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

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Class Objectives:

- Operationalizing the Problem: A few simple definitions
- Prevalence of Chronic Disease and Potential Link to Lifestyle
- Obesity: A side-effect or the fundamental issue?
- Defining the link between energy balance and alterations in weight
- The Role of Physical Activity: Form or Function?
- Important questions to consider

Evolution of the Human Physique

Drawing of human evolution ending in obesity removed

Similar image: http://media.photobucket.com/image/human%20evolution%20obese/rhy1/November/evolution_obesity_picture.jpg

Defining Obesity: Simple, right…?

- Many definitions –
  - WHO defines obesity for adults as a BMI of > 30.
  - Wikipedia: a condition in which the natural energy reserve, stored in fat exceeds healthy limits.

Original Images: ebaumsworld

What to Shoot For??

"Ideal Weight"…?

- Miller Formula
  - Men: Ideal Body Weight (in kilograms) = 56.2 kg + 1.41 kg for each inch over 5 feet
  - Women: Ideal Body Weight (in kilograms) = 53.1 kg + 1.36 kg for each inch over 5 feet.

Ideal Weight: An Example

- Hmmm
- Male Research Fellow…
- Height: 6’2”
- Calculating Ideal Weight
  - Ideal Weight = 56.2 kg + (1.41 kg x 14 inches)
  - Ideal Weight = 56.2 kg + 19.74 kg
  - = 75.94 kg
  - = 167.44 lbs

BMI (Body Mass Index): A Good Proxy for Obesity

- Body Mass Index = wt/ ht^2 (kg/ M^2)
- Utility of BMI is particularly relevant to Cross-sectional research, i.e. RISK of disease increases when BMI increases
- Be aware that BMI is NOT based on fat mass. Athletic individuals who are very muscular will have a high BMI.

BMI Standard Classification

Classification	BMI	Risk
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

BMI Standard Classification

Body Mass Index (BMI)

- Classification:

- Example 5'9", 175 lb Male
  - BMI = 26, Classified "Overweight"
  - Who is Maurice Green

Maurice Green

- Former "World's Fastest Man"
- Overweight

You're special.

- Bodies are not created equally…
- It is inappropriate to assign a single geometrical calculation of body dimensions
- Two Component Model…
  - Fat Component
  - Fat-free body component (FFB)

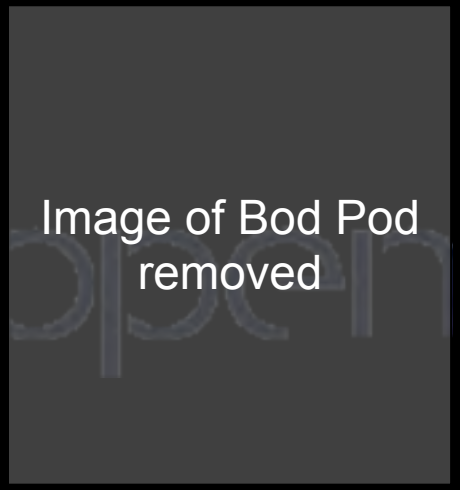
Original Images: http://www.bodyforumtr.com/egzersizler/bacak/vt.gif

Standards of Body Fat Percentages

Obese	35+ % *	25% +**

* Must consider Waist Circumference > 85 cm
**Must consider Waist Circumference > 100 cm

Numerous Ways to Measure/Estimate Body Composition



Original image: http://gizmodo.com/images/2006/05/bodpod.jpg

- Anthropometrics
  - Skinfold Measurements
  - Girth Measurements
- Hydrostatic Weight (Former "Gold Standard")
- Whole Body Plethysmography
- Bioelectrical Impedance Analysis (BIA)
- Dual-energy X-ray absorptiometry (DXA)
  - New Gold Standard

For the purpose of this talk

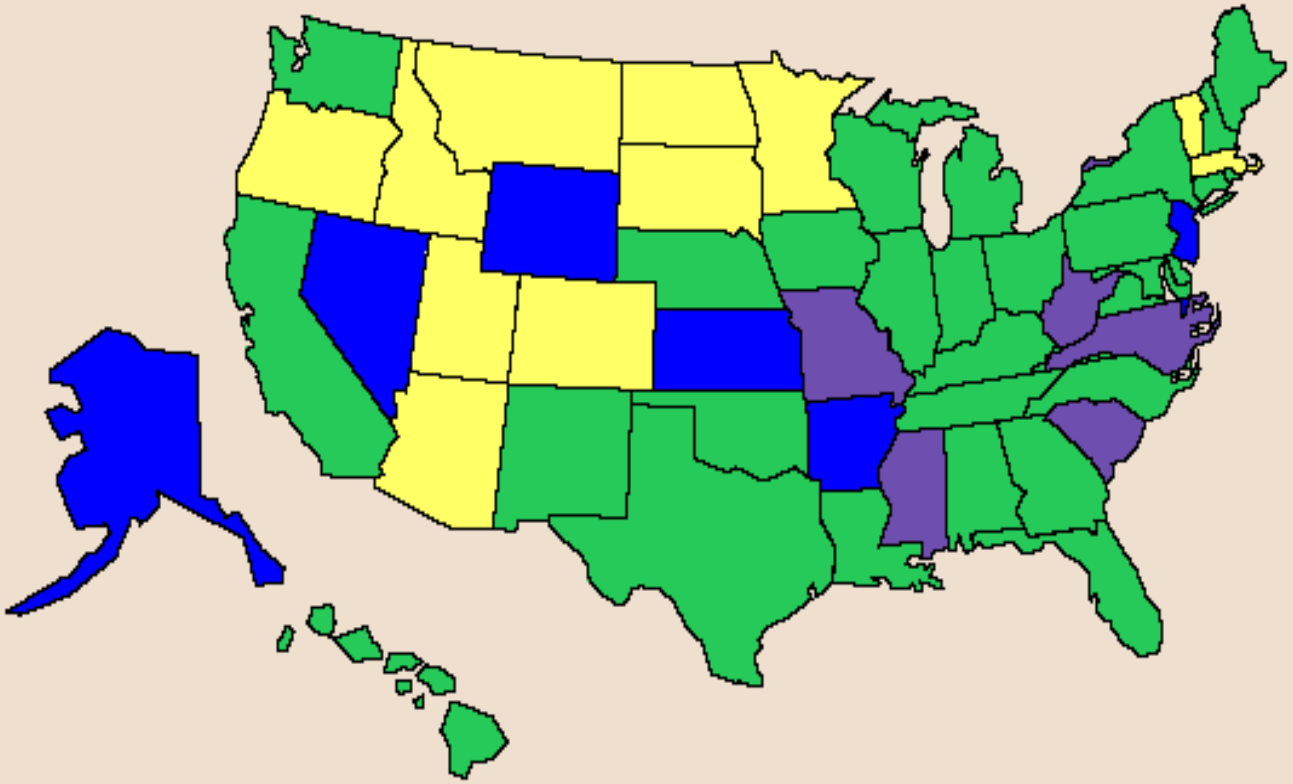
- **Weight loss** = decrease in excess body fat

- Not
  - Loss of body water (dehydration)
  - Loss of lean muscle mass (atrophy during sarcopenia, cachexia, or space travel…)
  - Limb amputations

Regardless of the Operationalization of Obesity!

- Excess body fat or too little lean (muscle) tissue
- Associated with increased risk for cardiovascular disease, pulmonary dysfunction, orthopedic difficulties, type 2 diabetes mellitus and certain cancers

