

Energy Balance and Body Composition

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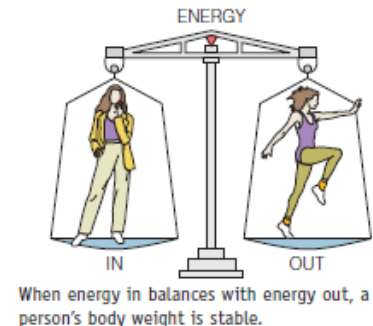
OVERVIEW

- It's a simple equation: energy in + energy out = energy balance.

→ The reality, of course, is much more complex.

- The body's remarkable machinery can cope with many extremes of diet.

- 1 lb (454gm) body fat = 3500 kcal
- **1 Kilogram of body fat= 7,700kcal**



Energy Balance

- Quick changes in body weight are not simple changes in fat stores.
- Weight gained or lost rapidly includes some fat, large amounts of fluid, and some lean tissues such as muscle proteins and bone minerals.
- Because **water** constitutes about 60 percent of an adult's body weight, retention or loss of water can greatly influence body weight.
- Even **over the long term**, the composition of weight gained or lost is normally about 75 percent fat and 25 percent lean.
- During starvation, losses of fat and lean are about equal.
- Invariably, though, ***fat gains and losses are gradual.***

Energy In:

The kCalories Foods Provide

1- FOOD COMPOSITION

2- FOOD INTAKE

1- Food Composition

How Are Calories in Foods Measured?

→ The food is burned

→ A sample of the food is placed in an insulated, oxygen-filled chamber that is surrounded by water. This chamber is called a bomb calorimeter. The sample is burned completely. The heat from the burning increases the temperature of the water, which is measured, and which indicates the number of calories in the food.

For example, if water temperature increases by 20 degrees, the food contains 20 calories. This method of measuring calories is called **direct calorimetry**.

✓ **Direct calorimetry**, measures the amount of heat released.

✓ **Indirect calorimetry** → which measures the amount of oxygen consumed.

A bomb calorimeter *measures the available energy in foods but **overstates** the amount of energy that the human body derives from foods.*

- The **body is less efficient** than a calorimeter and **cannot** metabolize all of the energy-yielding nutrients in a food completely.

