Cultural and societal perceptions of attractiveness and good health present challenges to responsible weight management. One person may be perfectly healthy yet somewhat plump and be judged harshly by peers or the media. Another person may be frightfully unhealthy but willowy thin, and because of an arbitrary standard of body type and appearance, that person might be hailed as a paragon of health and beauty. The impact of this dynamic to personal esteem alone is staggering.

Managing body weight involves choosing the right amount of food and exercise to keep weight in the healthy range. But food producers and sellers urge us to buy, eat, and supersize, while the weight-loss and diet industry “experts” urge us to try the latest device, diet plan, or superfood. Is there a middle ground?

As developing nations strive for Western patterns of consumption—as well as Western perceptions of health and beauty—weight problems manifest themselves in their populations as well. Sadly, vast numbers of humans still lack access to food that provides adequate nutrients and are subject to afflictions ranging from vitamin deficiencies to starvation. How these people look may be the least of their concerns; for them, weight management may mean simply having enough food to meet the body’s energy demands.
CHAPTER OUTLINE

Body Weight and Health 310
- What’s Wrong with Having Too Much Body Fat?
- What Is a Healthy Weight?

Energy Balance 315
- America’s Energy Imbalance
- Balancing Energy Intake and Expenditure
- Estimated Energy Requirements

What Determines Body Size and Shape? 322
- Genes vs. Environment
  - Thinking It Through: A Case Study on Genetics, Lifestyle, and Body Weight
- Regulation of Food Intake and Body Weight
  - What a Scientist Sees: Leptin and Body Fat
- Why Do Some People Gain Weight More Easily?

Managing Body Weight 327
- Who Should Lose Weight?
- Weight-Loss Goals and Guidelines
- What Should I Eat? Weight Management
- Suggestions for Weight Gain
- Diets and Fad Diets
- Weight-Loss Drugs and Supplements
  - What a Scientist Sees: Alli
- Weight-Loss Surgery
  - DEBATE: Is Surgery a Good Solution to Obesity?

Eating Disorders 337
- Anorexia Nervosa
- Bulimia Nervosa
- Binge-Eating Disorder
- Eating Disorders in Special Groups

CHAPTER PLANNER

- Stimulate your interest by reading the introduction and looking at the visual.
- Scan the Learning Objectives in each section:
  - p. 310
  - p. 315
  - p. 322
  - p. 327
  - p. 337
- Read the text and study all figures and visuals. Answer any questions.

Analyze key features

- Nutrition InSight, p. 314
- What a Scientist Sees, p. 326
- Process Diagram, p. 328
- Thinking It Through, p. 323
- Stop: Answer the Concept Checks before you go on:
  - p. 315
  - p. 321
  - p. 327
  - p. 336
  - p. 345

End of chapter

- Review the Summary, Key Terms, and Online Resources.
- Answer the Critical and Creative Thinking Questions.
- Answer What is happening in this picture?
- Complete the Self-Test and check your answers.
CHAPTER 9 Energy Balance and Weight Management

Body Weight and Health

LEARNING OBJECTIVES

1. Discuss the obesity epidemic.
2. Describe the health consequences of excess body fat.
3. Calculate your BMI and determine whether it indicates increased health risks.
4. Discuss how the amount and location of body fat affect the health risks associated with being overweight.

In the United States today, a staggering 68% of adults are either overweight or obese. The numbers have increased dramatically over the past 5 decades (Figure 9.1). In 1960, only 13.4% of American adults were obese. By 1990, about 23% were obese, and today, only two decades later, almost 34% are obese. Obesity affects both men and women and all racial and ethnic groups. Obesity rates for minorities often exceed those in the general population: Among African Americans, more than 49% of women and 37% of men are obese, and among Hispanic Americans, more than 34% of men and about 43% of women are obese.\(^1\)

Obesity is a growing concern worldwide. It is such an important trend that the term globeesity has been coined to reflect the escalation of global obesity and overweight. Around the world, approximately 1.5 billion adults are overweight, and of these, 500 million are obese. The World Health Organization projects that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese.\(^2\)

Once considered a problem only in high-income countries, overweight and obesity are now on the rise in low- and middle-income countries, particularly in urban settings.

**Obesity on the rise • Figure 9.1**

These maps show the percentage of the adult population classified as obese in each state in 1990 and 2009. The dramatic rise in overweight and obesity in the United States over the past few decades has led medical and public health officials to label the situation an epidemic.
What’s Wrong With Having Too Much Body Fat?

Having too much body fat increases a person’s risk of developing a host of chronic health problems, including high blood pressure, heart disease, high blood cholesterol, diabetes, gallbladder disease, arthritis, sleep disorders, respiratory problems, menstrual irregularities, and cancers of the breast, uterus, prostate, and colon (Figure 9.2). Obesity also increases the incidence and severity of infectious disease and has been linked to poor wound healing and surgical complications. The more excess body fat you have, the greater your health risks. The longer you carry excess fat, the greater the risks; individuals who gain excess weight at a young age and remain overweight throughout life face the greatest health risks.

Being overweight also has psychological and social consequences. Overweight and obese individuals of any age are at increased risk of experiencing depression, negative self-image, and feelings of inadequacy. They may also be discriminated against in college admissions, in the workplace, and even on public transportation. The physical health consequences of excess body fat may not manifest themselves as disease for years, but the psychological and social problems are experienced every day.

Because obesity increases health problems, it increases health care costs. Estimates suggest that obesity “costs” about $147 billion per year. The greater the number of obese people, the higher the nation’s health care expenses and the higher the cost to society as a whole in terms of lost wages and productivity.

What Is a Healthy Weight?

A healthy weight is a weight that minimizes health risks. Your body weight is the sum of the weight of your fat and your lean body mass. Some body fat is essential for health, but too much increases your risk for a number of chronic health problems. How much weight and fat is too much depends on your age, gender, and lifestyle and where your fat is located.