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

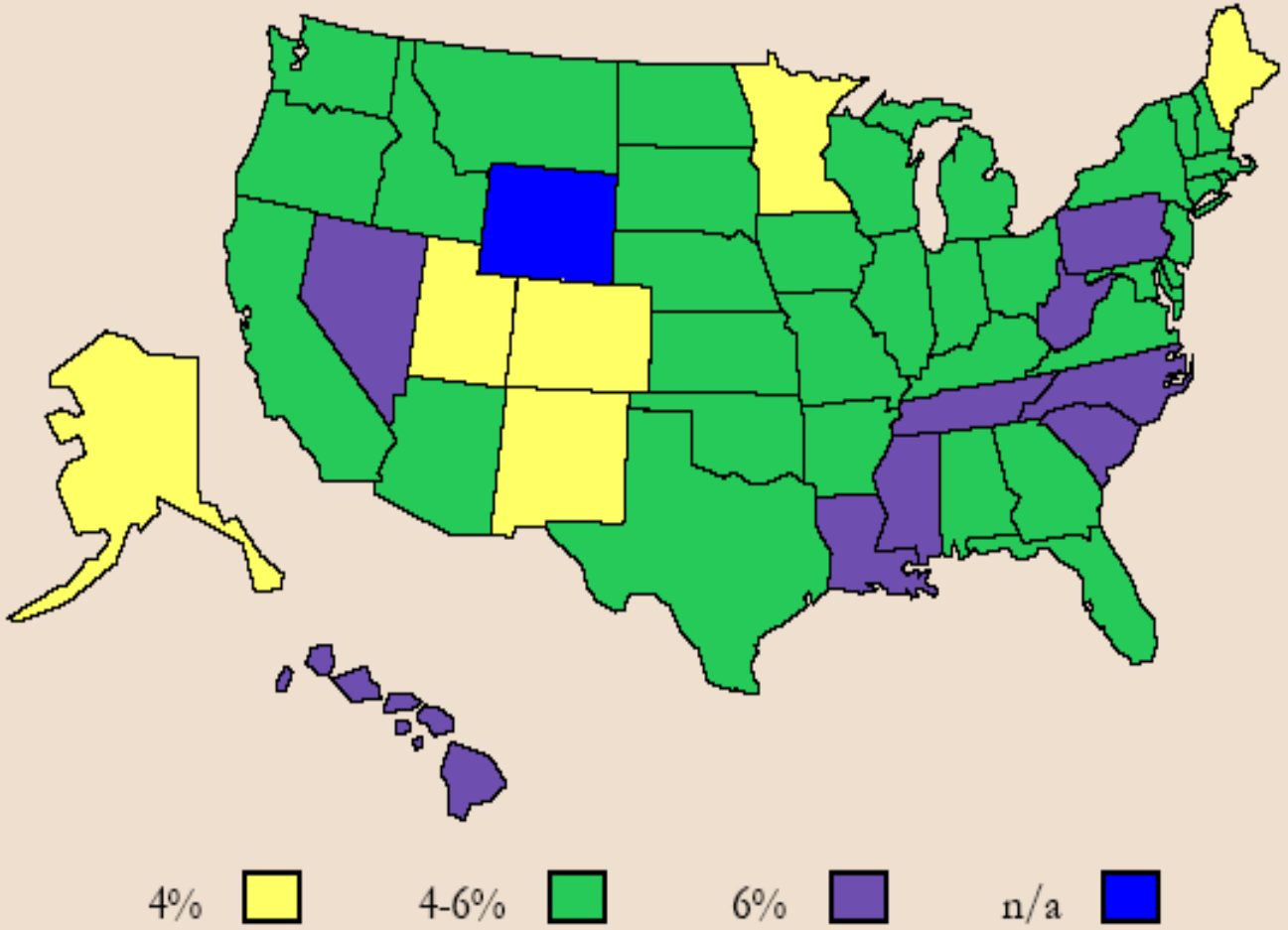


4% 4-6% 6% n/a

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

CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

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



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

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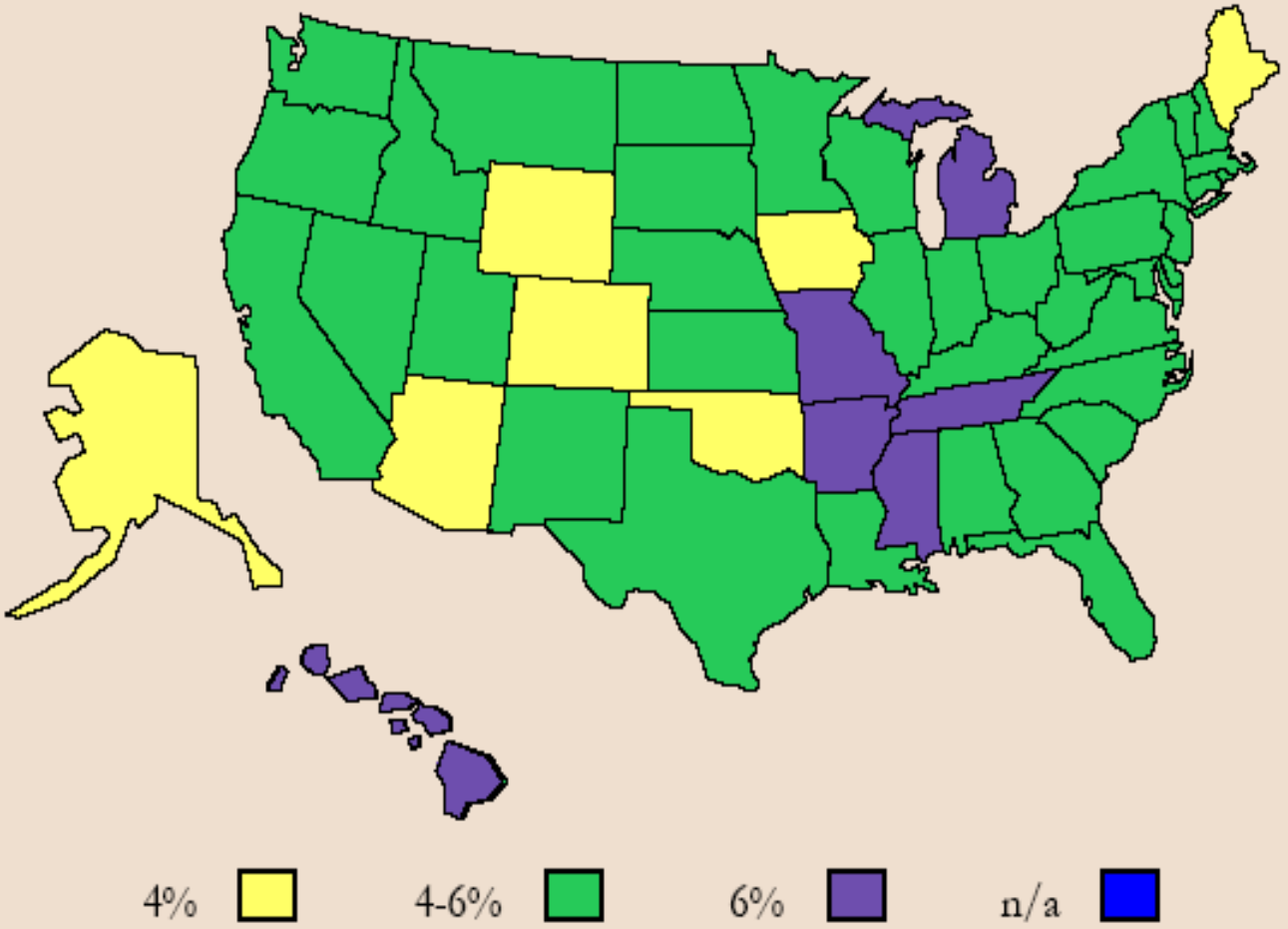
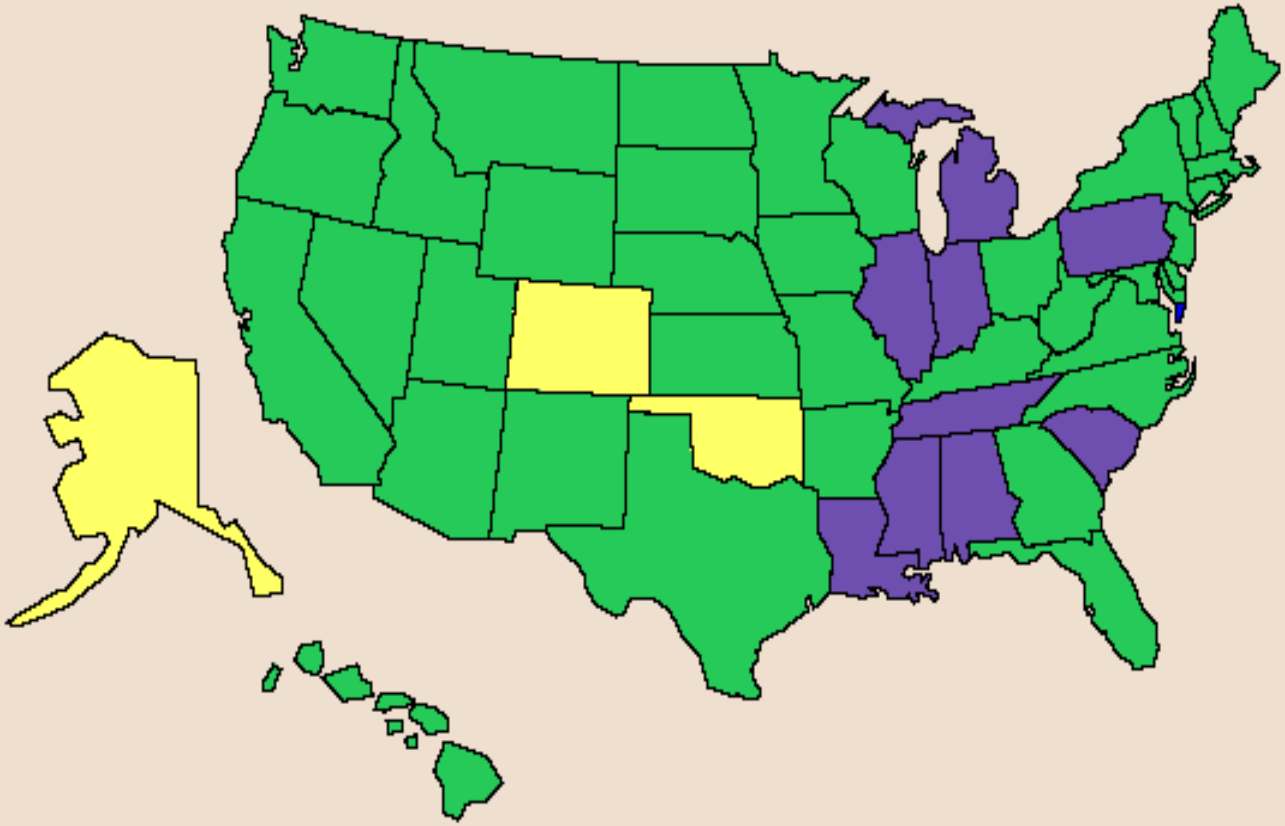
Prevalence of Diabetes Among U.S. Adults, BRFSS, 1993-1994



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

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



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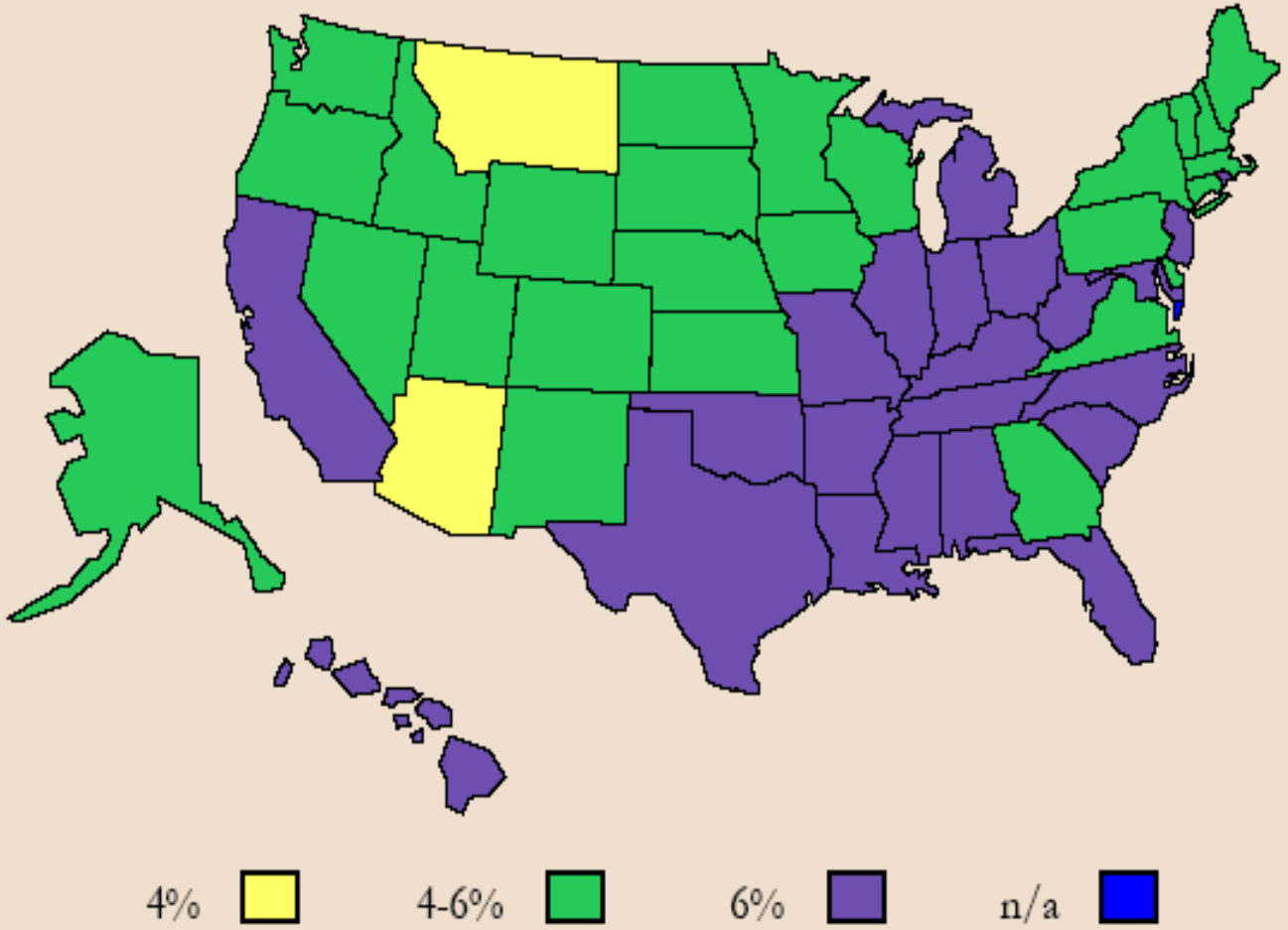
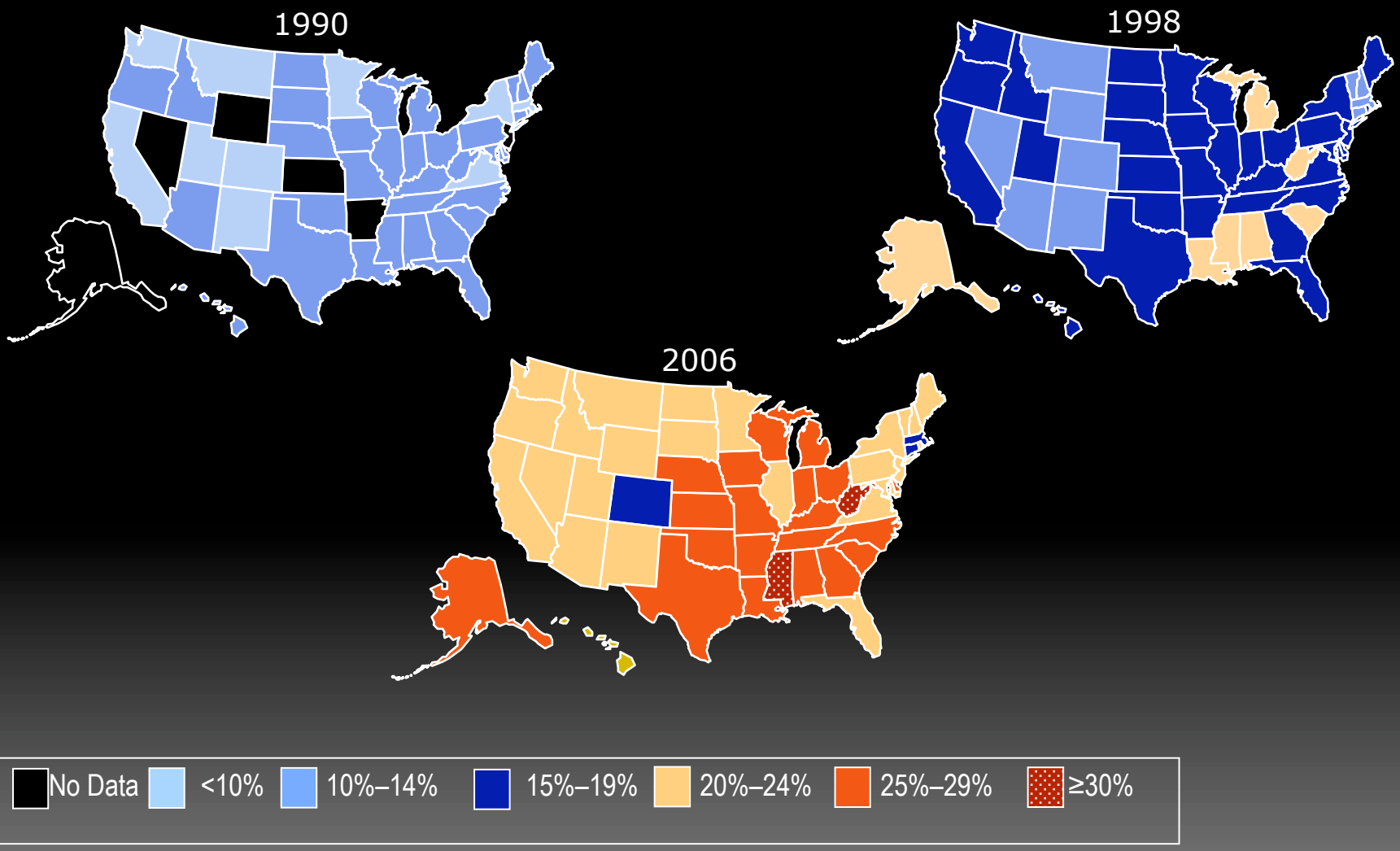