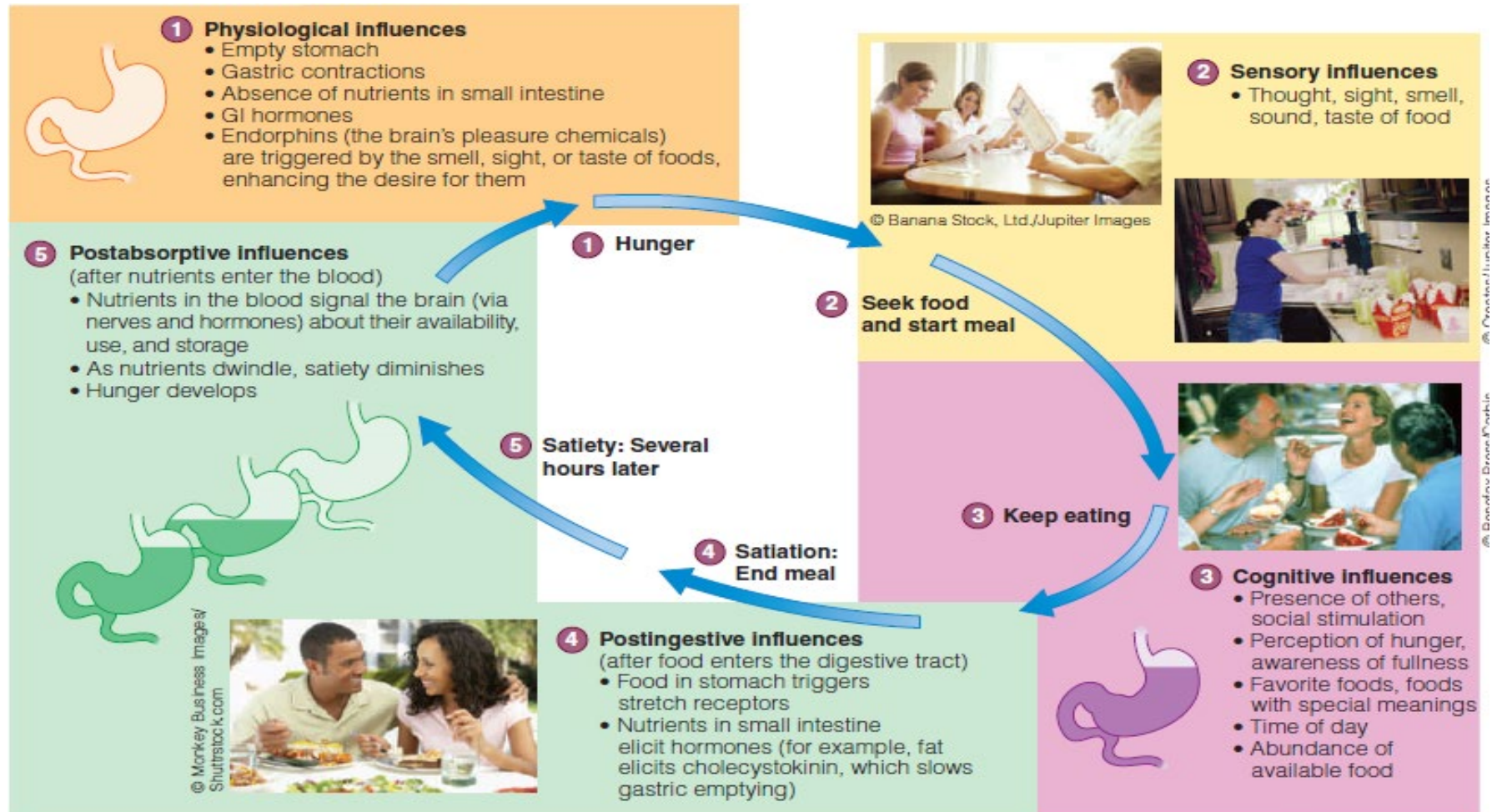
2- Food Intake

- Somehow the body decides how much and how often to eat—when to start eating and when to stop.
 - Many signals—from both the environment and genetics—initiate or delay eating.
-

Factors affect food intake:

- **Appetite:** the integrated response to the sight, smell, thought, or taste of food that initiates or delays eating.
- **Hunger:** the painful sensation caused by a lack of food that initiates food-seeking behavior.
- **Hypothalamus:** a brain center that controls activities such as maintenance of water balance, regulation of body temperature, and control of appetite.
- **Satiation:** the feeling of satisfaction and fullness that occurs **during a meal** and halts eating. Satiation determines **how much food** is consumed **during** a meal.
- **Satiety:** the feeling of fullness and satisfaction that occurs **after a meal** and **inhibits** eating until the next meal. Satiety determines **how much time** passes between meals.

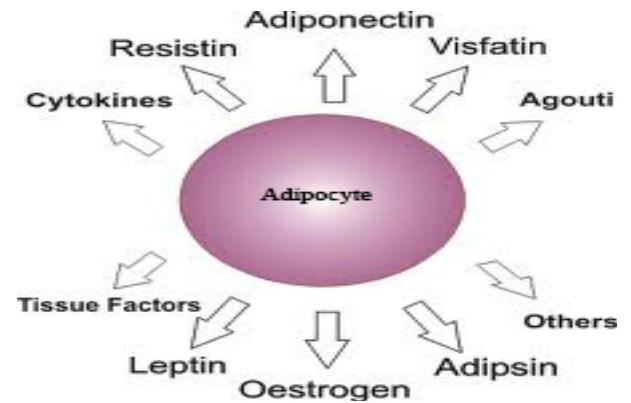
Hunger, Satiation, and Satiety



Proteins Involved in Regulation of Food Intake and Energy Homeostasis

Protein	Concentration	Secreted from	Action
Adiponectin	Lower in obesity	Adipose tissue	Increases insulin sensitivity
Ghrelin	Increases with fasting Decreases after a meal	Stomach	Stimulates appetite
Leptin	Higher in obesity	Adipose tissue	Suppresses appetite Increases energy expenditure
Oxyntomodulin	Increases after a meal	Central nervous system GI tract	Suppresses appetite
Pancreatic peptide (PP)	Increases after a meal	Pancreas	Suppresses appetite
PYY	Lower in obesity Increases after a meal	Small intestine	Suppresses appetite
Resistin	Higher in obesity	Adipose tissue, bone marrow, and immune system cells	Provides short-term satiety Opposes insulin
Visfatin	Higher in obesity	Adipose tissue (specifically visceral)	Mimics glucose-lowering effects of insulin

ADIPOKINES



- Proteins released from adipose tissue that signal changes in the body's fat and energy status.
- More than 50 adipokines have been identified, some of which play a role in inflammation.

Energy Out:

The kCalories the Body
Expend

INTRODUCTION

The generation of heat, known as **thermogenesis**, can be measured to determine the amount of energy expended.

The total energy a body expends reflects three main categories of thermogenesis:

1. Energy expended for **basal metabolism**.
2. Energy expended for **physical activity**.
3. Energy expended for **food consumption**.

A fourth category is sometimes involved:

4. Energy expended for **adaptation**.

Components of Energy Expenditure

1- Basal Metabolism

Definition :

Basal metabolism: the energy needed to maintain life when a body is at complete digestive, physical, and emotional rest.