Body mass index (BMI) The current standard for assessing the healthfulness of body weight is body mass index (BMI), which is determined by dividing body weight (in kilograms) by height (in meters)
What’s your BMI? • Figure 9.3

To find your BMI, locate your height in the leftmost column and read across to your weight. Follow the column containing your weight up to the top line to find your BMI. A BMI < 18.5 kg/m² is classified as underweight, a BMI ≥ 25 and < 30 kg/m² is classified as overweight, and a BMI of ≥ 30 kg/m² is classified as obese. A BMI ≥ 40 kg/m² is considered extreme obesity or morbid obesity.5

<table>
<thead>
<tr>
<th>Height (feet/inches)</th>
<th>Body Weight (pounds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4'10”</td>
<td>81 86 91 96 100 105 110 115</td>
</tr>
<tr>
<td>4'11”</td>
<td>84 89 94 99 104 109 114 119</td>
</tr>
<tr>
<td>5'0”</td>
<td>87 92 97 102 107 112 118 123</td>
</tr>
<tr>
<td>5'1”</td>
<td>90 95 100 106 111 116 122 127</td>
</tr>
<tr>
<td>5'2”</td>
<td>93 98 104 109 115 120 126 131</td>
</tr>
<tr>
<td>5'3”</td>
<td>96 102 107 113 118 124 130 135</td>
</tr>
<tr>
<td>5'4”</td>
<td>99 105 110 116 122 128 134 140</td>
</tr>
<tr>
<td>5'5”</td>
<td>102 108 114 120 126 132 138 144</td>
</tr>
<tr>
<td>5'6”</td>
<td>105 112 118 124 130 136 142 148</td>
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<tr>
<td>5'7”</td>
<td>108 115 121 127 134 140 146 153</td>
</tr>
<tr>
<td>5'8”</td>
<td>112 119 125 131 138 144 151 158</td>
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<tr>
<td>5'9”</td>
<td>115 122 128 135 142 149 155 162</td>
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<td>5'11”</td>
<td>122 129 136 143 150 157 164 172</td>
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<td>5'12”</td>
<td>125 133 140 147 154 162 169 177</td>
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<td>5'13”</td>
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<td>5'14”</td>
<td>132 140 148 155 163 171 179 186</td>
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<tr>
<td>5'15”</td>
<td>136 144 152 160 168 176 184 192</td>
</tr>
<tr>
<td>5'16”</td>
<td>140 148 156 164 172 180 189 197</td>
</tr>
</tbody>
</table>

Being underweight is associated with increased risk of early death, but this does not mean that all thin people are at risk.6 People who are naturally lean have a lower incidence of certain chronic diseases and do not face increased health risks due to their low body weight. However, low body fat due to starvation, eating disorders, or a disease process decreases energy reserves and the ability of the immune system to fight disease.

Although BMI can be a useful tool, other information is also needed to determine health risks. For example, someone who is overweight based on BMI but consumes a healthy diet and exercises regularly may be more fit and at lower risk for chronic diseases than someone with a BMI in the healthy range who is sedentary and eats a poor diet.

A high BMI may be caused by either too much body fat or a large amount of muscle. Therefore, in muscular athletes, BMI does not provide an accurate estimate of health risk. Both of these individuals have a BMI of 33, but only the man on the right has excess body fat. The high body weight of the man on the left is due to his large muscle mass. His body fat, and hence disease risk, is low.

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squared. A healthy BMI for adults is between 18.5 and 24.9 kg/m². People with a BMI in this range have the lowest health risks. Although BMI is not actually a measure of body fat, it is recommended as a way to assess body fatness that is better than measuring weight alone.3 You can use Figure 9.3 to determine your BMI or calculate it according to either of these equations:

\[
\text{BMI} = \frac{\text{Weight in kilograms}}{\text{Height in meters}}^2
\]

or

\[
\text{BMI} = \frac{\text{[Weight in pounds/(Height in inches)}^2] \times 703}{\text{ }}
\]

**Body composition**

Body composition, which refers to the relative proportions of fat and lean tissue that make up the body, affects the risks associated with excess body weight. Having more than the recommended percentage of body fat increases health risks, whereas having more lean body mass does not. In general, women store more body fat than men do, so the level that is healthy for women is somewhat higher than the level that is healthy for men. A healthy level of body fat for a young adult female is between 21 and 32% of total weight; for young adult males, it is between 8 and 19%.7 With aging, lean body mass decreases and body fat increases, even if body weight remains the same. Some of this change may be prevented through exercise. Body composition can be measured using a variety of techniques (Figure 9.4).

**Techniques for measuring body composition • Figure 9.4**

**Underwater weighing.** Underwater weighing relies on the fact that lean tissue is denser than fat tissue. The difference between a person’s weight on land and his or her weight underwater is used to calculate body density; the higher a person’s body density, the less fat he or she has. Underwater weighing is accurate but can’t be used for small children or for ill or frail adults.

**Skinfold thickness.** Skinfold thickness uses calipers to measure the thickness of the fat layer under the skin at several locations. This technique assumes that the amount of fat under the skin is representative of total body fat. It is fast, easy, and inexpensive but can be inaccurate if not performed by a trained professional.

**Air displacement.** The BOD POD measures the amount of air displaced by the body in a closed chamber and uses this along with body weight to determine body density, which is related to body fat mass. This method is accurate and easy for the subject but expensive and not readily available.

**Bioelectric impedance.** Bioelectric impedance analysis measures an electric current traveling through the body. It is based on the fact that current moves easily through lean tissue, which is high in water, but is slowed by fat, which resists current flow. Bioelectric impedance measurements are fast, easy, and painless but can be inaccurate if the amount of body water is higher or lower than typical. For example, in someone who has been sweating heavily, the estimate of percentage body fat obtained using bioelectric impedance will be artificially high.

**Dual-energy X-ray absorptiometry (DXA).** DXA distinguishes among various body tissues by measuring differences in levels of X-ray absorption. A single investigation can accurately determine total body mass, bone mineral mass, and body fat percentage, but the apparatus is expensive and not readily available.
a. People who carry their excess fat around and above the waist have more visceral fat. Those who carry their extra fat below the waist, in the hips and thighs, have more subcutaneous fat. In the popular literature, these body types have been dubbed “apples” and “pears,” respectively.

b. Waist circumference is indicative of the amount of visceral fat, the type of fat that is associated with increased health risk. Waist measurements along with BMI are used to estimate the health risk associated with excess body fat. These waist circumference “cutpoints” are not useful in patients with a BMI of 35 kg/m² or greater.
Location of body fat  The location of body fat stores affects the risks associated with having too much fat (Figure 9.5). Excess subcutaneous fat, which is adipose tissue located under the skin, does not increase health risk as much as does excess visceral fat, which is adipose tissue located around the organs in the abdomen. Generally, fat in the hips and lower body is subcutaneous, whereas fat in the abdominal region is primarily visceral. Visceral fat is more metabolically active than subcutaneous fat, releasing dozens of biologically active substances that can contribute to disease. An increase in visceral fat is associated with a higher incidence of heart disease, high blood cholesterol, high blood pressure, stroke, diabetes, and breast cancer.

Where your extra fat is deposited is determined primarily by your genes. Visceral fat storage is more common in men than in women, but after menopause, the amount of visceral fat in women increases. Age and environment also influence where fat is stored. Visceral fat storage increases with age. Stress, tobacco use, and alcohol consumption predispose people to visceral fat deposition, and weight loss and exercise reduce the amount of visceral fat.

CONCEPT CHECK

1. How has the incidence of overweight and obesity changed in the United States over the past few decades?
2. What are two chronic disorders that are more common in obese individuals than in lean individuals?
3. When is a high BMI not associated with an increased health risk?
4. What type of body fat increases health risks?