Mokdad, A H, et al. Diabetes Care 2000;23:1278-83

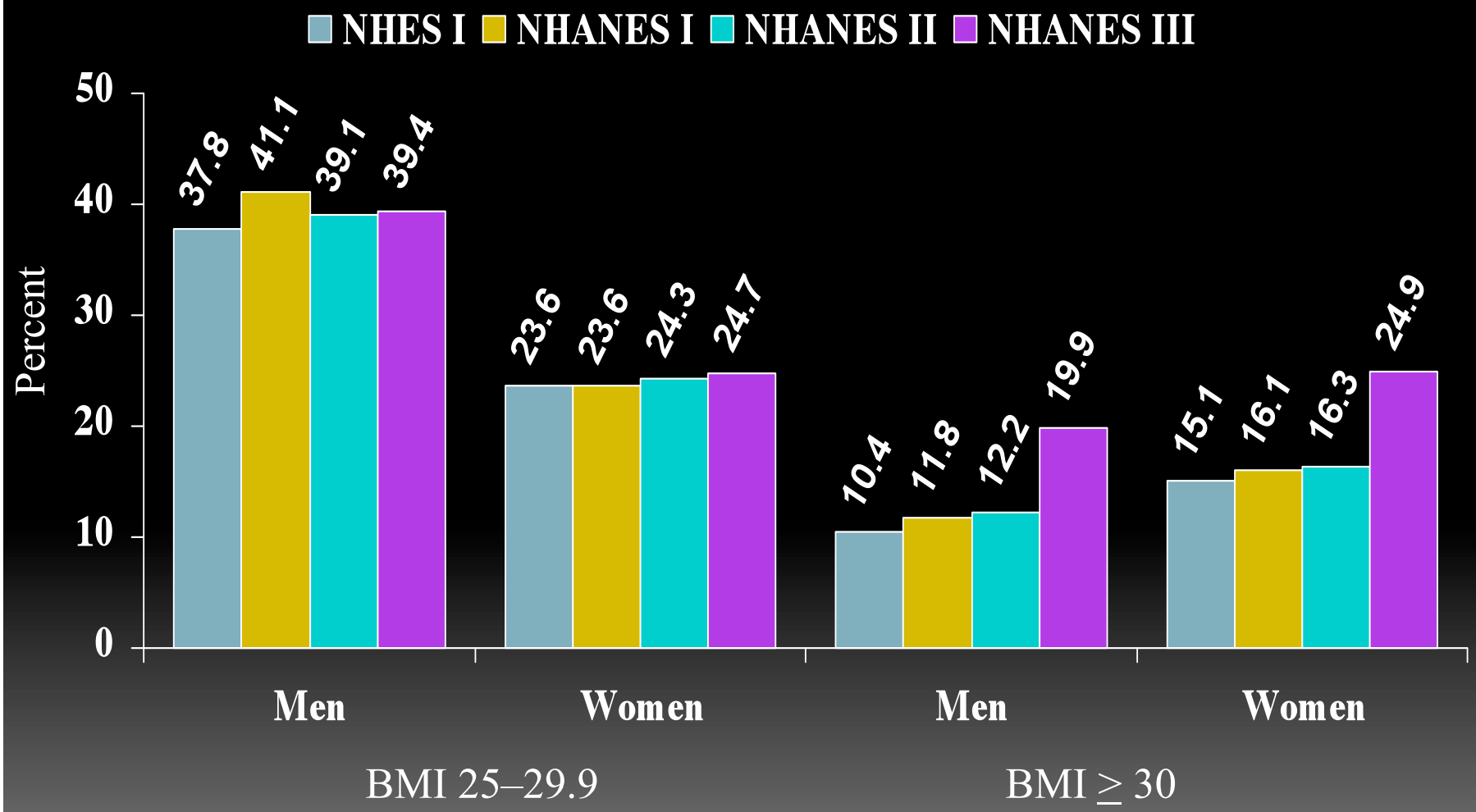
Obesity Trends* Among U.S. Adults

BRFSS, 1990, 1998, 2006

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

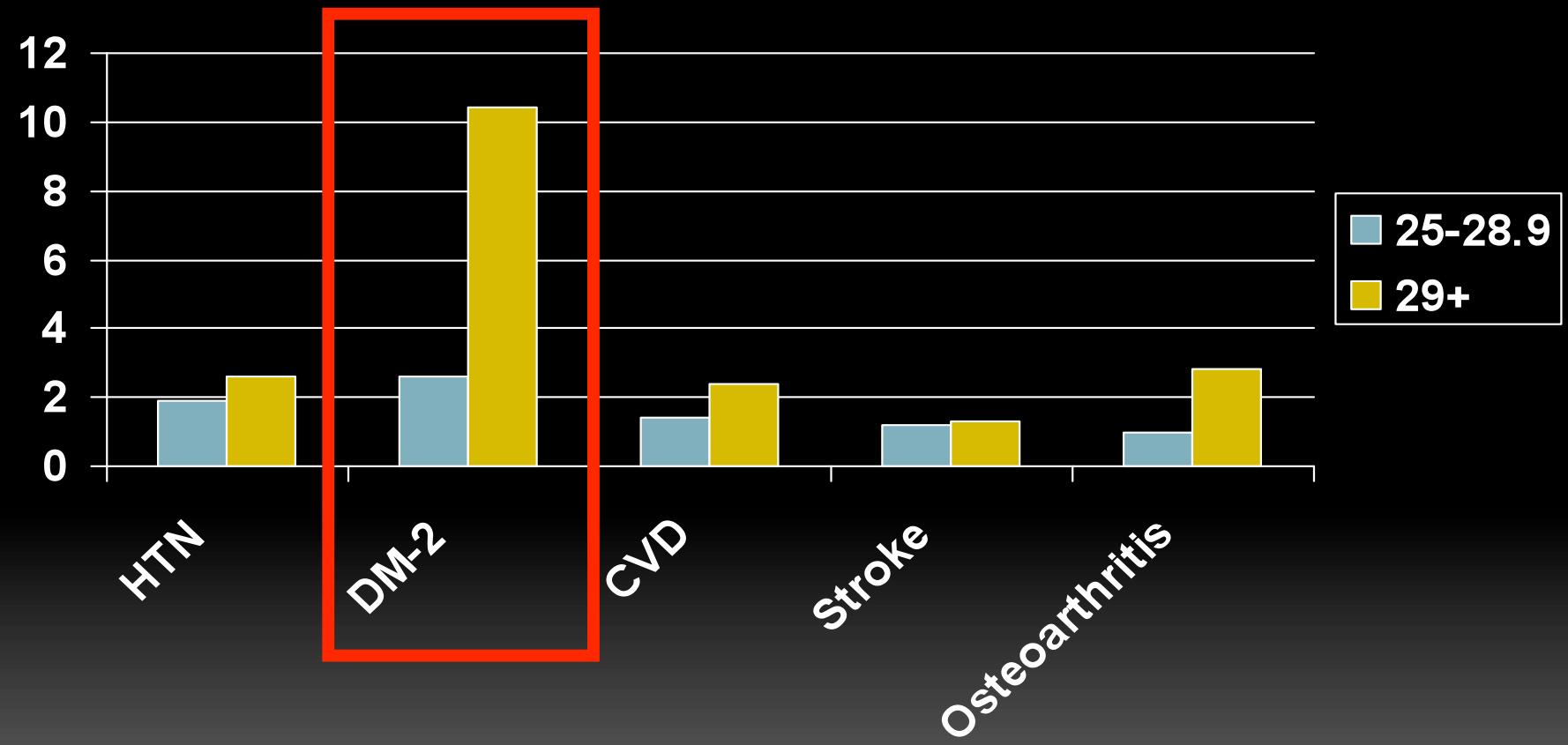


Age-Adjusted Standardized Prevalence of Overweight (BMI 25–29.9) and Obesity (BMI ≥30)



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

Relative Risks of Obesity-Related Diseases by BMI for Men



Oster et al, Am. J. Managed Care, 2000

Childhood Obesity: Gut Check Time for Parents

Original Images: Tab, The Calgary Sun, caglecartoons.com

Childhood Overweight & Obesity

- The Centers of Disease Control (CDC) has operationally defined "Overweight" among children as a body mass index greater than, or equal to the 75th percentile for age and gender

- What about "Obesity"?