Metabolic activities maintain the body temperature, keep the lungs inhaling and exhaling air, the bone marrow making new red blood cells, the heart beating 100,000 times a day, and the kidneys filtering wastes—in short, they support all the basic processes of life.

Components of Energy Expenditure

1- Basal Metabolism (continued-1)

- **Basal Metabolic Rate (BMR):** the rate of energy use for metabolism under specified conditions

- After a 12-hour fast and restful sleep, **without** any physical activity or emotional excitement, and in a **comfortable setting**.
 - It is usually expressed as kcalories per kilogram body weight per hour.
-

- **Resting Metabolic Rate (RMR):** similar to the basal metabolic rate (BMR)

- A measure of the energy use of a person at rest in a comfortable setting, **but** with less stringent criteria for recent food intake and physical activity.
- Consequently, the RMR is slightly higher than the BMR.

Components of Energy Expenditure

1- Basal Metabolism (continued-2)

- **LEAN BODY MASS: THE BODY MINUS ITS FAT.**
- For the most part, the **BMR** is **highest** in people who are **growing** (children, adolescents, and pregnant women) and in those with considerable **lean body mass** (physically fit people and males). The BMR is also **high** in people with **fever or under stress** and in people with highly **active thyroid glands**.
- One way to **increase** the BMR then is to participate in **endurance and strength-training** activities **regularly** to maximize lean body mass.
- The BMR **slows** down with a loss of lean body mass and during **fasting and malnutrition**.

Components of Energy Expenditure

2- Physical Activity

- Voluntary movement of the skeletal muscles and support systems.
- Physical activity is the most **variable**—and the **MOST** changeable—component of energy expenditure.
- Its influence on both weight gain and weight loss can be significant.
- **Physical activity** depends on three factors:
 1. Muscle mass.
 2. Body weight.
 3. Activity.

Components of Energy Expenditure

2- Physical Activity (continued-1)

- The activity's **duration**, **frequency**, and **intensity** also influence energy expenditure:

→ the longer, the more frequent, and the more intense the activity, the more kcalories expended.

An activity's duration, frequency, and intensity also **influence the body's use of the energy-yielding nutrients.**

Components of Energy Expenditure

3- Thermic Effect of Food (Tef)

- Definition: an estimation of the **energy required** to process food → (digest, absorb, transport, metabolize, and store ingested nutrients);
- For most purposes, however, the thermic effect of food **can be ignored** when estimating energy expenditure because its contribution to total energy output is **smaller** than the probable errors involved in estimating overall energy intake and output.

Components of Energy Expenditure

4- Adaptive Thermogenesis

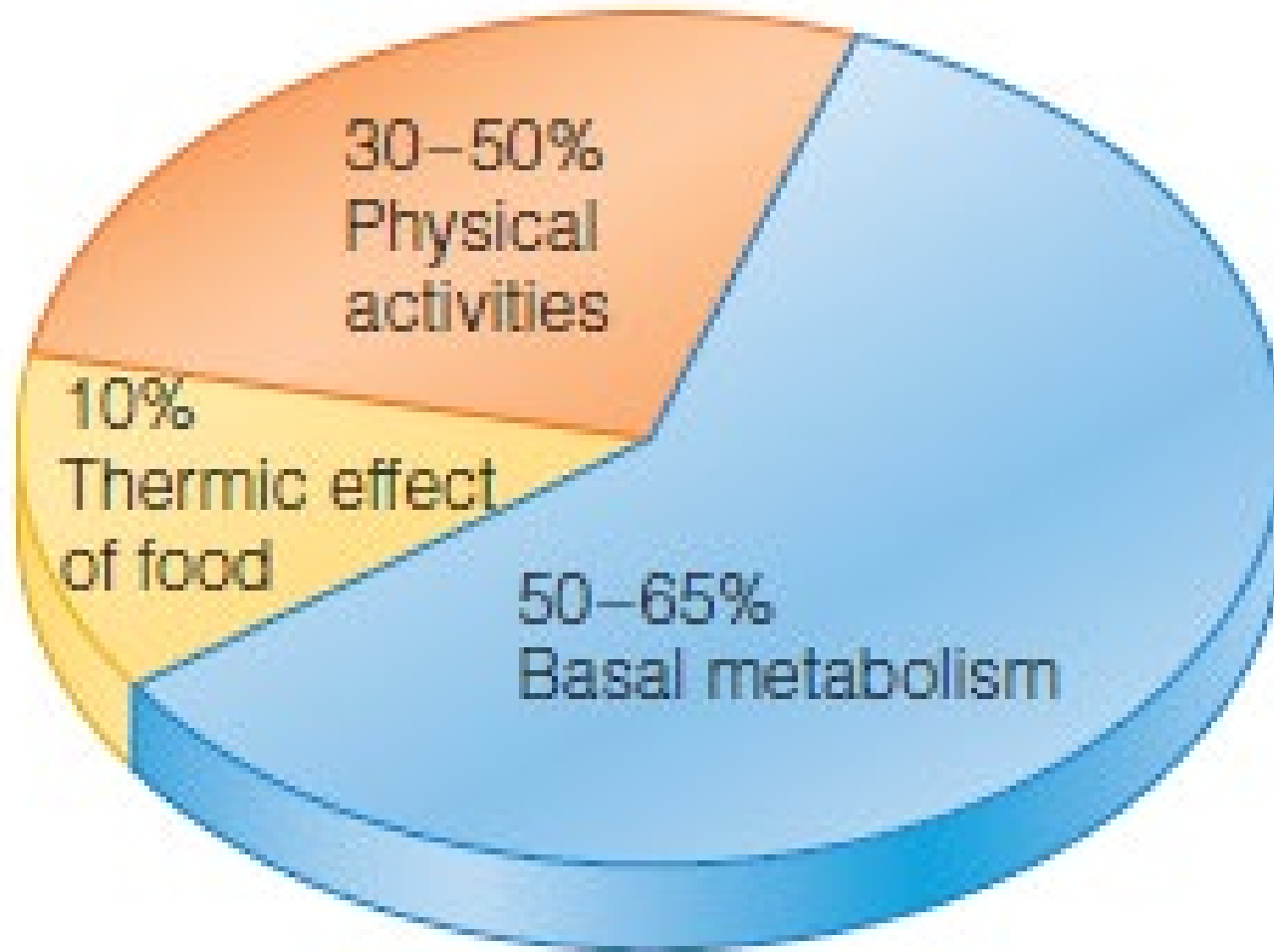
Definition:

Adjustments in energy expenditure related to changes in **environment** such as **extreme cold** and to **physiological events** such as overfeeding, trauma, and **changes in hormone status**.

The amount of energy spent in a day differs for each individual, but in general, **basal metabolism is the largest component** of energy expenditure and the thermic effect of food is the smallest.

- The amount spent in **VOLUNTARY** physical activities has the **greatest** variability, depending on a person's activity patterns.
- For a **SEDENTARY** person, physical activities may account for less than half as much energy as basal metabolism, whereas an **extremely active person** may expend as much on activity as for basal metabolism.

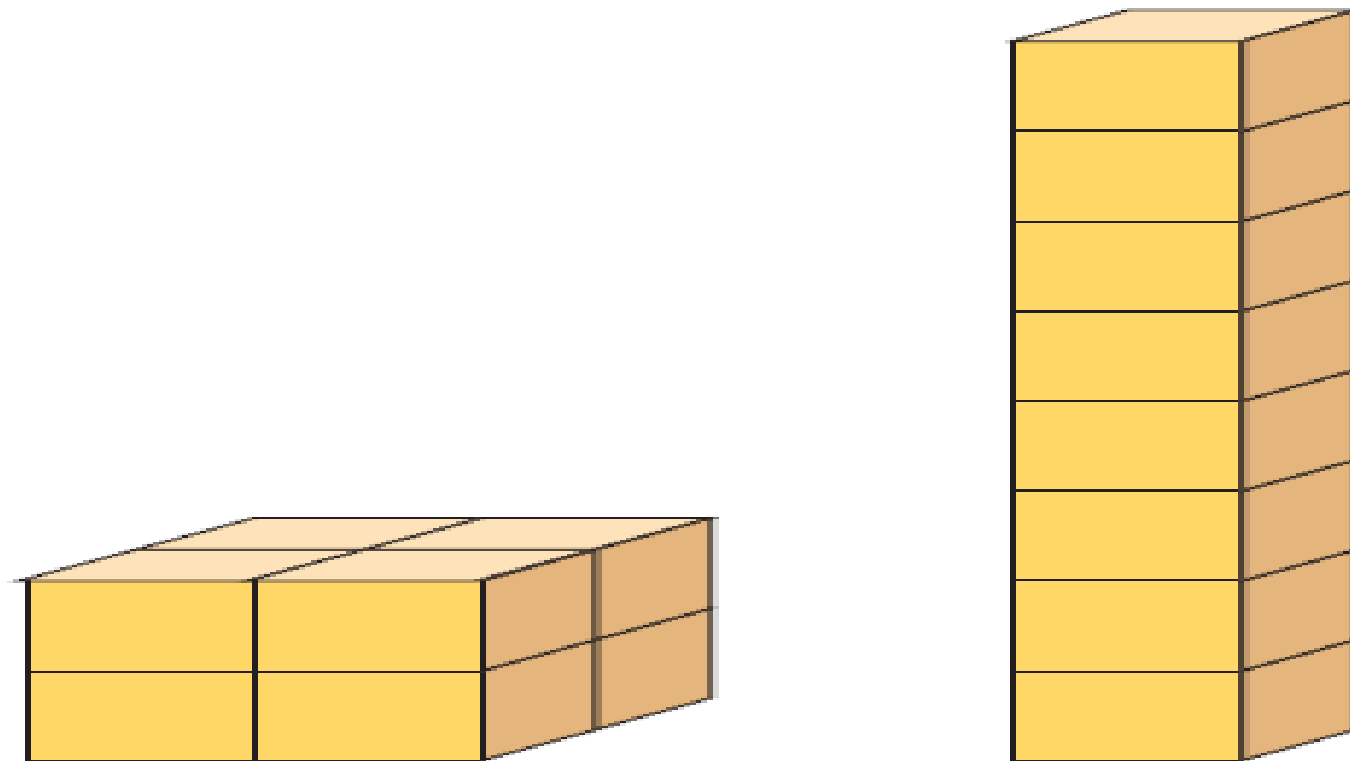
Components of Energy Expenditure



Estimating Energy Requirements

The following factors influence energy expenditure:

1. *Gender* → Men more than women.
2. *Growth* → The BMR is high in people who are growing.
3. *Age* → The BMR declines during adulthood as lean body mass diminishes.
4. *Physical activity* → typical intensity of a day's efforts.
5. *Body composition and body size* → The BMR is high in people who are tall and so have a large surface area. Similarly, the more a person weighs, the more energy is expended on basal metabolism.



- ◆ Each of these structures is made of eight blocks. They weigh the same, but they are arranged differently. The short, wide structure has 24 sides exposed and the tall, thin one has 34. Because the tall, thin structure has a greater surface area, it will lose more heat (expend more energy) than the short, wide one. Similarly, two people of different heights might weigh the same, but the taller, thin one will have a higher BMR (expending more energy) because of the greater skin surface.

QUICK AND EASY ESTIMATES FOR **BASAL** ENERGY NEEDS

- **Men:** Slightly >1 kcal/min
→ (1.1 to 1.3 kcal/min) or **24** kcal/kg/day
- **Women:** Slightly <1 kcal/min
→ (0.8 to 1.0 kcal/min) or **23** kcal/kg/day

BMR equations use **actual weight** in **kilograms**, **height** in **centimeters**, and **age** in **years**:

Men:

$$(10 \times \text{wt}) + (6.25 \times \text{ht}) - (5 \times \text{age}) + 5$$