Energy Balance

LEARNING OBJECTIVES
1. Identify lifestyle factors that have led to weight gain among Americans.
2. Explain the principle of energy balance.
3. Describe the components of energy expenditure.
4. Calculate your EER at various levels of activity.

The rising rates of overweight and obesity in virtually every population group in the United States demonstrate that many Americans are in energy imbalance. According to the principle of energy balance, if you consume the same amount of energy—or calories—as you expend, your body weight will remain the same. If you consume more energy than you expend, you will gain weight, and if you expend more energy than you consume, you will lose weight. In the United States today, our energy intake is exceeding our energy expenditure. Bringing it back into balance requires an understanding of how many calories we need and how we use energy.

America’s Energy Imbalance

Over the past 40 years, changes in our food supply and lifestyle have affected what we eat, how much we eat, and how much exercise we get. Simply put, more Americans are overweight than ever before because we are eating more and burning fewer calories than we did 40 years ago. Food is plentiful and continuously available, and little activity is required in our daily lives.

Eating more In America today, supermarkets, fast-food restaurants, and convenience marts make palatable, affordable food readily available to the majority of the population 24 hours a day. We are constantly bombarded with cues to eat: Advertisements entice us with tasty, inexpensive foods, and convenience stores, food courts, and vending machines tempt us with the sights and smells of fatty, sweet, high-calorie snacks. As a result, since 1970 the amount of energy available to us has increased by about 600 Calories per day, with the greatest increases in added fats, grains, dairy products, and sweeteners. The accessibility of tempting treats stimulates appetite. Because appetite is triggered by external cues such as the sight or smell of food, it is usually
appetite, and not hunger, that makes us stop for an ice cream cone on a summer afternoon or give in to the smell of freshly baked chocolate chip cookies while strolling through the mall. Studies examining the relationship between the food environment and BMI have found that people in communities with more fast-food or quick-service restaurants tend to have higher BMIs. In addition to having more enticing choices available to us, we consume more calories today because portion sizes have increased (Figure 9.6). The more food that is put in front of people, the more they eat. Portion size is associated with body weight; being served and consuming larger portions is associated with weight gain, whereas small portions are associated with weight loss.

Social changes over the past few decades have also contributed to the increase in the number of calories Americans consume. Busy schedules and an increase in the number of single-parent households and households with two working parents mean that families are often too rushed to cook meals at home. As a result, prepackaged, convenience, and fast-food meals have become mainstays. These foods are typically higher in fat and energy than foods prepared at home.

Moving less Along with America’s rising energy intake, there has been a decline in the amount of energy Americans expend, both at work and at play. Fewer American adults today work in jobs that require physical labor. People drive to work rather than walk or bike, take elevators instead of stairs, use dryers rather than hang clothes outside, and cut the lawn with riding mowers rather than with push mowers. All these modern conveniences reduce the amount of energy expended daily (Figure 9.7). Americans are also less active during their leisure time because busy schedules and long days at work and commuting leave little time for active recreation. Instead, at the end of the day, people tend to sit in front of television sets, video games, and computers. Inactivity is also contributing to excess body weight among children. In the 1960s, schools provided daily physical education classes, and children spent their after-school hours playing outdoors; today, they are more likely to spend their afternoons indoors with televisions, video

Activity reduces the risk of obesity • Figure 9.7

A typical office worker today walks only about 3000 to 5000 steps per day (2000 steps = approximately 1 mile). In contrast, in the Amish community—where automobiles and other modern conveniences are not allowed—a typical adult takes 14,000 to 18,000 steps a day. The overall incidence of obesity among the Amish is only 4%.11

---

**hunger** A desire to consume food that is triggered by internal physiological signals.
Balancing Energy Intake and Expenditure

The energy needed to fuel your body comes from the food you eat and the energy stored in your body. You use this energy to stay alive, process your food, move, and grow.

Energy Intake The amount of energy you consume depends on what and how much you eat and drink. The carbohydrate, fat, protein, and alcohol consumed in food and drink all contribute energy: 4, 9, 4, and 7 Calories/gram, respectively (Figure 9.8a). Vitamins, minerals, and water, though essential nutrients, do not provide energy. You can determine your calorie intake by using food labels or looking up values in a food composition table or database (Figure 9.8b).

Energy Expenditure The total amount of energy used by the body each day is called total energy expenditure. It includes the energy needed to maintain basic body functions as well as that needed to fuel physical activity and process food. In individuals who are growing or pregnant, total energy expenditure also includes the energy used to deposit new tissues. In women who are lactating, it includes the energy used to produce milk. A small amount of energy is also used to maintain body temperature in a cold environment.

For most people, about 60 to 75% of total energy expenditure is used for basal metabolism. Basal metabolism includes all the essential metabolic reactions and life-sustaining functions needed to keep you alive, such as breathing, circulating blood, regulating body temperature, synthesizing tissues, removing waste products, and sending nerve signals. The rate at which energy is used for these basic functions is the basal metabolic rate (BMR). The energy expended for basal metabolism does not include the energy needed for physical activity or for the digestion and absorption of food.

BMR increases with increasing body weight and is affected by body composition because it takes more energy to maintain lean tissue than to maintain body fat (Figure 9.8c). BMR is generally higher in men than in women because men have a greater amount of lean body mass. BMR decreases with age, partly because of the decrease in lean body mass that occurs as we get older. BMR is also lower when calorie intake is consistently below the body’s needs. This drop in BMR reduces the amount of energy needed to maintain body weight. It is a beneficial adaptation in someone who is starving, but in someone who is trying to lose weight, it is frustrating because it makes weight loss more difficult.

Physical activity is the second major component of total energy expenditure. In most people, physical activity accounts for a smaller proportion of total energy expenditure than basal metabolism does—about 15 to 30% of energy requirements (Figure 9.8d). The energy we expend in physical activity includes both planned exercise and daily activities such as walking to work, typing, performing yard work, work-related activities, and even fidgeting. This non-exercise activity thermogenesis (NEAT) includes the energy expended for everything that is not sleeping, eating, or sports-like exercise. It accounts for the majority of the energy expended for activity and varies enormously, depending on an individual’s occupation and daily movements.

The amount of energy used for activity depends on the size of the person, how strenuous the activity is, and the length of time it is performed. Because it takes more energy to move a heavier object, the amount of energy expended for many activities increases as body weight increases. More strenuous activities, such as jogging, use more energy than do less strenuous activities, such as walking, but if you walk for an hour, you will probably burn as many calories as you would by jogging for 30 minutes (Appendix I).