Childhood Overweight & Obesity

Table 6.2 Obesity Risk—BMI

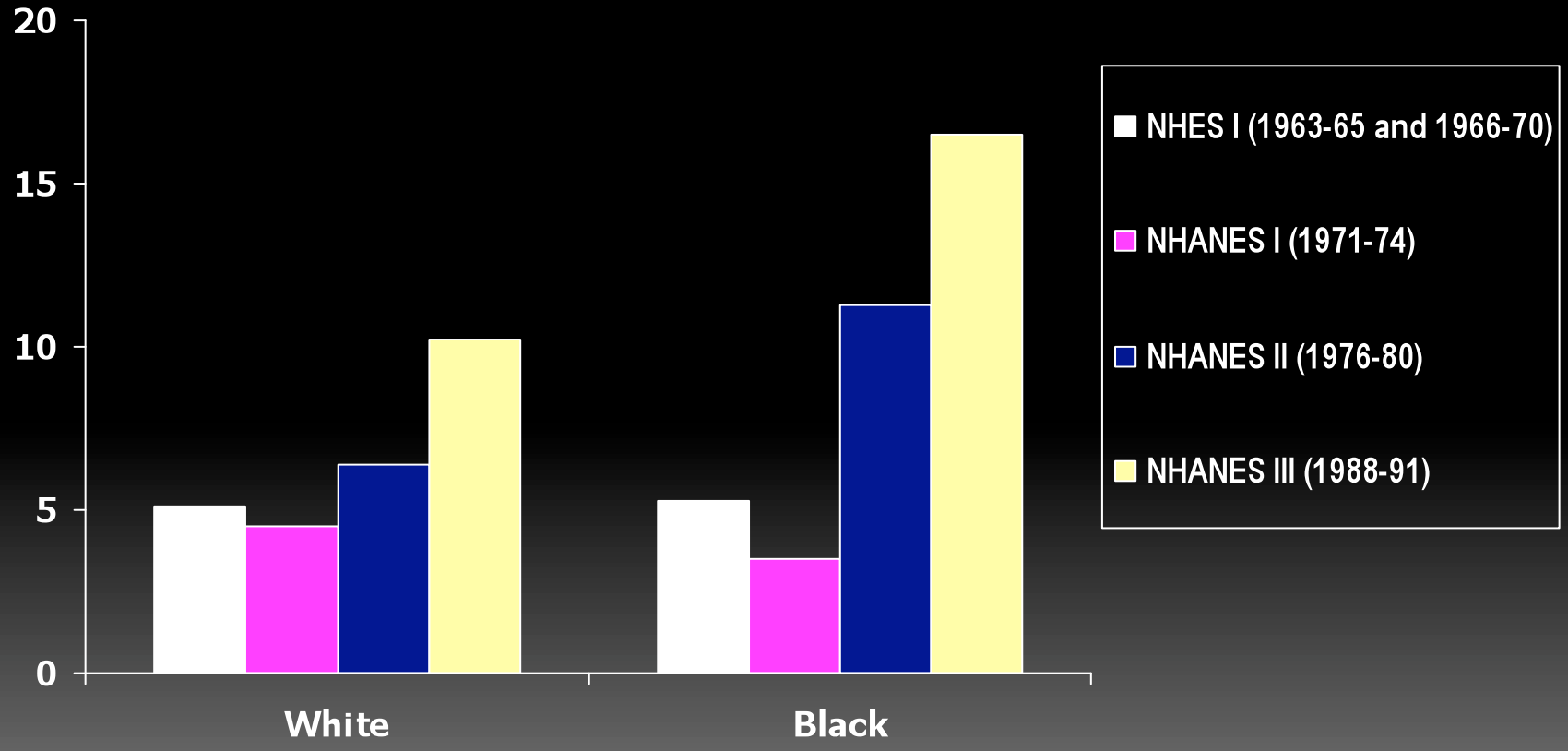
Age	Boys BMI (85%) (at risk for obesity)	Boys BMI (95%) (obese)	Girls BMI (85%) (at risk for obesity)	Girls BMI (95%) (obese)
10	19.5	22.5	20.0	23.0
11	20.2	23.2	20.5	23.5
12	20.2	23.2	21.5	25.5
13	23.0	25.2	22.5	26.2
14	22.5	26.0	26.2	27.0
15	23.5	26.5	24.0	28.0
16	24.0	27.5	24.5	29.0
17	25.0	28.0	25.0	29.5
18	25.5	29.0	25.5	30.5

Note. >85th percentile is considered at risk for overfat; >95th percentile is overfat. BMI = body mass index.

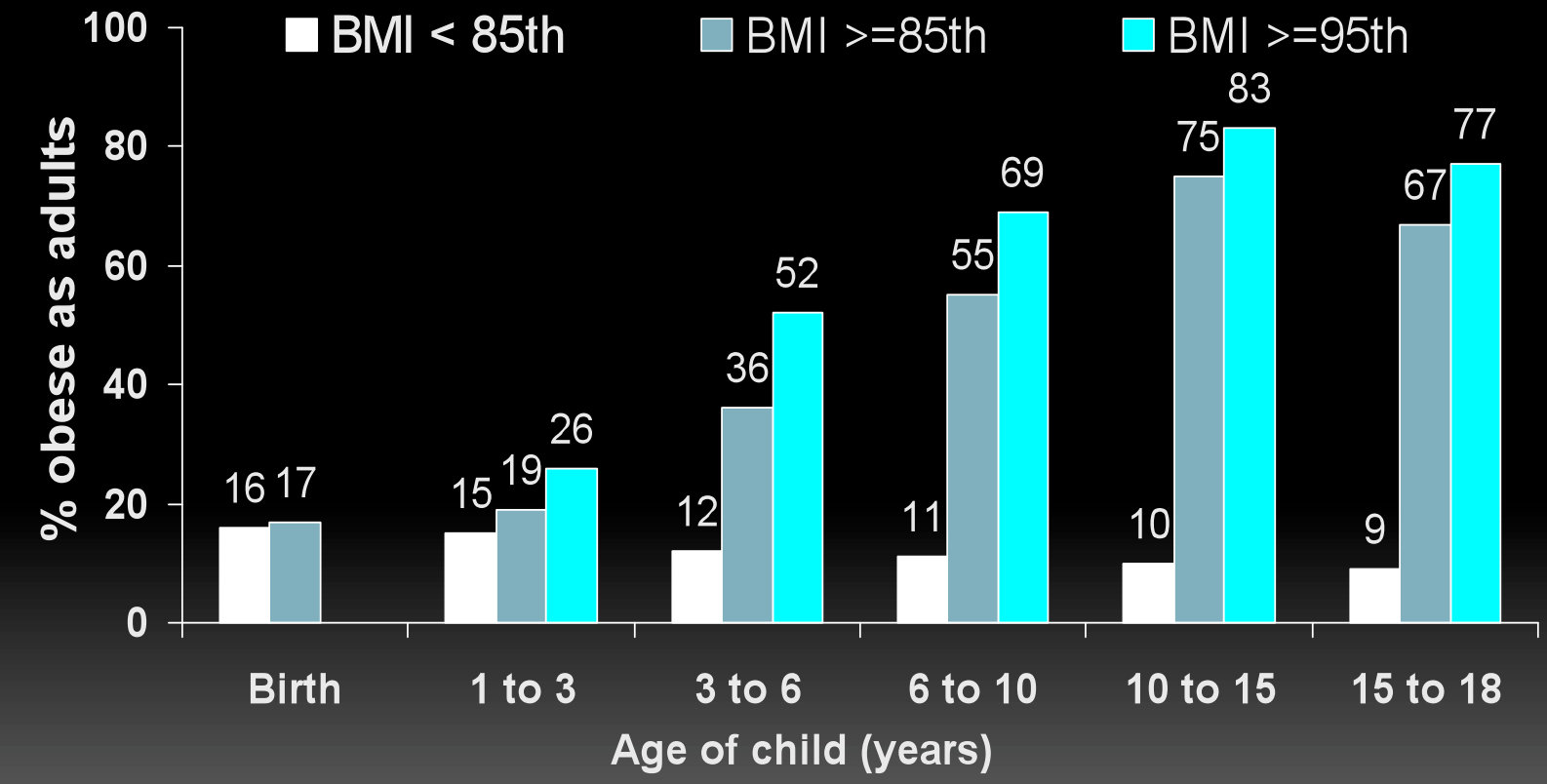
Data from National Center for Health Statistics, *Prevalence of overweight among children and adolescents.*

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 25[1]



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 levels:

27.1%

- % of children, aged 5-10, with 2 or more adverse CVD risk factor levels:

6.9%

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

CVD Risks in Youth

→% of OVERWEIGHT children, aged 5-10, with 1 or more adverse CVD risk factor levels:

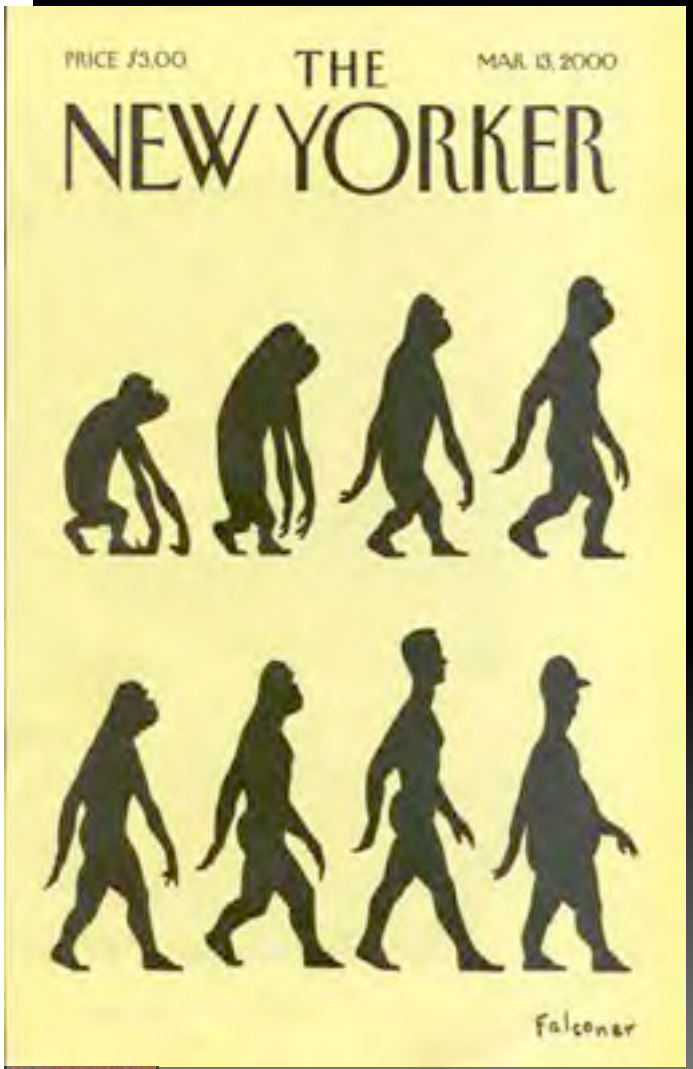
60.6%

- % of OVERWEIGHT children, aged 5-10, with 2 or more adverse CVD risk factor levels:

26.5%

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

Explaining the Epidemic:



FAIR USE Ian Falconer, The New Yorker

- Genetic
  - Heritability of obesity-related phenotypes is high (60-90%) Hebebrand, et al Int J Obes, 2001
- Poor Diet/ Lack of Physical Activity
  - Cannot be explained by genetics
- Environmental Conditions
  - Physical and social environment influence our choices
- "Genes are the gun BUT the environment is the trigger" Bray 2001
  - Genetic susceptibility (i.e., diet and physical activity may not influence us the same)

“The human body is the only machine that breaks down when it is not used.”

