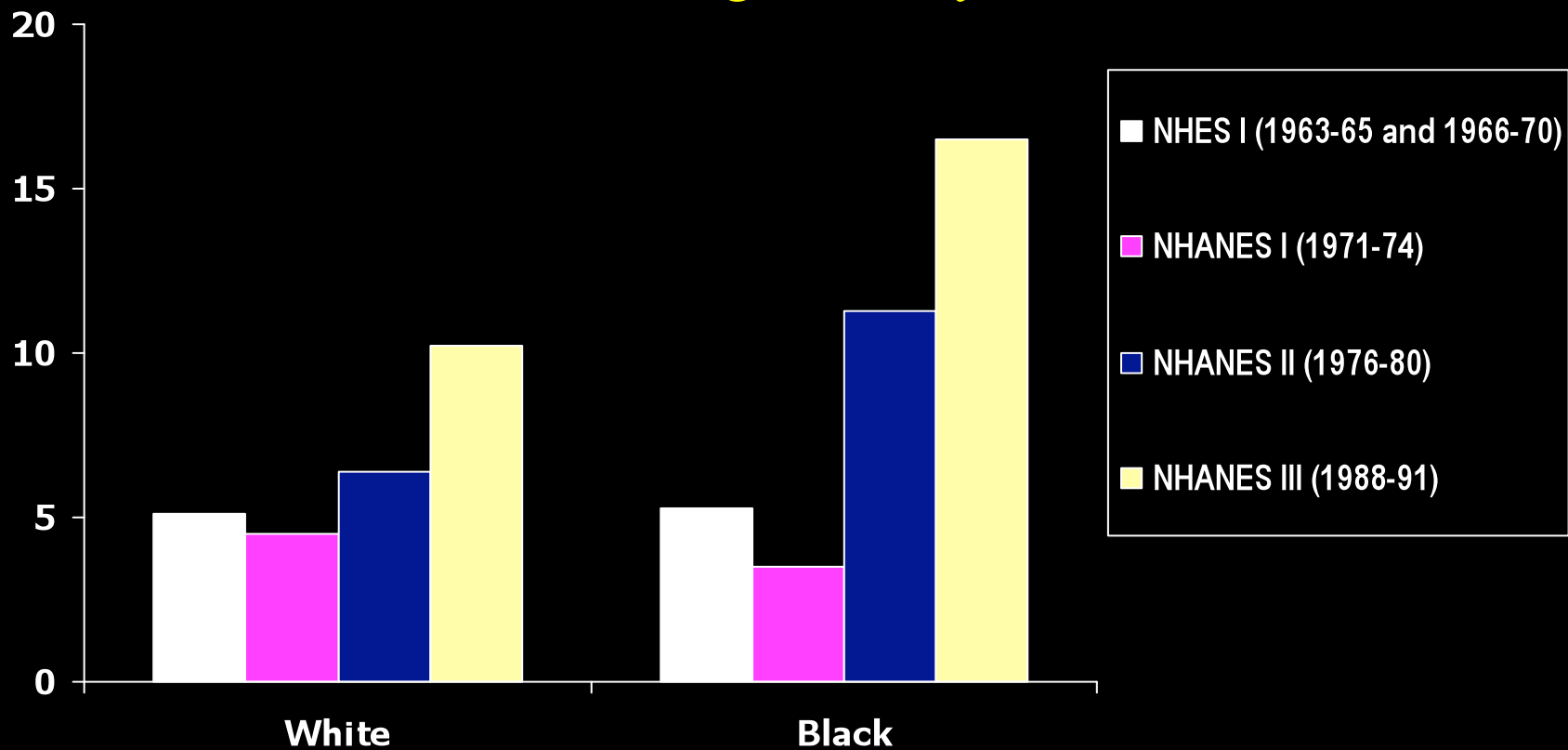


Is obesity bad? Is it limited to adults?