We also use energy to digest food and to absorb, metabolize, and store the nutrients from this food. The energy used for these processes is called either the thermic effect of food (TEF) or diet-induced thermogenesis. This energy expenditure causes body temperature to rise slightly for several hours after a person has eaten. The energy required for TEF is estimated to be about 10% of energy intake but can vary, depending on the amounts and types of nutrients consumed (Figure 9.8e).
What you weigh is determined by the balance between how much energy you take in and how much energy you expend.

a. The number of calories in a food depends on how much carbohydrate, fat, and protein it contains. Each of these tacos contains 9 g of protein, 16 g of carbohydrate, and 13 g of fat. The energy content of each is:

\[
(9 \text{ g} \times 4 \text{ Cal/g protein}) + (16 \text{ g} \times 4 \text{ Cal/g carbohydrate}) + (13 \text{ g} \times 9 \text{ Cal/g fat}) = 217 \text{ Cal.}
\]

b. The Nutrition Facts panel shows the Calories per serving, but to know how many Calories your portion contains, you need to check the serving size. Often the portions of foods and beverages that people consume are larger than the servings listed on the label. As a result, they consume more calories than they think they do.

Ask Yourself

If you drank this entire bottle of iced tea, how many Calories would you be consuming?
c. The hood in the photo below collects expired air. Because aerobic metabolism uses oxygen and produces carbon dioxide, the amounts of these gases in expired air can be used to estimate the amount of energy that is being used. BMR can be measured in the morning, in a warm room, before rising, and at least 12 hours after food intake or activity. For convenience, measurements are often made after only 5 to 6 hours without food or exercise. This measurement, called the **resting metabolic rate (RMR)**, yields values about 10 to 20% higher than BMR values.14

<table>
<thead>
<tr>
<th>Factors that affect basal metabolism</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher lean body mass</td>
<td>↑</td>
</tr>
<tr>
<td>Greater height and weight</td>
<td>↑</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>↑</td>
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<tr>
<td>Lactation</td>
<td>↑</td>
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<tr>
<td>Growth</td>
<td>↑</td>
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<tr>
<td>Low-calorie diet</td>
<td>↓</td>
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<tr>
<td>Starvation</td>
<td>↓</td>
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<tr>
<td>Fever</td>
<td>↑</td>
</tr>
<tr>
<td>Low thyroid hormone levels</td>
<td>↑</td>
</tr>
<tr>
<td>Stimulant drugs such as caffeine and tobacco</td>
<td>↑</td>
</tr>
</tbody>
</table>

Energy needs

- **Sedentary person** (1800 Cal/day)
- **Physically active person** (2200 Cal/day)
- **Very active person** (3500 Cal/day)


d. Sedentary people must plan their intake carefully so it does not exceed energy expenditure. More active people burn more calories for activity so they can eat more and still maintain their weight. Very active people, such as professional athletes, can actually burn more calories for activity than they do for basal metabolism.

e. The amount of energy used to process the food we eat varies with the size and composition of the meal. A bigger meal produces a greater thermic effect of food (TEF). A high-fat meal yields a lower TEF than one high in carbohydrate or protein because dietary fat can be used and stored more efficiently.15
CHAPTER 9 Energy Balance and Weight Management

When calories are consumed in excess of needs, they are stored, mostly as fat. If the excess calories are consumed as fat, they are easily stored as body fat. If the excess calories are consumed as carbohydrate, they are stored as glycogen or converted into fat. If excess calories are consumed as protein, they are converted into body fat. When calorie intake is less than needs, energy can be retrieved from stores. Glycogen and a small amount of body protein can be broken down to supply glucose, and triglycerides in adipose tissue can be broken down to supply fatty acids.

The basics of weight gain and weight loss If you consume more energy than you expend, the excess energy is stored for later use (Figure 9.9). A small amount of energy is stored as glycogen in liver and muscle, but most is stored as triglycerides in adipocytes, which make up adipose tissue. Adipocytes contain large fat droplets (see Figure 5.11b in Chapter 5). The cells increase in size as they accumulate more fat, and they shrink as fat is removed. If intake exceeds needs over the long term, adipocytes enlarge, and the amount of body fat increases, causing weight gain. The larger the number of adipocytes, the greater the body’s ability to store fat. Most adipocytes are formed during infancy and adolescence, but excessive weight gain can cause the formation of new adipocytes at any time of life.

Stored energy is used when energy intake is reduced, both in the short term, such as when you haven’t eaten a meal for a few hours, and in the long term, such as when you are trying to lose weight. To maintain a steady supply of blood glucose, liver glycogen is broken down (see Figure 9.9). Glucose is also supplied by the breakdown of small amounts of body protein, primarily muscle protein, to yield amino acids. These amino acids can then be used to make glucose or produce ATP. Energy for tissues that don’t require glucose is provided by the breakdown of stored fat (triglycerides). Nutrients consumed in the next meal replenish these stores, but with prolonged energy restriction, fat and protein are lost, and body weight is reduced. It is estimated that an energy deficit of about 3500 Calories results in the loss of a pound of adipose tissue.

Estimated Energy Requirements

The current recommendations for energy intake in the United States are the Estimated Energy Requirements (EER; see Chapter 2), the number of calories needed for a healthy individual to maintain his or her weight. They are calculated using equations that take into account gender, age, height, weight, activity level, and life stage, all of which affect calorie needs.

To calculate your EER, you must first determine your physical activity level. You can do this by keeping a daily log of your activities and recording the amount of time spent at each. Use Figure 9.10 to help translate the amount of time you spend engaged in moderate-intensity or vigorous activity into an activity level (sedentary, low active, active, or very active). Each activity level corresponds to a numerical physical activity (PA) value that can be used to calculate your EER. For example, if you spend about an hour a day walking (a moderate-intensity activity) or about 30 minutes jogging (a vigorous activity), you are in the active category and should use the active PA value corresponding to your age and gender when calculating your EER.

Activity level has a significant effect on calorie needs. For example, a 22-year-old man who is 6 feet tall and weighs 185 pounds needs about 2770 Calories/day if he is sedentary but almost 600 more if he is at the active physical activity level.

Once you have determined your physical activity level, you can calculate your EER by entering your age, weight, height, and PA value (see Figure 9.10) into the appropriate EER prediction equation. Table 9.1 provides equations for normal-weight adults and children age 9 and older. Equations for other groups are in Appendix A.
Physical activity level, which is used to calculate EER, is categorized as sedentary, low active, active, or very active. A sedentary person spends about 2.5 hours per day engaged in the activities of daily living, such as housework, homework, and yard work. Adding activity moves the person into the low-active, active, or very-active category. Activity can be moderate or vigorous or a combination of the two; compared to moderate-intensity activity, vigorous activity will burn the same number of calories in less time.