(DiNubile 1993)

PD-GOV
CDC

OBESITY IS A NORMAL ADAPTATION TO A STATE OF ENERGY IMBALANCE

Simple Energy Balance

In Energy Balance
Energy Intake = Energy Expenditure

In Energy Excess
Increase in Stored Energy
Energy Intake > Energy Expenditure

Energy Deficit
Decrease in Stored Energy
Energy Intake < Energy Expenditure

Calorie Restriction and Weight Loss

- Small controlled / physiologic trials.
- Large Randomized Controlled Trials.
- Very large historical events / disasters.
  - Somalia
  - Holocaust
  - Irish Potato Famine

Why isn't calorie restriction the answer?

Most people cannot do it when:

- Tasty, cheap high calorie density foods are readily available
- Friends and family eat without restriction
- Lots of competing demands distract you or cause stress leading to emotional eating
- Limited financial resources

Self-Imposed Calorie Restrictions

- Being hungry is unpleasant.
- People eat to relieve non-hunger stimuli
- Unconscious eating
- Calories are hard to track
- Most people have other high priority tasks
- Calorie dense food is cheap and satisfying
- Diet fatigue and rebound weigh gain

However…

Is it easier to create a calorie deficit by

- A. Calorie Restriction (i.e. less intake)
- B. Increased Calorie Expenditure
- C. A combination of both

- What is the calorie deficit required to lose one (1) lb of weight?
- Implications for Diet and Physical Activity?

Energy Expenditure

EE = Basal Metabolic Rate +
Thermic Effect of Food +
Physical Activity

Basal Metabolic Rate (BMR)

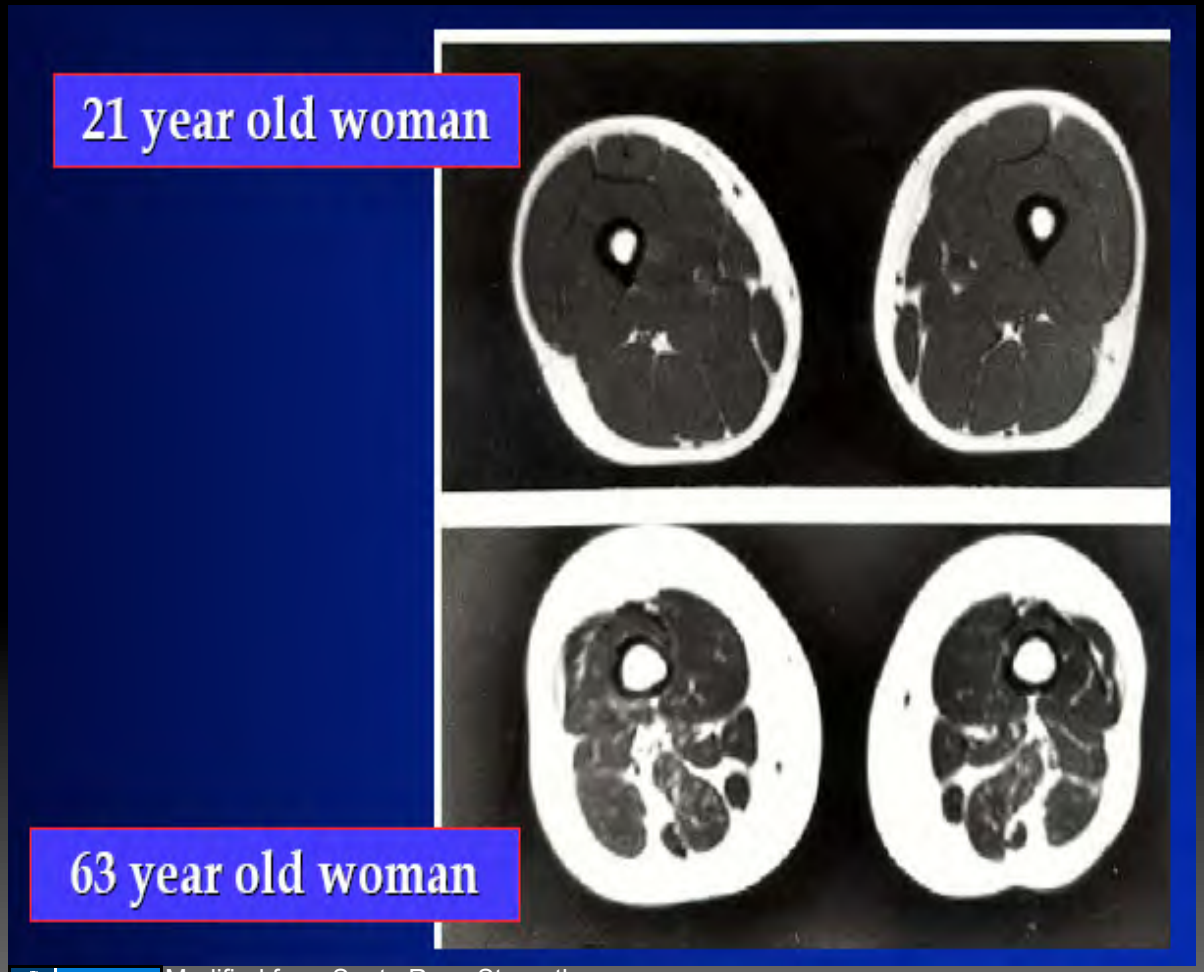
- AKA Resting Metabolic Rate (RMR)
- The energy your body expends at rest
  - Keep your brain functioning
  - Breathing
  - Circulating and cleaning blood

Basal Metabolic Rate (BMR)

- Gender inequality
- For the same body mass, age, and height, **MEN** have greater BMR

- Why?
- Lean Body Mass (LBM) or muscle is a metabolic tissue
- Implications for Aging…?
  - Sarcopenia?

Aging and Sarcopenia…



PD-INCL Modified from Santa Rosa Strength

Image of Arnold Schwarzenegger removed

Original Image: http://z.about.com/d/politicalhumor/1/0/N/9/arnold_then_now.jpg

Basal Metabolic Rate (BMR)

- Important Question:
- Is Obesity caused by low BMR?

- Interestingly, although BMR comprises a large percentage of the total kcal expended during the course of a day, cross sectional data demonstrate that mean BMR between obese and non-obese adults are not necessarily lower… more in a minute

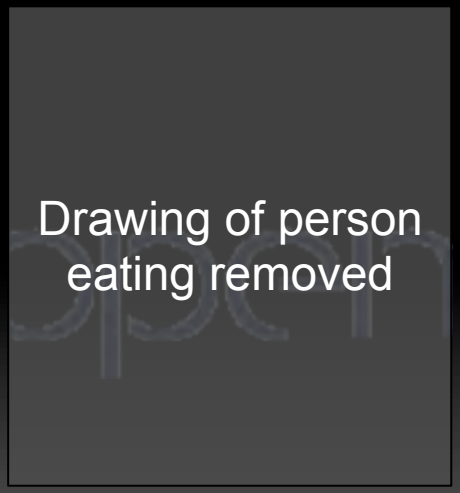
Thermic Effect of Food (TEF)

- Energy required to digest, absorb and assimilate food.
- Averages 10 to 30% of BMR
- Protein digestion requires more energy than carbohydrates or fats.

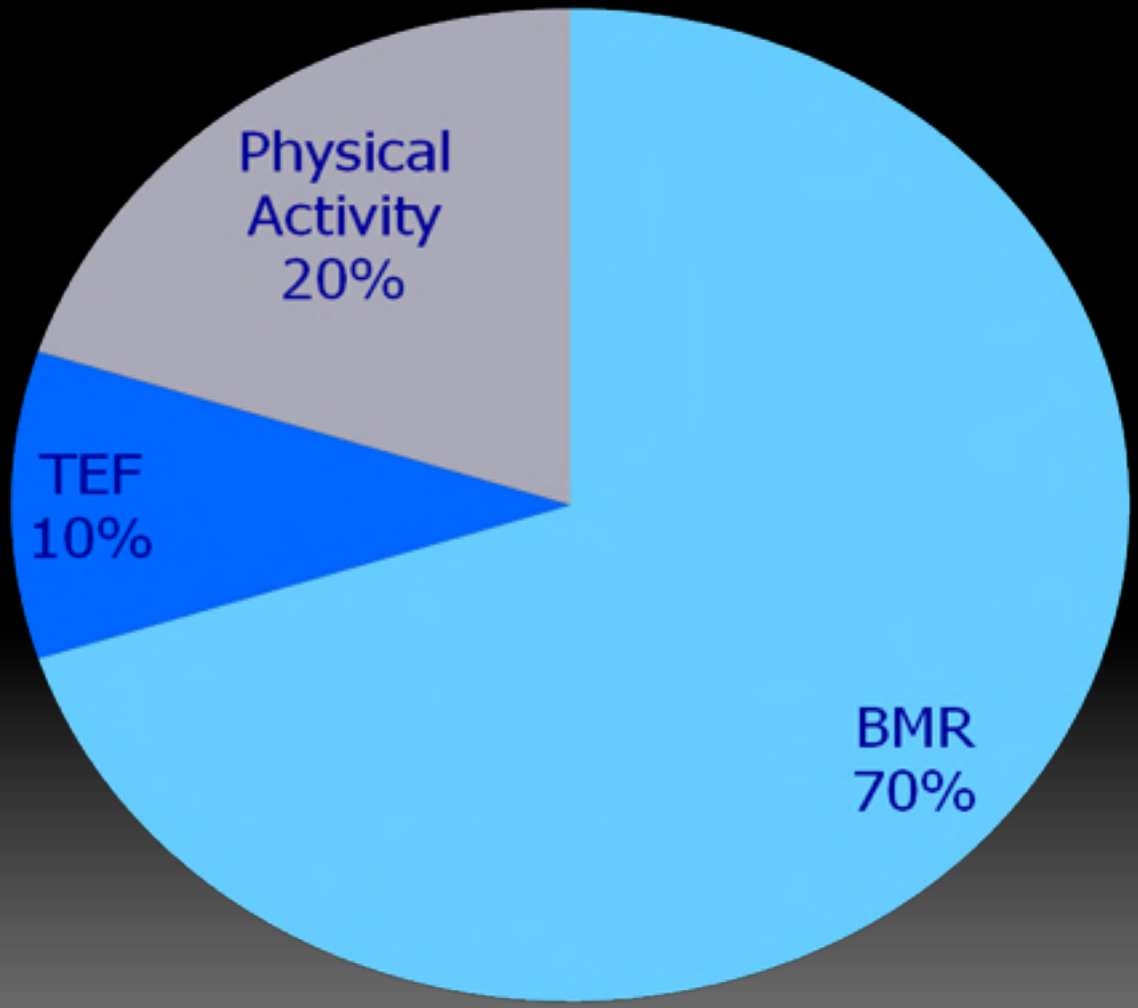
Physical Activity

Includes all voluntary muscle activity that expends energy beyond rest.