Women:

$$(10 \times \text{wt}) + (6.25 \times \text{ht}) - (5 \times \text{age}) - 161$$

BODY COMPOSITION

Definition:

- The proportions of muscle, bone, fat, and other tissue that make up a person's total body weight.
- Body weight = fat + lean tissue (including water)

Estimate Energy Requirements (EER)

- To determine your estimated energy requirement (EER), use the appropriate equation, inserting your age in years, weight (wt) in kilograms, height (ht) in **meters**, and **physical activity (PA)** factor from the accompanying table.
- (To convert pounds to kilograms, divide by 2.2; to convert inches to meters, divide by 39.37.)

Estimate Energy Requirements (EER) – continued-1

For men 19 years and older:

$$\text{EER} = [662 - (9.53 \times \text{age})] + \text{PA} \times [(15.91 \times \text{wt}) + (539.6 \times \text{ht})]$$

For women 19 years and older:

$$\text{EER} = [354 - (6.91 \times \text{age})] + \text{PA} \times [(9.36 \times \text{wt}) + (726 \times \text{ht})]$$

**PA = physical activity*

Estimate Energy Requirements (EER) – continued-2

Physical Activity (PA) Factors for EER Equations

	Men	Women	Physical Activity
Sedentary	1.0	1.0	Typical daily living activities
Low active	1.11	1.12	Plus 30–60 min moderate activity
Active	1.25	1.27	Plus $\geq$ 60 min moderate activity
Very active	1.48	1.45	Plus $\geq$ 60 min moderate activity and 60 min vigorous or 120 min moderate activity

NOTE: Moderate activity is equivalent to walking at 3 to 4½ mph.

HOMEWORK:

TRY IT Estimate your energy requirement based on your current age, weight, height, and activity level.

Body Mass Index

- **Body Mass Index (BMI):** an index of a person's weight in relation to height; determined by dividing the weight (in kilograms) by the square of the height (in meters).
- **Underweight:** body weight below some standard of acceptable weight that is usually defined in relation to height (such as BMI); BMI below 18.5.
- **Overweight:** body weight above some standard of acceptable weight that is usually defined in relation to height (such as BMI); BMI 25 to 29.9.
- **Obese:** overweight with adverse health effects; BMI 30 or higher.