### EER prediction equations Table 9.1

<table>
<thead>
<tr>
<th>Life stage</th>
<th>EER prediction equation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boys 9–18 years</td>
<td>( \text{EER} = 88.5 - (61.9 \times \text{Age in yrs}) + \text{PA} [(26.7 \times \text{Weight in kg}) + (903 \times \text{Height in m})] + 25 )</td>
</tr>
<tr>
<td>Girls 9–18 years</td>
<td>( \text{EER} = 135.3 - (30.8 \times \text{Age in yrs}) + \text{PA} [(10.0 \times \text{Weight in kg}) + (934 \times \text{Height in m})] + 25 )</td>
</tr>
<tr>
<td>Men ≥ 19 years</td>
<td>( \text{EER} = 662 - (9.53 \times \text{Age in yrs}) + \text{PA} [(15.91 \times \text{Weight in kg}) + (539.6 \times \text{Height in m})] )</td>
</tr>
<tr>
<td>Women ≥ 19 years</td>
<td>( \text{EER} = 354 - (6.91 \times \text{Age in yrs}) + \text{PA} [(9.36 \times \text{Weight in kg}) + (726 \times \text{Height in m})] )</td>
</tr>
</tbody>
</table>

For example, if you are an active 19-year-old male who weighs 72.7 kg and is 1.75 m tall, \( \text{EER} = 662 - (9.53 \times 19 \text{ yrs}) + 1.25 [(15.91 \times 72.7 \text{ kg}) + (539.6 \times 1.75 \text{ m})] = 3107 \text{ Cal/day} \)

* These equations are appropriate for determining EER in normal-weight individuals. Equations that predict the amount of energy needed for weight maintenance in overweight and obese individuals are also available (see Appendix A).

### CONCEPT CHECK

1. **Why** are more Americans obese today compared to 40 years ago?
2. **What** happens to energy stores when energy intake exceeds expenditure?
3. **Which** component of energy expenditure is easiest to modify?
4. **What** is your EER?
What Determines Body Size and Shape?

LEARNING OBJECTIVES

1. Discuss genetic and environmental factors that affect body weight.
2. List four physiological signals that determine whether you feel hungry or full.
3. Describe how hormones regulate body fat levels.
4. Discuss factors that cause some people to gain weight more easily than others.

You are probably shaped like your mother or your father. This is because the information that determines body size and shape is contained in the genes you inherit from your parents (Figure 9.11). Some of us inherit long, lean bodies, and others inherit huskier builds and the tendency to put on pounds. Genes involved in regulating body weight have been called obesity genes. More than 100 genes that are associated with body weight regulation have been identified; it is estimated that 20 to 30 of these may contribute to obesity in humans.\(^\text{17}\) Obesity genes are responsible for the production of proteins that affect how much food you eat, how much energy you expend, and the way fat is stored in your body. But genes are not the only factor; regardless of your genetic background, the lifestyle choices you make play an important role in determining what you weigh.

Genes vs. Environment

The genes you inherit play a major role in determining your body weight. If one or both of your parents is obese, your risk of becoming obese is increased by a factor of 2 or 3, and the risk increases with the magnitude of the obesity. By studying identical twins, who have the same genetic makeup, researchers have been able to determine that about 75% of the variation in BMI can be attributed to genes.\(^\text{18,19}\) This means that the remaining 25% is determined by the environment in which you live and the lifestyle choices you make (see Thinking It Through).

Genes and body shape • Figure 9.11

The genes we inherit from our parents are important determinants of our body size and shape. The boy on the left inherited his father’s long, lean body, whereas the boy on the right has his father’s huskier build and will likely have a tendency to be overweight throughout his life.
THinking it through
A Case Study on Genetics, Lifestyle, and Body Weight

Aysha was a chubby baby. Into her teens, she continued to be slightly overweight. Because her parents are both obese, no one was surprised by Aysha’s size. During her freshman year at college, she gained 15 pounds and became resigned to the inevitability that she would be fat like her parents. Then she noticed that the choices many of her thin friends made—both in the foods they ate and how they spent their free time—were different from the choices she made. She decided to make some changes.

Aysha, now 23 years old, is 5 feet 4 inches tall and weighs 155 lb.

What is her BMI? Is it in the healthy range?

Your answer:

By recording and analyzing her food intake for three days, Aysha determines that she consumes about 2450 Calories/day. By keeping an activity log, she estimates that a typical day includes 30 minutes of walking rapidly around campus—a moderate-intensity activity.

What is her EER?

Your answer:

How does Aysha’s EER compare with her intake? Is she in energy balance?

Your answer:

Aysha decides to start exercising more and to cut down on her portions at meals and make healthier choices. Meal A, shown below, used to be her typical lunch, and Meal B is her new lunch.

How can Meal B have fewer calories even though it looks like more food?

Your answer:

Why might Meal B satisfy hunger just as well as or better than Meal A?

Your answer:

If Aysha adds an additional 30 minutes of moderate-intensity exercise every day, by how much will her EER increase?

Your answer:

Do you think Aysha is destined to be overweight? Explain your answer.

Your answer:

(Check your answers in Appendix J.)
When individuals who are genetically susceptible to weight gain find themselves in an environment where food is appealing and plentiful and physical activity is easily avoided, obesity is a likely outcome but not the only possible one. If you inherit genes that predispose you to being overweight but carefully monitor your diet and exercise regularly, you can maintain a healthy weight. It is also possible for individuals with no genetic tendency toward obesity to end up overweight if they consume a high-calorie diet and get little exercise. The interplay between genetics and lifestyle is illustrated by the higher incidence of obesity in Pima Indians living in Arizona than in a genetically similar group of Pima Indians living in Mexico (Figure 9.12).20

**Regulation of Food Intake and Body Weight**

What we eat and how much we exercise vary from day to day, but body weight tends to stay relatively constant for long periods. The body compensates for variations in diet and exercise by adjusting energy intake and expenditure to keep weight at a particular level, or set point. This set point, which is believed to be determined in part by genes, explains why your weight remains fairly constant, despite the added activity of a weekend hiking trip, or why most people gain back the weight they lose when they follow a weight-loss diet.23

To regulate weight and fatness at a constant level, the body must be able to respond both to short-term changes in food intake and to long-term changes in the amount of stored body fat. Signals related to food intake affect hunger and satiety over a short period—from meal to meal—whereas signals from adipose tissue trigger the brain to adjust both food intake and energy expenditure for long-term weight regulation.

<table>
<thead>
<tr>
<th>a. Genetic analysis of the Pima Indian population living in Arizona has identified a number of genes that may be responsible for this group’s tendency to store excess body fat.21 When this genetic susceptibility is combined with an environment that fosters a sedentary lifestyle and consumption of high-calorie, high-fat processed foods, the outcome is the strikingly high incidence of obesity seen in this population.</th>
</tr>
</thead>
<tbody>
<tr>
<td>b. The Pima Indians of Mexico have the same genetic susceptibility to obesity as the Arizona Pimas but are farmers who work in the fields and consume the food they grow.22 They still have higher rates of obesity than would be predicted from their diet and exercise patterns, suggesting that they possess genes that favor fat storage, but they are significantly less obese than the Arizona Pimas.20</td>
</tr>
</tbody>
</table>

**Genes vs. lifestyle • Figure 9.12**

Average BMI (kg/m²)

<table>
<thead>
<tr>
<th></th>
<th>Mexico Pima</th>
<th>Arizona Pima</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOTE HERE</td>
<td>VOTA AQUI!</td>
<td></td>
</tr>
<tr>
<td>Foot Limit</td>
<td>PCT. 29</td>
<td></td>
</tr>
</tbody>
</table>

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What Determines Body Size and Shape?