- Physical Exercise
- Walking
- Sitting or Standing
- Fidgeting
  - NEAT: Non-exercise activity thermogenesis).



Total Energy Expenditure



Source Undetermined

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
- Steve Blair – Fat and fit live longer than thin and unfit.
- Predict mortality independently.

Total Daily Energy Expenditure and Voluntary Physical Activity

- Estimate total daily calorie needs as a function of BMR and Physical Activity Level:

Confined to bed	1.2 * BMR
Ambulatory, low activity	1.3 * BMR
Average activity	1.5 * BMR
Highly active	2.0 * BMR

Energy Expenditure Examples

- Tour de France: 6000 calories / day
- Triathlons: 4500 calories / day
- Distance Runners: 3500 calories /day

- Energy expenditure from physical activity = ____ (intensity, duration, frequency)

METs - Metabolic Equivalents

- A measure of physical activity intensity
- Expressed as multiple of BMR

- Relative to BMR vs Absolute

Walking

- The number one choice of people who exercise regularly
- Highly variable in intensity
- Moderate activity = 3 to 6 METs = walking at 3 to 4.5 miles per hour.
- Increased if you are carrying or pushing something, walking up a hill
- 2000 steps = 1 mile

Leptin

- A peptide hormone
- Generated by Adipose Tissue
- High Levels → Energy Excess

  (Increase Activity, Decrease Appetite)
- Low Levels → Energy shortage

  (Decrease Activity, Increase Appetite)

Do Obese People Have High or Low Leptin Levels ?

Metabolic Characteristics in Obesity

(compared to non-obese controls)

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

Metabolic Characteristics in Obesity and Pre-Obesity (compared to non-obese controls)

	Obese	Pre-obese
Leptin	High	Low
RMR	High	Low
Fat Oxidation	High	Low
Sympathetic NS	High	Low
Insulin Sensitivity	Low	High

Physical Activity and Obesity – Editor Claude Bouchard, p72.

Hypothetical Sedentary Person

- Intake / day = 2000 calories
- Energy Burned / day

= 1200 calories for BMR

\+ 120 calories for Thermogenesis

\+ 180 calories for Physical Activity

1500 calories burned

➔ 500 calorie energy excess / day

Theoretical Result of Energy Excess

- 500 calories / day
- X 7 days = 3500 calorie excess

- → 1 pound weight gain per week.

Actual Results

- However, there is large inter-individual variation in actual weight gain/loss
- Weight regulation is a complex system with multiple metabolic and hormonal pathways, lots of feedback loops, redundancy, and a strong tendency dampen the effect of changes in energy supply.

Contrary to Popular Belief

- As you gain weight, your basal metabolic rate increases.

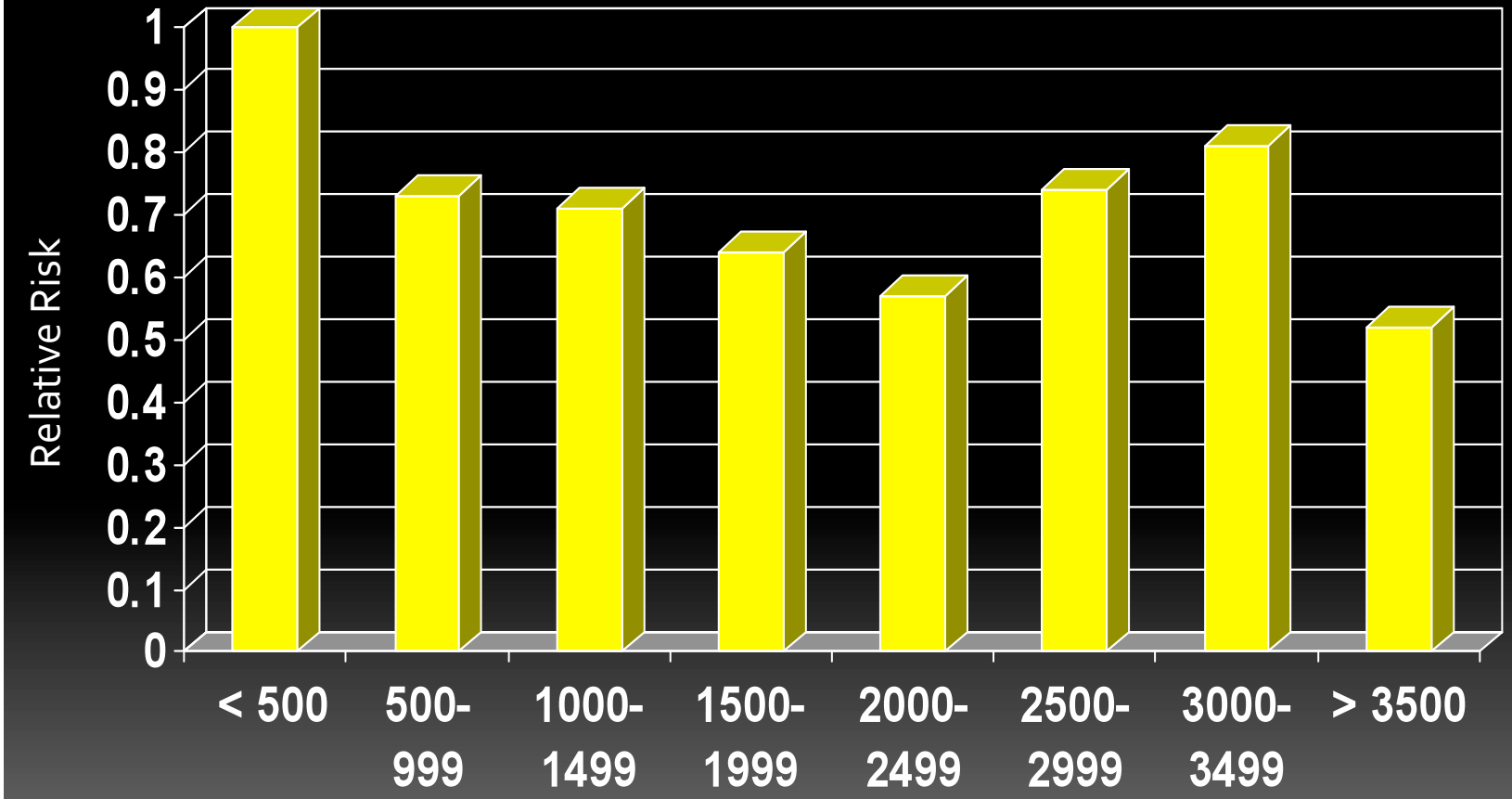
- So after day one, if you gained 1/7th of a pound, you also increased your BMR → day 2 energy excess is less than 500 cal.

Health Benefits of Exercise

- Decreased CVD risk
- Decreased Cancer risk
- Decreased obesity
- Improved blood lipids/ lipoproteins
- Improved glucose tolerance
- Improved fibrinolytic activity
- Reduced blood pressure
- Prevention of osteoporosis
- Improved mental health

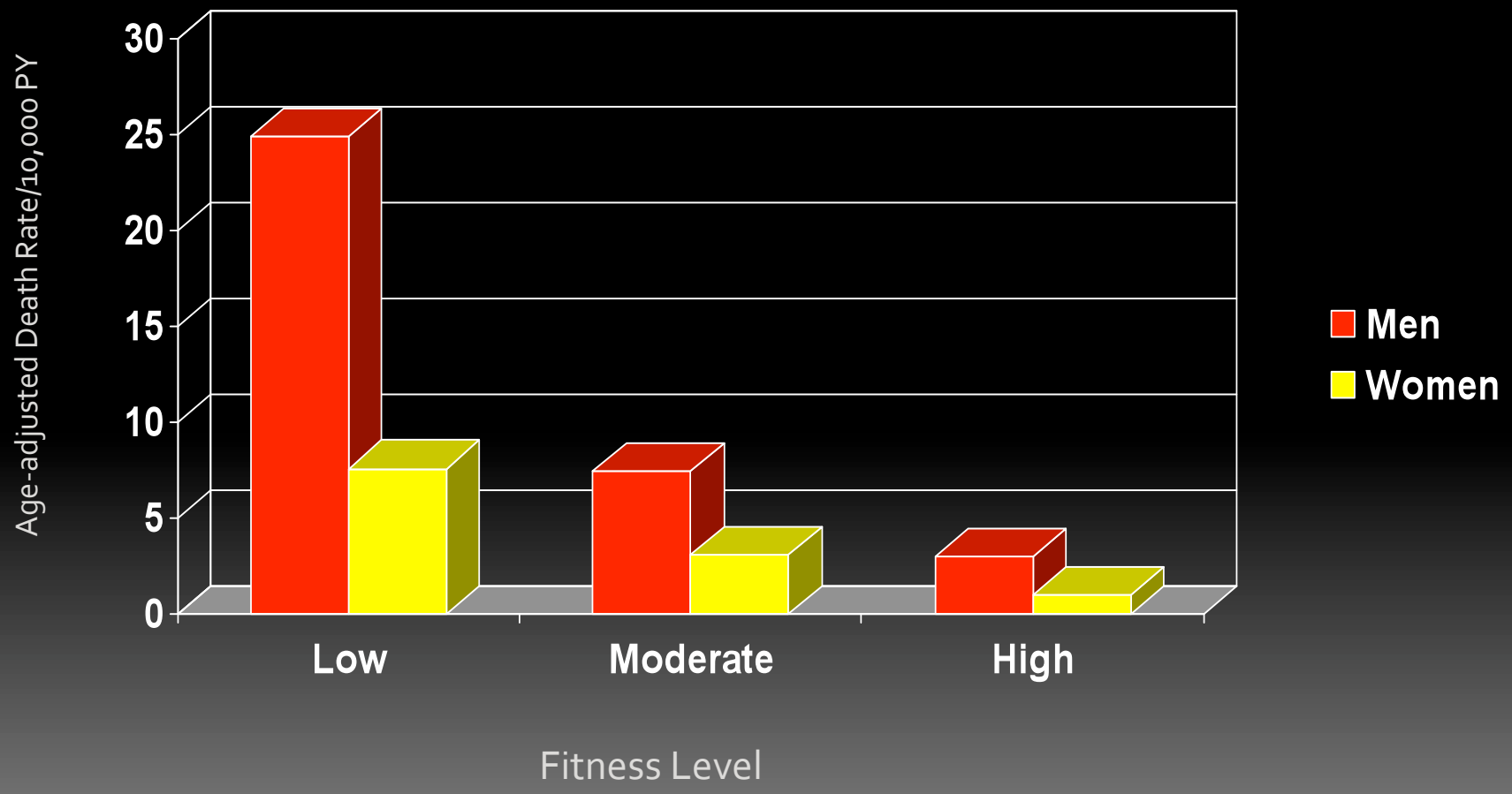
Energy Expenditure and All-Cause Mortality