How to calculate BMI?

$$\text{BMI} = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

or

$$\text{BMI} = \frac{\text{weight (lb)}}{\text{height (in)}^2} \times 703$$

Body Mass Index - (Kg/m²)

Below 18.5
Underweight



18.5 to 24.9
Normal



25 to 29.9
Overweight



30 to 34.9
Obese class I



35 to 40
Obese class II



Above 40
Obese class III

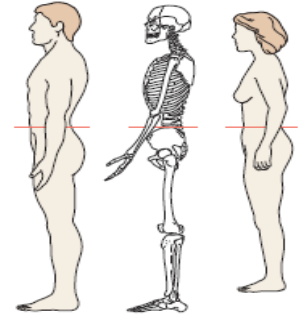


Fat Distribution

- The distribution of fat on the body may be more critical than the total amount of fat alone.
- **Visceral fat**: fat stored within the abdominal cavity in association with the internal abdominal organs; also called *intra-abdominal fat*.
- **Central obesity**: excess fat around the trunk of the body; also called *abdominal fat or upper-body fat*.
- **Subcutaneous fat**: fat stored directly under the skin.

Waist Circumference

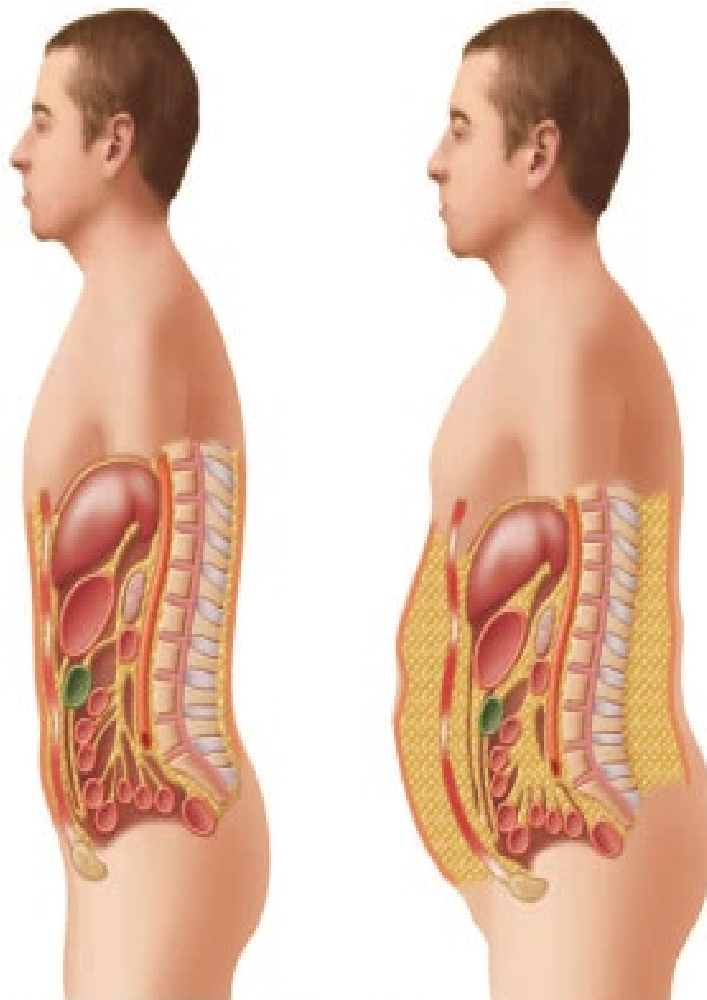
- **Waist Circumference:** an anthropometric measurement used to assess a person's abdominal fat.
 - **It is a good indicator of fat distribution and central obesity.**
 - *As waist circumference increases, disease risks increase.*
- **Women** with a waist circumference of greater than 35 inches (**88 centimeters**) and **men** with a waist circumference of greater than 40 inches (**102 centimeters**) have a high risk of central obesity—related health problems, such as diabetes and cardiovascular disease.



How to Measure Waist Circumference

- Place the measuring tape around the waist just above the bony crest of the hip. The tape runs parallel to the floor and is snug (but does not compress the skin).
- The measurement is taken at the end of normal **expiration**

FIGURE 8-8 Abdominal Fat



In healthy-weight people, some fat is stored around the organs of the abdomen.

In overweight people, excess abdominal fat increases the risks of diseases.