Regulating how much we eat at each meal How do you know how much to eat for breakfast or when it is time to eat lunch? The physical sensations of hunger or satiety that determine how much you eat at each meal are triggered by signals from the gastrointestinal tract, levels of nutrients and hormones circulating in the blood, and messages from the brain. Some signals are sent before you eat to tell you that you are hungry, some are sent while food is in the gastrointestinal tract, and some occur when nutrients are circulating in the bloodstream (Figure 9.13).

The hormone ghrelin may cause you to feel hungry around lunchtime, regardless of when and how much you ate for breakfast. Ghrelin, which is produced by the stomach, is believed to stimulate the desire to eat at usual mealtimes. Blood levels of ghrelin rise an hour or two before a meal and drop very low after a meal. Another hormone, peptide YY, causes a reduction in appetite. It is released from the gastrointestinal tract after a meal, and the amount released is proportional to the number of calories in the meal.

Psychological factors can also affect hunger and satiety. Some people eat for comfort and to relieve stress. Others lose their appetite when they experience these emotions. Psychological distress can alter the mechanisms that regulate food intake.

Regulating how much we weigh over the long term Sometimes we don’t pay attention to how full we are after a meal, and we make room for dessert anyway. If this happens often enough, it can cause an increase in body weight and fatness. To return fatness to a set level, the body must be able to monitor how much fat is present. Some of this information comes from hormones.
Leptin is a good example of a hormone that can affect body weight. Leptin is produced by the adipocytes. The amount produced is proportional to the size of the adipocytes, and the effect of leptin on energy intake and expenditure depends on the amount released (see What a Scientist Sees). Unfortunately, leptin regulation, like other regulatory mechanisms, is much better at preventing weight loss than at preventing weight gain. Obese individuals generally have high levels of leptin, but these levels are not effective at reducing calorie intake and increasing energy expenditure.\textsuperscript{26}

Despite regulatory mechanisms that act to keep our weight stable, changes in physiological, psychological, and environmental circumstances cause the level at which body weight is maintained to change, usually increasing it over time. This supports the hypothesis that the mechanisms that defend against weight loss are stronger than those that prevent weight gain.\textsuperscript{27}

WHAT A SCIENTIST SEES

**Leptin and Body Fat**

The average person looking at the photo on the right sees a normal mouse and a very fat mouse. A scientist sees an explanation for obesity. Leptin acts in a part of the brain called the hypothalamus to help maintain body fat at a normal level. As shown in the diagram, the effect of leptin depends on how much of it is present. If the mouse loses weight, fat is lost from adipocytes, and less leptin is released, causing an increase in food intake and a decrease in energy expenditure. If the mouse gains weight, the adipocytes accumulate fat, and more leptin is released, triggering events that decrease food intake and increase energy expenditure.

The mouse on the left inherited a defective leptin gene, so it produces no leptin. Even when the adipocytes enlarge, leptin levels do not increase. The lack of leptin continues to signal the mouse to eat more and expend less energy. The mouse on the right also inherited a defective leptin gene, but treatment with leptin injections returned its weight to normal.

**Think Critically** What might happen to a mouse with a defect that causes overproduction of leptin?
Obese individuals use fewer calories for NEAT than their lean counterparts. When obese and lean individuals who do not engage in any planned exercise were compared, the lean people walked more and sat less, by about 2 hours per day, than the obese study subjects. If obese individuals could adopt the same patterns as the lean subjects, they would expend an extra 350 Calories per day.28

Why Do Some People Gain Weight More Easily?

A few cases of human obesity have been linked directly to defects in specific genes,21 but mutations in single genes are not responsible for most human obesity. Rather, variations in many genes interact with one another and affect metabolic rate, food intake, fat storage, and activity level. These in turn affect body weight, determining why some of us stay lean and others put on pounds.

Some people, such as the Pima Indians discussed earlier, may gain weight more easily because they inherited genes that make them more efficient at using energy and storing fat. Throughout human history, starvation has threatened survival. Over time, the human body has evolved ways to conserve body fat stores and prevent weight loss. Individuals with the “thriftiest” metabolism would have been more likely to survive. In the United States today, however, food is abundant, so people who inherited these “thrift genes” are more likely to be obese.

Some people may gain weight more easily because they inherit a tendency to expend less energy on activity. Even if they spend the same amount of time engaged in planned exercise as a lean person, their total energy expenditure may be lower because they expend less energy for NEAT activities, such as housework, walking between classes, fidgeting, and moving to maintain posture (Figure 9.14).

CONCEPT CHECK

1. What is the role of genes in regulating body weight?
2. Why do we feel hungry at about the same times every day?
3. What happens to leptin levels when you lose weight?
4. Why are some of us fat and some of us lean?

Managing Body Weight

LEARNING OBJECTIVES

1. Evaluate an individual’s weight and medical history to determine whether weight loss is recommended.
2. Discuss the recommendations for the rate and amount of weight loss.
3. Distinguish between a good weight management program and a fad diet.
4. Explain how medications and surgery can promote weight loss.
Who Should Lose Weight?
These days, just about everybody wants to lose a few pounds or more, but not everyone who is concerned about their weight needs to lose weight in order to be healthy. The risks associated with carrying excess weight are related to the degree of the excess, the location of the excess fat, and the presence of other diseases or risk factors that often accompany excess body fat (Figure 9.15).

Weight-Loss Goals and Guidelines
Losing weight requires tipping the energy balance scale by eating less, exercising more, or some combination of the two. A pound of adipose tissue provides about 3500 Calories. Therefore, to lose a pound of fat, you need to decrease your intake and/or increase your expenditure by this amount. To lose a pound in a week, you would need to tip your energy balance by about 500 Calories/day.

Decreasing energy intake For healthy weight loss, intake must be low in energy but high in nutrients in order to provide for all the body's nutrient needs (see What Should I Eat?). Even when choosing nutrient-dense foods, it is difficult to meet nutrient needs with an intake of fewer than 1200 Calories/day; therefore, dieters consuming less than this amount should take a multivitamin/multimineral supplement. Medical supervision is recommended if intake is below 800 Calories/day.
Increasing physical activity Exercise increases energy expenditure and therefore makes weight loss easier. If food intake stays the same, adding enough exercise to expend 200 Calories five days a week will result in the loss of a pound in about three and a half weeks. Exercise also promotes muscle development, and because muscle is metabolically active tissue, increased muscle mass increases energy expenditure. In addition, physical activity improves overall fitness and relieves boredom and stress. Weight loss is maintained better when physical activity is included. The benefits of exercise are discussed more fully in Chapter 10.