Harvard Alumni Study



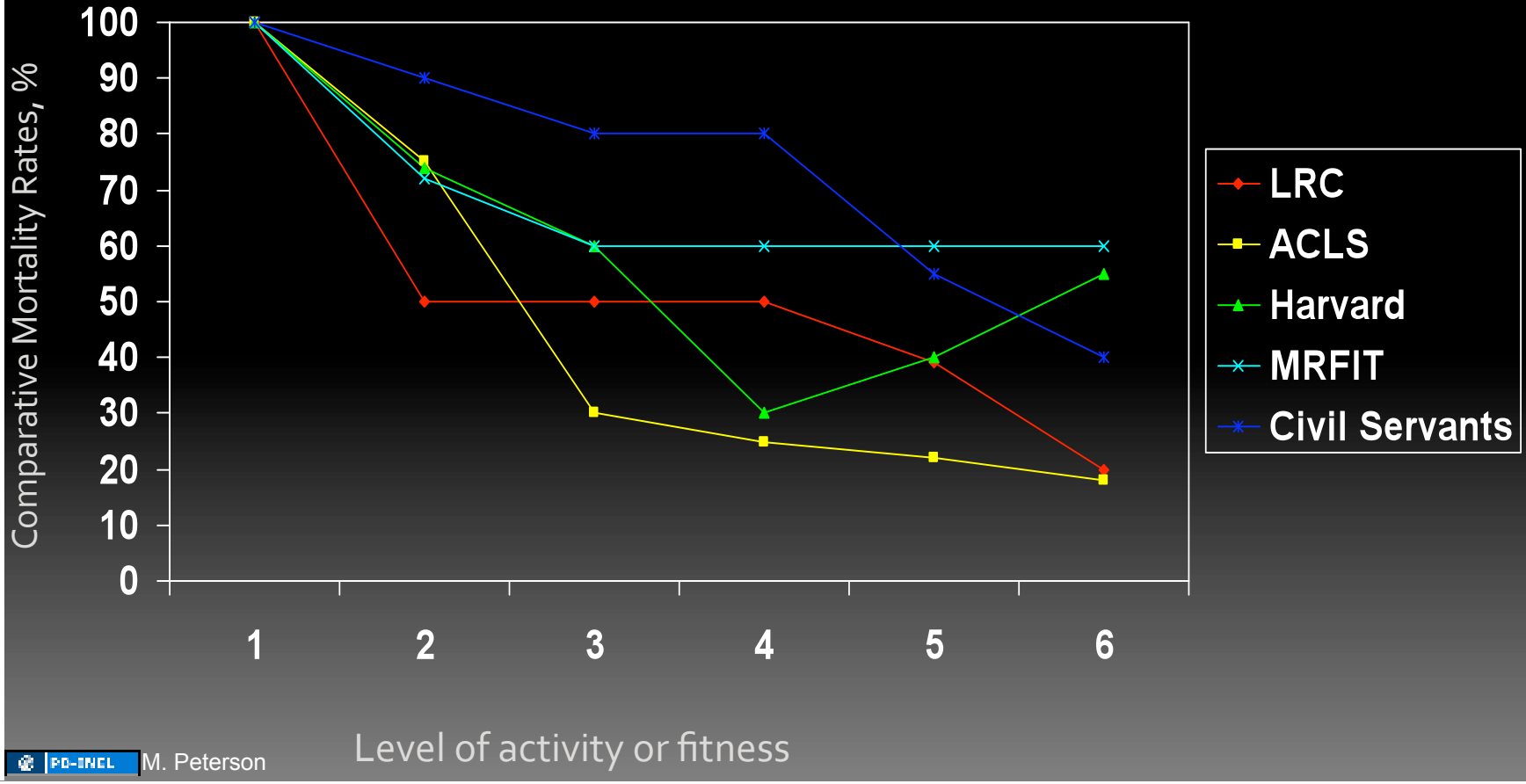
PD-INCL Harvard Alumni Study

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

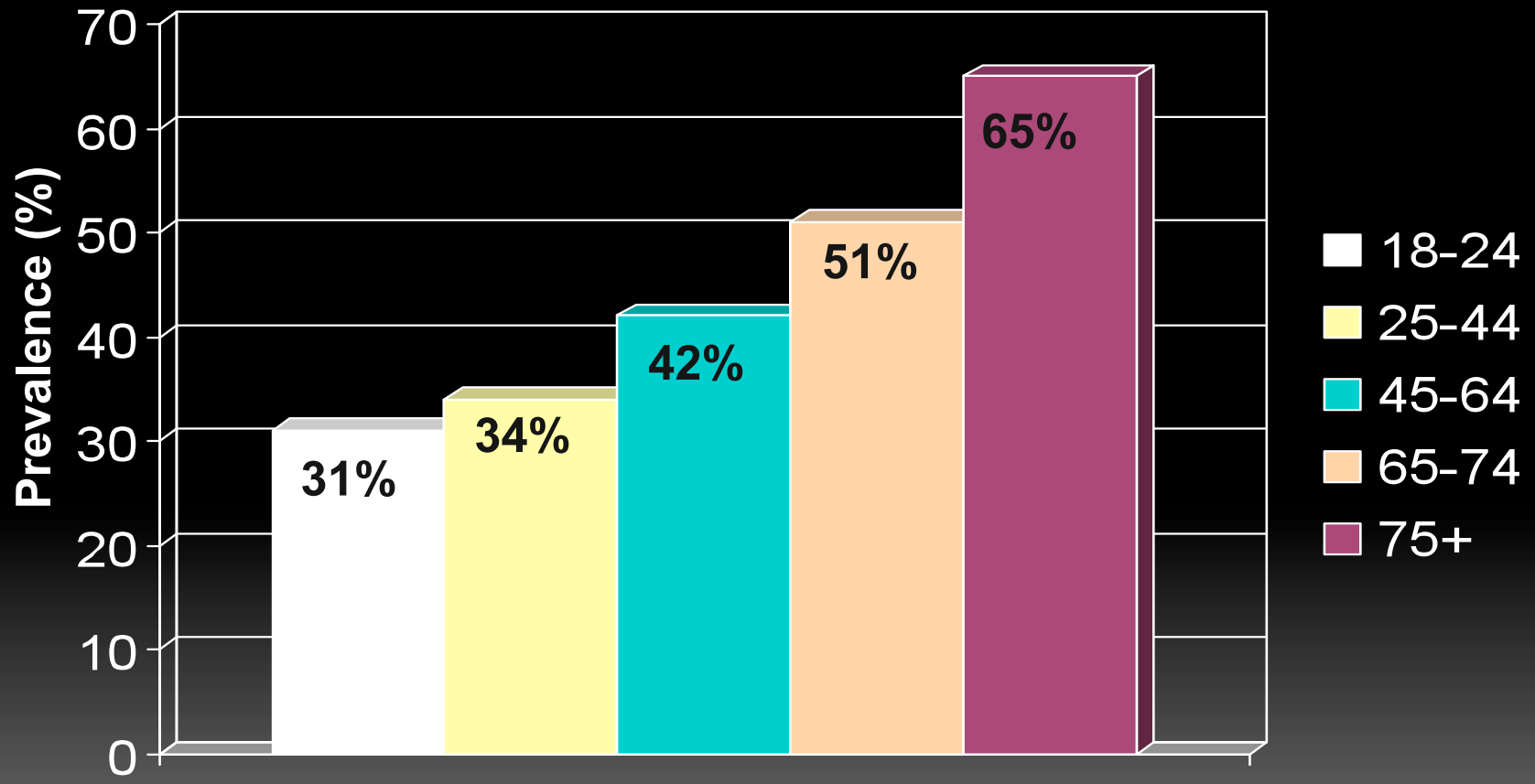


JAMA 282:2397, 1980

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

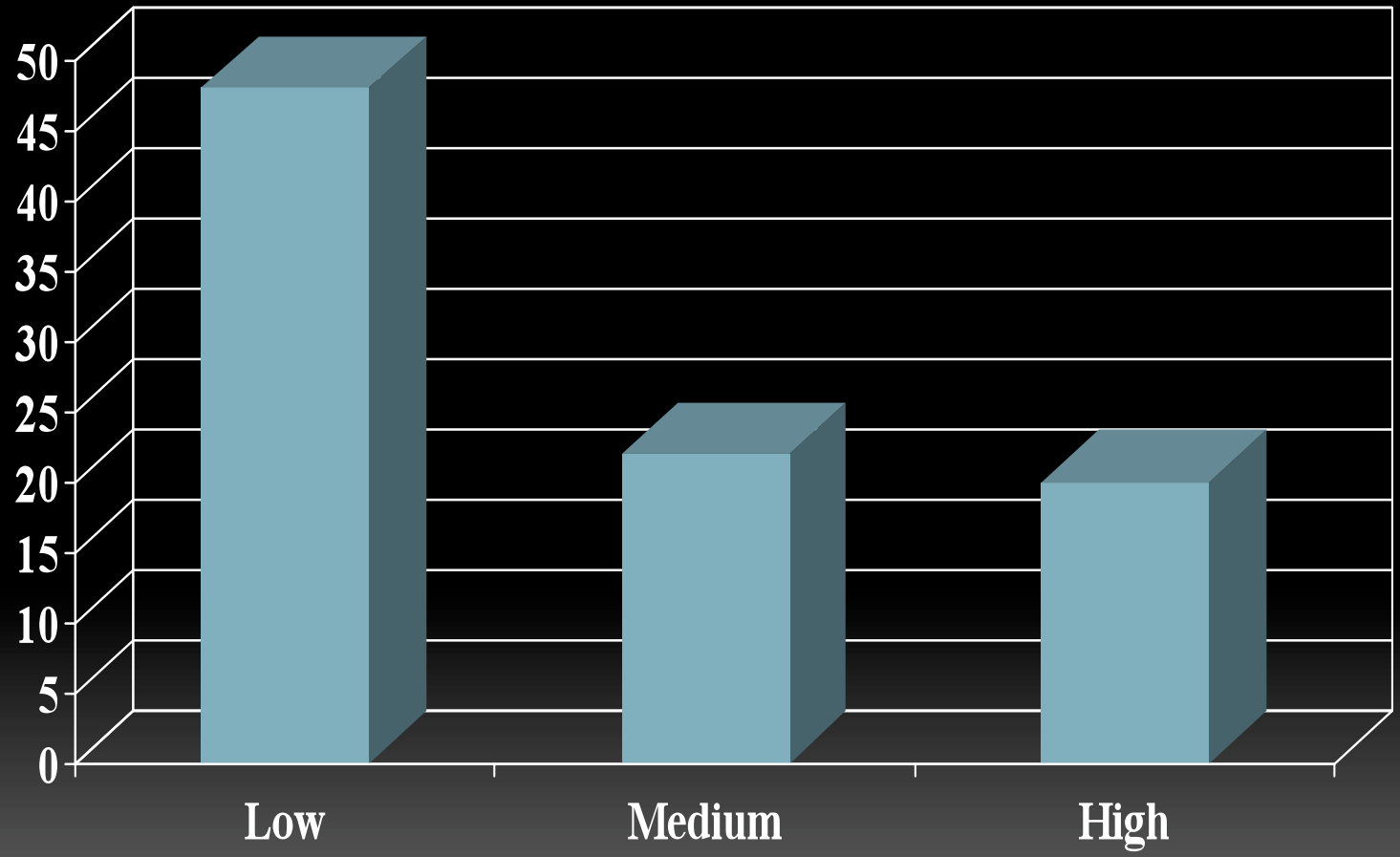


Prevalence of Inactivity



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

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

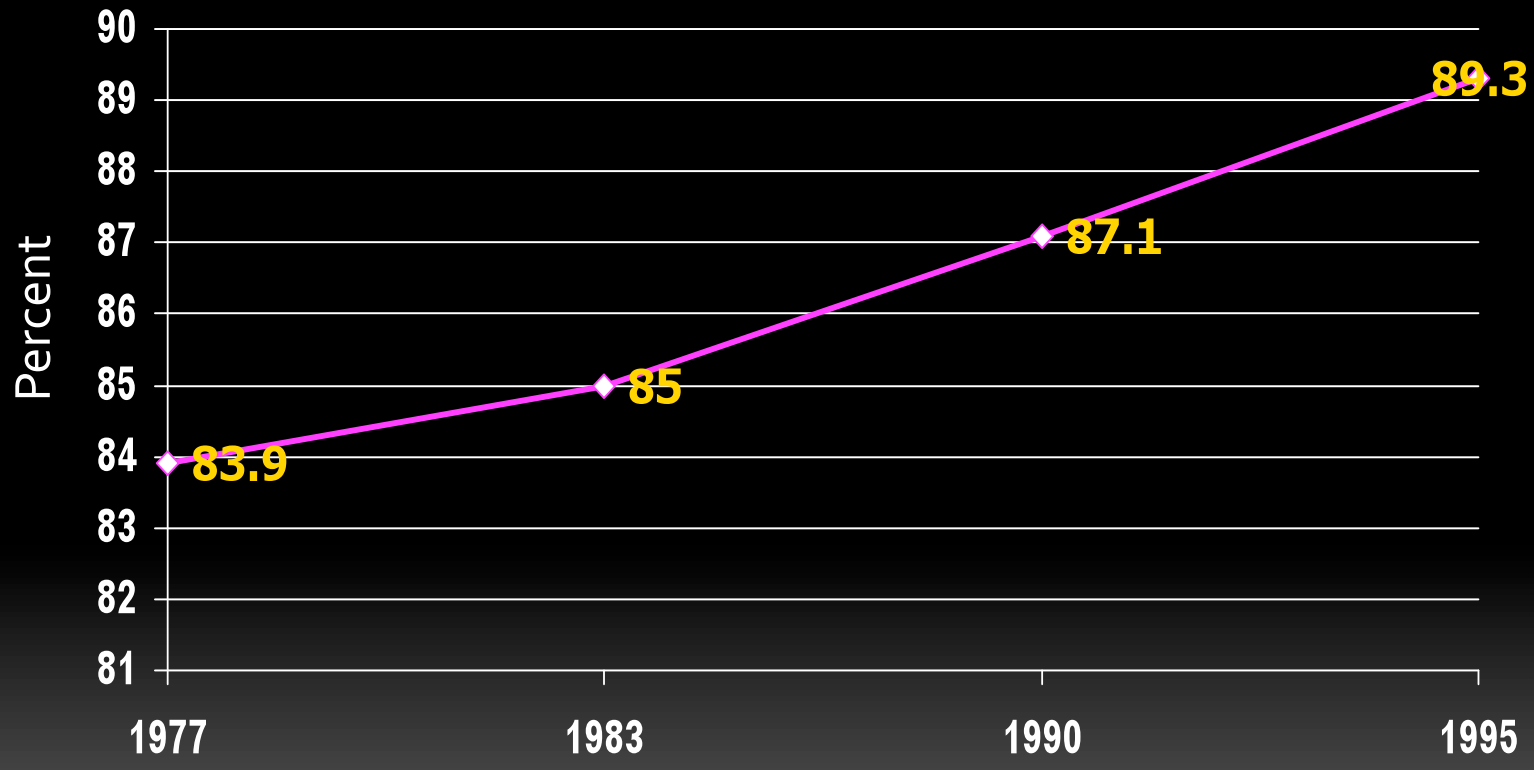


Blair, SN et al. Physical Fitness and all-cause mortality, JAMA 1989; 262:2395-2401.

Lifestyle Changes that Promote Sedentary Behavior

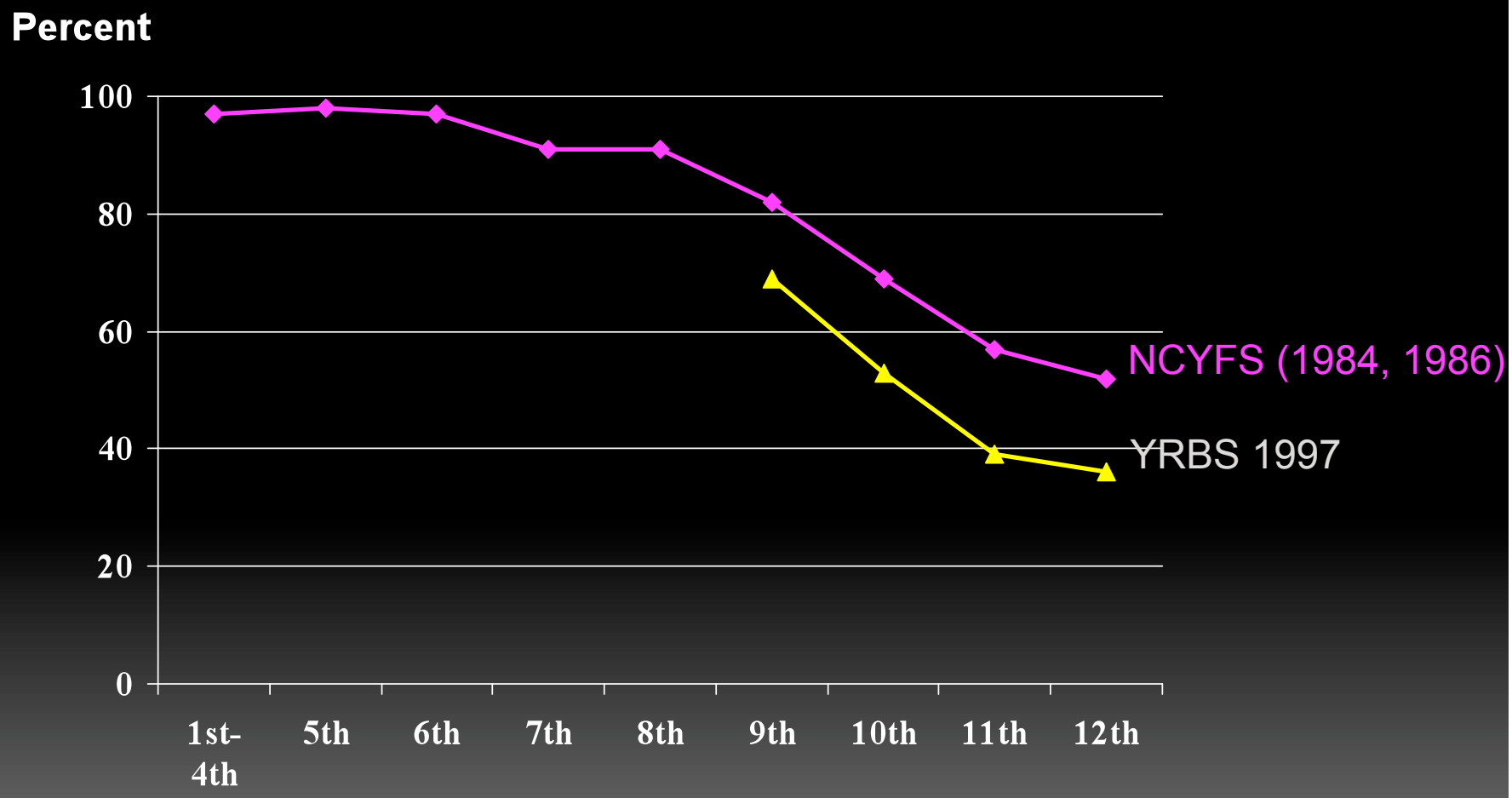
- Increased use of electronic media
- Labor saving devices
- Increased use of cars / reductions in walking
- Reductions in school physical activity programs

Percent of Trips Made From Home by Auto 1977 - 1995



PD-INCL National Personal Transportation Survey, 1995

Percentage of Students Enrolled in Physical Education Class, by Grade



NCYFS = National Child and Youth Fitness Study
YRBS = National Youth Risk Behavior Survey

Ok… So How Much Exercise or Physical Activity is Recommended?!

General Exercise Guidelines for Health: Still Frequently Sited

"All individuals should accumulate a minimum of 30 minutes of moderate exercise on most, preferably all days per week "

CDC/ACSM 1995

IV. ACSM/AHA Guidelines for Physical Activity in Healthy Adults

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

A. Rationale for Update

- Clarify recommended frequency for moderate intensity physical activity
- Explicitly incorporate vigorous physical activity
- Specify that moderate and vigorous physical activity are complementary in the production of health benefits

A. Rationale for Update (Continued)

- Cleary state that recommended physical activity is in addition to activities of daily living