FIGURE 8-9 “Apple” and “Pear” Body Shapes Compared

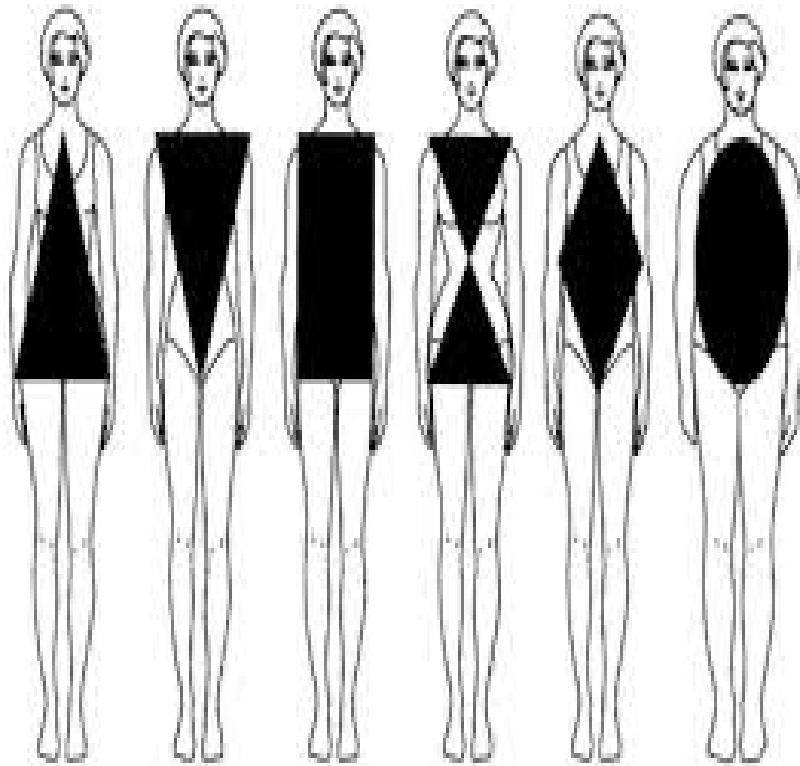
Popular articles sometimes call bodies with upper-body fat “apples” and those with lower-body fat, “pears.” Researchers sometimes refer to upper-body fat as “android” (manlike) obesity and to lower-body fat as “gynoid” (womanlike) obesity.



Upper-body fat is more common in men than in women and is closely associated with heart disease, stroke, diabetes, hypertension, and some types of cancer.

Lower-body fat is more common in women than in men and is not usually associated with chronic diseases.