WHAT SHOULD I EAT?

Weight Management

Balance your intake and output
- Know your calorie needs and monitor what you eat.
- Weigh yourself once a week; if the number goes up, cut down your calories.
- When you add dessert, add extra exercise.
- Watch your alcohol consumption and count the calories in alcoholic beverages.
- Don’t snack while watching TV.

Cut down on calories
- Replace your sugar-sweetened soft drink with a glass of water with lemon.
- Have a plain burger, not one with a special sauce or an extra-large patty.
- Pour chips or crackers into a one-serving bowl rather than eating right from the bag or box.
- Bring your own lunch rather than eating out.
- Don’t supersize—choose a small drink and a small order of fries.
- When you eat out, share an entrée with a friend or take some home for lunch the next day.

Increase activity
- Go for a bike ride.
- Try bowling or miniature golf instead of watching TV on Friday nights.
- Take a walk during your lunch break or after dinner.
- Play tennis; you don’t have to be good to get plenty of exercise.
- Get off the bus one stop early.

Yo-yo dieting • Figure 9.16
Repeated cycles of weight loss and gain, referred to as weight cycling, or yo-yo dieting, decrease the likelihood that future attempts at weight loss will be successful.²⁹

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To achieve and maintain a healthy body weight, the 2010 Dietary Guidelines for Americans recommend that adults engage in the equivalent of 150 minutes of moderate-intensity aerobic activity per week. Those who are overweight may need to gradually increase their weekly minutes of aerobic physical activity over time and decrease calorie intake to achieve calorie balance and a healthy weight. The amount of activity needed to achieve and maintain a healthy body weight varies; some may need more than the equivalent of 300 minutes per week of moderate-intensity activity.

**Modifying behavior** After people lose weight, they typically go off their “diet.” When eating patterns return to what they were previously, these dieters then regain the weight they lost. To manage your weight at a healthy level, you need to establish a pattern of food intake and exercise that allows you to enjoy foods and activities you like and that you can maintain throughout your life without gaining weight. Changing food consumption and exercise patterns requires identifying behaviors that led to weight gain and replacing them with new ones that promote and maintain weight loss. This can be accomplished through **behavior modification** (Figure 9.17).

**Managing America’s weight** To become a thinner nation, we need strategies that can help all Americans improve their food choices, reduce serving sizes, and increase their physical activity. Although successful weight management ultimately depends on an individual’s choices, food manufacturers and restaurants can help us cut calories by offering healthier foods and packaging or serving foods in smaller portions. Communities can help increase activity by providing parks, bike paths, and other recreational facilities for people of all ages. Businesses and schools can contribute by offering more opportunities for physical activity at the workplace and during the school day.

Even small changes, if they are consistent, can arrest the increase in obesity in the population. It has been estimated that a population-wide shift in energy balance of only 100 Calories/day, the equivalent of walking a mile or cutting out a scoop of ice cream, would prevent further weight gain in 90% of the population.

**Suggestions for Weight Gain**
As difficult as weight loss is for some people, weight gain can be equally elusive for underweight individuals. The first step toward weight gain is a medical evaluation to rule out medical reasons for low body weight. This is particularly important when weight loss occurs unexpectedly. If low body weight is due to low energy intake or high energy expenditure, gradually increasing consumption of energy-dense foods is suggested. Energy intake can be increased by eating meals more frequently; adding healthy high-calorie snacks, such as nuts, peanut butter, or milk-shakes, between meals; and replacing low-calorie drinks such as water and diet beverages with 100% fruit juices and milk.

To encourage a gain in muscle rather than fat, muscle-strengthening exercise should be a component of any weight gain program. This approach requires extra calories to fuel the activity needed to build muscles. These weight-gain recommendations apply to individuals who are naturally thin and have trouble gaining weight on the recommended energy intake. However, this dietary approach may not promote weight gain for those who limit intake because of an eating disorder.

**Diets and Fad Diets**
Want to lose 10 lb in just 5 days? What dieter wouldn’t? People who are desperate to lose weight are prey to all sorts of diets that promise quick fixes. They willingly eat a single food for days at a time, select foods on the basis of special fat-burning qualities, and consume odd combinations at specific times of the day. Most diets, no matter how outlandish, will promote weight loss because they reduce energy intake. Even diets that focus on modifying fat or carbohydrate intake or promise to allow unlimited amounts of certain foods work because intake is reduced. The true test of the effectiveness of a weight-loss plan is whether it promotes weight loss that can be maintained over the long term.

People often don’t recognize that if you lose weight, you need to eat less to stay at the lower weight. For example, an inactive 30-year-old, 5’4” woman who weighs 170 lb needs to consume about 2100 Calories/day to maintain her weight. If she loses 40 lb but does not change her activity level, she will need to consume only
about 1880 Calories to maintain her healthier reduced weight. If, once the weight is lost, she resumes her pre-weight-loss dietary pattern, eating 2100 Calories/day, she will regain all the lost weight.

Effective weight-management programs promote healthy weight-loss diets and encourage changes in the lifestyle patterns that led to weight gain. When selecting a program, look for one that is based on sound nutrition
and exercise principles, suits your individual preferences in terms of food choices as well as time and costs, and promotes long-term lifestyle changes. Quick fixes are tempting, but if the program’s approach is not one that can be followed for a lifetime, it is unlikely to promote successful weight management (Table 9.2).

Some of the most common methods for reducing calorie intake include using exchange lists for diet planning, eating pre-portioned meals or liquid meals, and reducing the fat or carbohydrate content of the diet (Figure 9.18). All these methods cause weight loss by limiting, in one way or another, the number of calories consumed.

### Weight-Loss Drugs and Supplements

Prescription drugs for the treatment of obesity include those that reduce appetite by affecting the activity of brain neurotransmitters (for example, phentermine, trade name Adipex) and those that decrease the absorption of fat in the intestine (for example, orlistat, brand name Xenical). Medications such as these are recommended only for individuals whose health is seriously compromised by their body weight: obese individuals (BMI greater than 30 kg/m²) and overweight individuals with a BMI greater than or equal to 27 kg/m² who have two or more obesity-related risk factors or diseases. One of the major disadvantages of drug treatment is that even if the drug promotes weight loss, the weight is usually regained when the drug is discontinued.