- Emphasize that physical activity above the minimum results in > health benefits
- Minimum length of short bouts clarified
- Specific muscle-strengthening activities added

B. 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

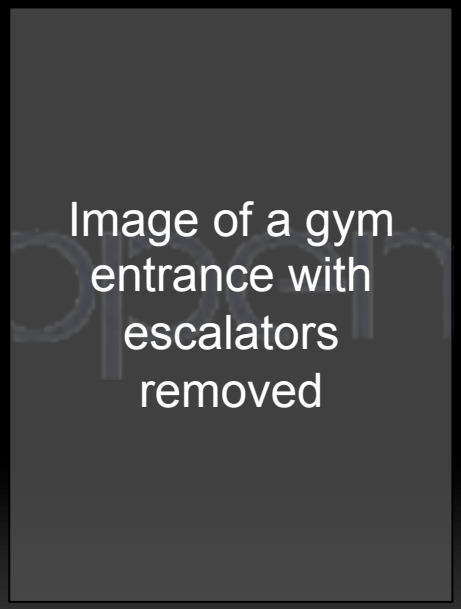
C. Weight Gain & Weight Loss

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

D. 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

A Packaging Problem



Original image: http://www.goodexperience.com/broken/i/04/02/america-fitness-s.jpg

- Automobile
- Television
- Computers
- Convenience Engineering
- Built Environment
- Human Nature

A New Public Health Paradigm: Using Planning and Transportation Strategies to Promote Active Living Behaviors

What is active living?

"Active living" is a way of life that integrates physical activity into daily routines. The goal is to accumulate at least 30 minutes of activity each day. You may do this in a variety of ways, such as walking or bicycling for transportation, exercise or pleasure; playing in the park; working in the yard; taking the stairs; and using recreation facilities.

Healthy People 2010 Objectives

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

U.S. Preventive Services Task Force 2000

2007-Present: ACSM Physical Activity Promotion Campaign

FAIR USE Exercise Is Medicine

CONCLUSIONS / RECOMMENDATIONS

- Overweight and obesity has become THE epidemic in the U.S.
- Obesity is associated with increased morbidity and mortality
- Physical activity reduces the risk of all-cause mortality, CVD, Diabetes, Cancer
- Reduce Sedentary Behaviors and Eliminate Physical and Social Barriers
- Exercise is Most Critical for Primary Prevention

Additional Source Information

for more information see: http://open.umich.edu/wiki/CitationPolicy

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