Female Body shapes



Triangle
shape

Inverted
triangle
shape

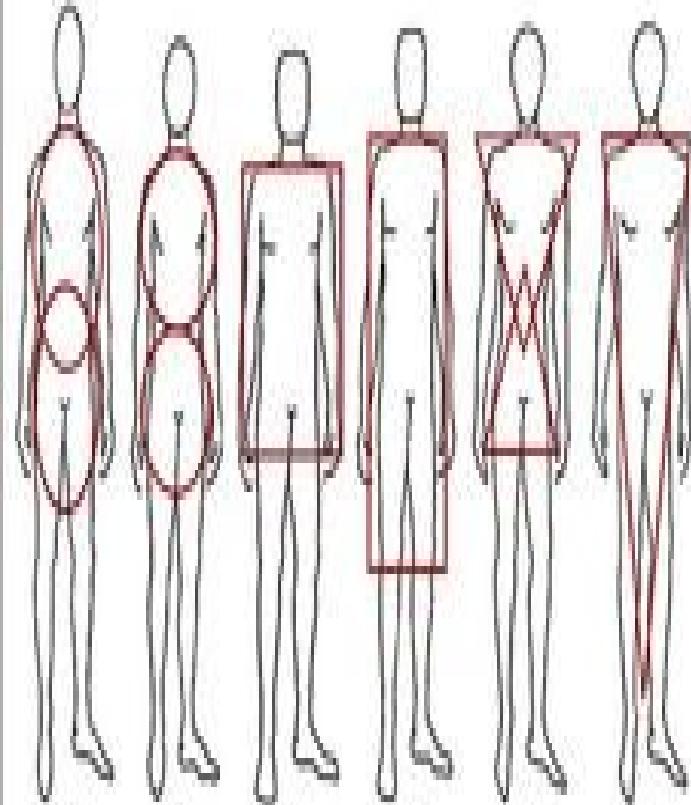
Rectangle
shape

Hourglass
shape

Diamond
shape

Rounded
shape

MALE BASIC BODY SHAPES



Oval

Circle

Square

Square
Rectangle

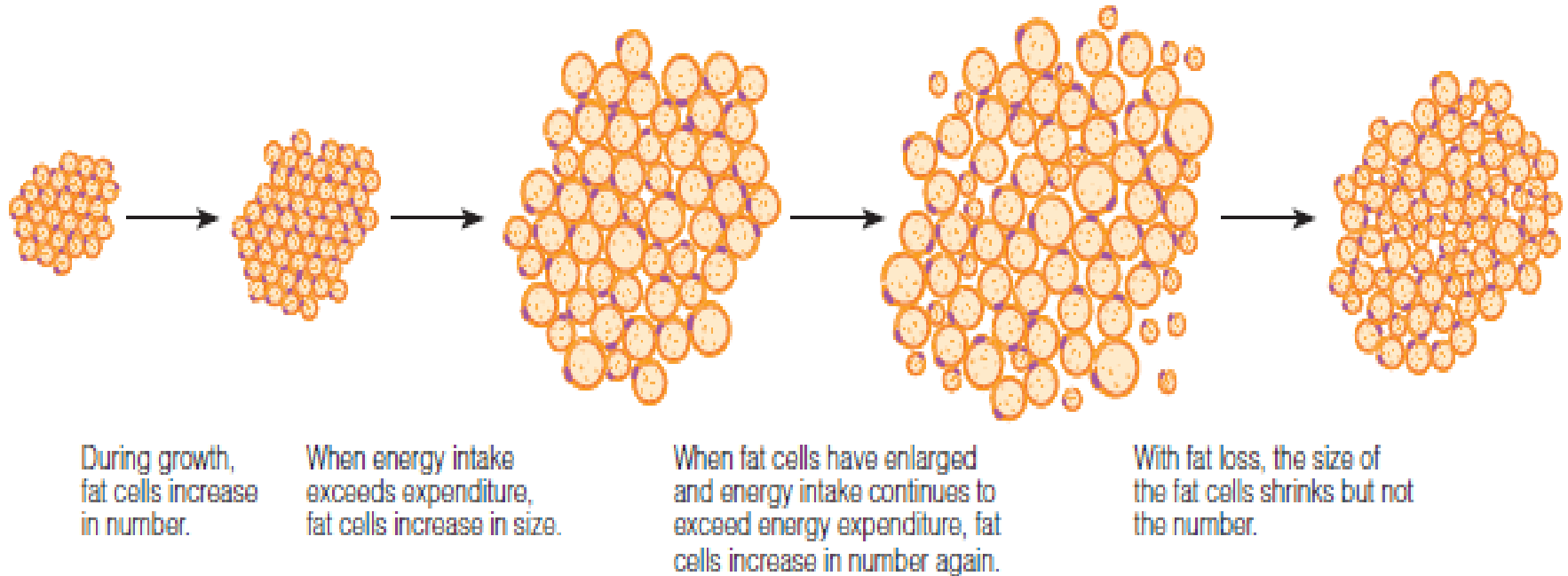
Triangle

Invert
Triangle

Overweight and Obesity

FIGURE 9-2 Fat Cell Development

Fat cells are capable of increasing their size by 20-fold and their number by several thousandfold.



Fat Cell Metabolism

- The enzyme **LIPOPROTEIN LIPASE** (LPL) removes triglycerides from the blood for storage in both adipose tissue and muscle cells.
- **Obese** people generally have much **more LPL** activity in their adipose cells than lean people do (their muscle cell LPL activity is similar, though).
- This **high LPL activity** makes fat storage especially **efficient**.
- **Consequently, even modest excesses in energy intake have a more dramatic impact on obese people than on lean people.**
- The activity of LPL in different regions of the body is partially influenced by gender → Apple shape vs. Pear shape.
- **Gender differences** are also apparent in the activity of the enzymes controlling the release and breakdown of fat in various parts of the body. *(Consequently, women may have a more difficult time losing fat in general, and from the hips and thighs in particular.)*
- Enzyme activity may also explain why some people who lose weight regain it so easily. *(After weight loss, adipose LPL activity increases).*

Set-Point Theory

- The hypothalamus and other regulatory centers constantly monitor and delicately adjust conditions to maintain homeostasis.
- The stability of such complex systems may depend on set-point regulators that maintain variables within specified limits.
- Researchers have confirmed that after weight gains or losses, the body adjusts its metabolism to restore the original weight.
- Energy expenditure increases after weight gain and decreases after weight loss.

WEIGHT-LOSS STRATEGIES

Successful weight-loss strategies embrace

→ **Small changes.**

→ **Moderate losses**

→ **Reasonable goals.**

- Gradual weight losses are more likely to be maintained than rapid losses, as it is a **lifelong journey**.

- **NO SPOT REDUCING!!!!!!**

Safe rate for weight loss:

- ½ to 2 lb/week (0.2 to 0.9 kg)

- **10% body weight/6 mo**

→ For a person weighing 110 kg, a 10% loss is 11 kg, or about 0.5 kg a week for six months.

HOME WORK!! Medications and Supplements that are used to control or reduce weight