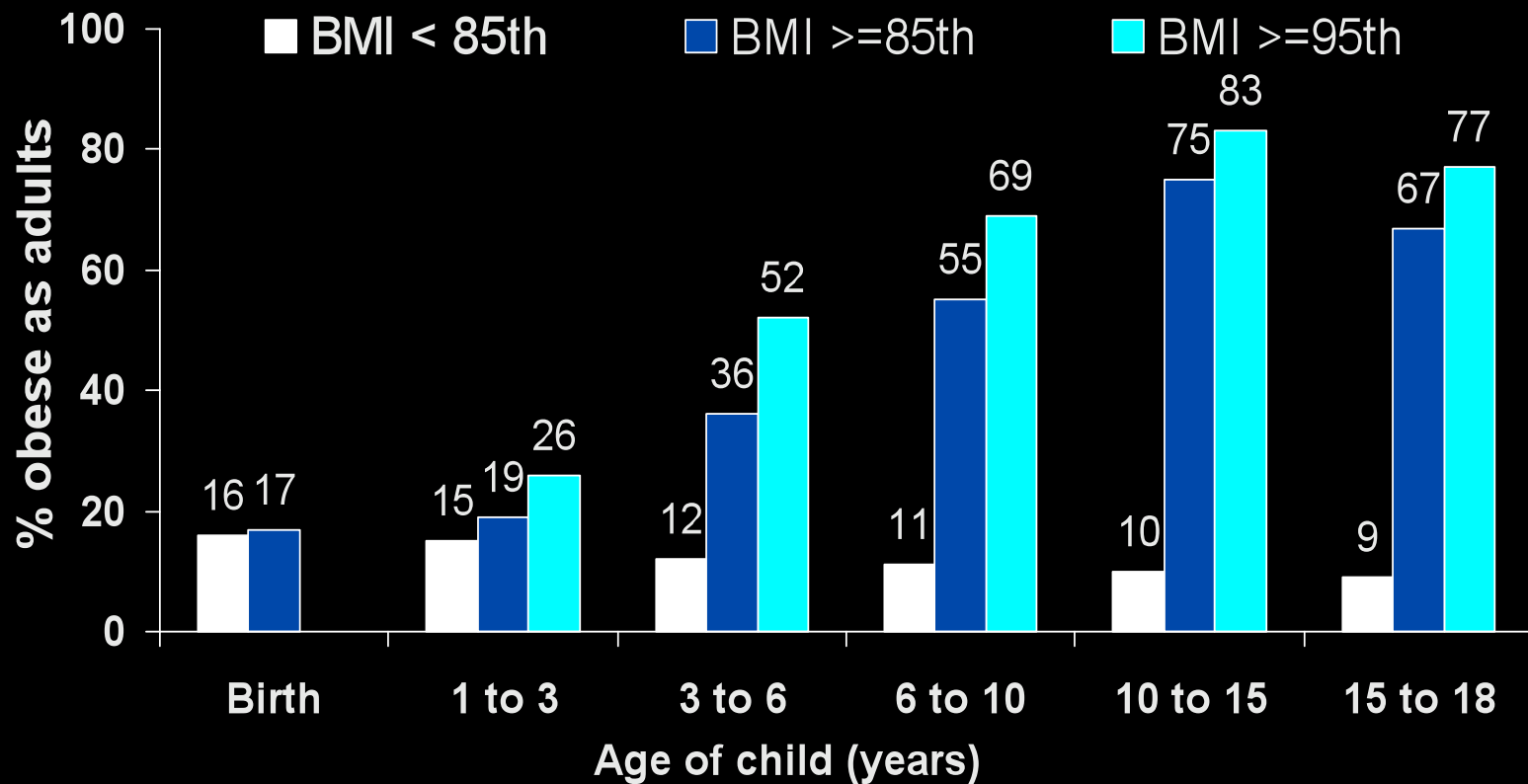
Childhood Obesity: Gut Check Time for Parents

Changes in the Prevalence of Obesity (BMI > 95th Percentile)

Among U.S. White and Black Female
Children Ages 6-11 years



Tracking BMI-for-Age from Birth to 18 Years with Percent of Overweight Children who Are Obese at Age 25¹



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%

Source: Freedman DS et al. Pediatrics 1999;103:1175-82

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 14: University of Michigan Vascular Biology Laboratory, <http://www-personal.umich.edu/~pfbodary/Projects.html>; University of

Michigan Vascular Biology Laboratory, <http://www-personal.umich.edu/~pfbodary/Projects.html>

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 37: Blair, SN et al. Physical Fitness and all-cause mortality, JAMA 1989; 262:2395-2401.

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