Like prescription drugs, over-the-counter weight-loss medications are regulated by the FDA and must adhere to strict guidelines regarding the dose per pill and the effectiveness of the ingredients. The FDA has approved only a limited number of substances for sale as nonprescription weight-loss medications. One of these is
a. Exchanges
Foods that are in the same exchange list, such as rice, bread, and potatoes, are similar in their energy and macronutrient content, so they can be exchanged for one another in a calorie-controlled diet (see Appendix E). Diets based on exchanges include a variety of foods and are likely to meet nutrient needs. They teach meal-planning skills that are easy to apply away from home and can be used over the long term.

\[
\begin{align*}
\frac{1}{3} \text{ cup rice} & \quad = \quad 1 \text{ slice bread} & \quad = \quad \frac{1}{2} \text{ medium potato, baked} \\
80 \text{ Calories} & \quad 80 \text{ Calories} & \quad 80 \text{ Calories} \\
15 \text{ g carbohydrate} & \quad 15 \text{ g carbohydrate} & \quad 15 \text{ g carbohydrate} \\
3 \text{ g protein} & \quad 3 \text{ g protein} & \quad 3 \text{ g protein} \\
0–1 \text{ g fat} & \quad 0–1 \text{ g fat} & \quad 0–1 \text{ g fat}
\end{align*}
\]

b. Liquid formulas
Liquid formulas and pre-portioned meals make it easier to eat less, but they are not practical when traveling or eating out, and they do not teach the food-selection skills needed to make a long-term lifestyle change. Programs that rely exclusively on liquid formulas are not recommended without medical supervision.

c. Low-fat diets
Low-fat diets typically reduce calorie intake because fat is high in calories. Low-fat diets can include large quantities of fresh fruits and vegetables, which are low in fat and calories and high in nutrients. But just because a food is low in fat does not mean it is low in calories. In the 1990s, low-fat cookies, crackers, and cakes flooded the market. These foods were low in fat but not in calories. When eaten in excess, they contributed to weight gain.

d. Low-carbohydrate diets
Where are the rice and potatoes? Low-carbohydrate diets limit grain products, fruits, some vegetables, and milk and allow unlimited quantities of meats and fats. Weight loss occurs on these diets because people eat less. This may be due to metabolic changes that suppress appetite, but intake is also reduced because of the monotony of the food choices.\textsuperscript{32}
Alli: Blocking Fat Absorption

Alli is an over-the-counter version of a prescription weight-loss drug. Consumers see using it as a way to lose weight without needing to watch food intake quite so carefully. Scientists see that it acts by disabling the enzyme lipase. Lipase breaks triglycerides into fatty acids and monoglycerides, which are absorbed and can then be used or stored for energy. When Alli is present, the triglycerides are not broken down, so they cannot be absorbed. The undigested fat continues through the intestines and is eliminated in the feces. This cuts the number of calories from fat that get into your body, but it is not without side effects. Fat in the colon may cause gas, diarrhea, and more frequent and hard-to-control bowel movements.

Think Critically
Will Alli be an effective weight-loss aid for someone who eats a low-fat diet?

Some products claiming to be weight-loss supplements have been found to contain hidden prescription drugs or compounds that have not been adequately studied in humans. It cannot be assumed that a product is safe simply because it is labeled a dietary supplement or as “herbal” or “all natural.”

Weight-loss supplements that contain soluble fiber promise to reduce the amount you eat by filling up your stomach. Although they are safe, there is little evidence that they promote weight loss.

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gated linoleic acid, and chromium picolinate are weight-loss supplements that promise to enhance fat loss by altering metabolism so as to prevent the synthesis and deposition of fat. None of these has been shown to be effective for promoting weight loss in humans. Supple-

ments that boost energy expenditure, often called “fat burners,” can be effective but have serious and potentially life-threatening side effects. One of the most popular and controversial herbal fat burners is ephedra, a stimulant that increases blood pressure and heart rate and constricts blood vessels. Due to safety concerns, the FDA banned it in 2004. After the ban was instituted, supplement manufacturers began substituting other herbal products, such as bitter orange, that contain similar stimulants and therefore may have similar side effects. Fat burners also typically contain guarana, an herbal source of caffeine. Green tea extract is another popular supplement used to boost metabolism and aid weight loss. It appears to be safe if used in appropriate amounts, but studies have not shown it to enhance weight loss.

Taking some dietary supplements results in weight loss through water loss—either because these supplements are diuretics or because they cause diarrhea. Water loss decreases body weight but does not cause a decrease in body fat. Herbal laxatives found in weight-loss teas and supplements include senna, aloe, buckthorn, rhubarb root, cascara, and castor oil. Overuse of these substances can have serious side effects, including diarrhea, electrolyte imbalances, and liver and kidney toxicity.

**Weight-Loss Surgery**
A number of surgical procedures decrease body weight by altering the gastrointestinal tract so as to reduce food intake and absorption. At present, the most popular surgical approaches to treating obesity are adjustable gastric banding, which limits the amount of food that can be consumed, and gastric bypass, which reduces the amount of food that can be consumed and the amount that can be absorbed (Figure 9.19). These surgical approaches are

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**Gastric banding and bypass • Figure 9.19**

a. Gastric banding involves surgically placing an adjustable band around the upper part of the stomach, creating a small pouch. The narrow opening between the stomach pouch and the rest of the stomach slows the rate at which food leaves the pouch. This promotes weight loss by reducing the amount of food that can be consumed at one time and slowing digestion. Gastric banding entails less surgical risk and is more easily reversible than other types of weight-loss surgery.

b. Gastric bypass involves bypassing part of the stomach and small intestine by connecting the intestine to the upper portion of the stomach. Food intake is reduced because the stomach is smaller, and absorption is reduced because the small intestine is shortened. Gastric bypass entails short-term surgical risks and a long-term risk of nutrient deficiencies, particularly of vitamin B₁₂, folate, calcium, and iron, because absorption of these nutrients is reduced.
Debate  
Is Surgery a Good Solution to Obesity?

The Issue: The medical, social, and financial costs of obesity are well known. So is the fact that eating less and moving more will promote weight loss. However, these conventional methods do not always work. When they fail, is surgery a good weight-loss option?

Obesity surgery, known as bariatric surgery, is becoming increasingly common; over the past decade, there has been a 15-fold increase in the frequency of these procedures. They are effective, and for some they can be lifesaving. When compared with conventional treatment, weight loss was greater at 2 years and at 10 years in those who had bariatric surgery. The incidence and control of type 2 diabetes, hypertension, high blood cholesterol, gastrointestinal reflux disease, and sleep apnea all improved with weight-loss surgery. In addition, quality of life improved in those who had surgery, and medication costs and overall mortality decreased.

About 1 in 20 Americans is severely obese and meets the criteria for treatment with bariatric surgery, but only 0.6% of eligible patients have the surgery each year. This is because bariatric surgery is not without costs and complications. Gastric bypass surgery costs about $18,000 to $22,000, and adjustable gastric banding costs about $17,000 to $30,000. Complications are common; although fewer than 1% of patients die during or immediately after surgery, 20% experience adverse events. The major complications, some of which require follow-up surgery, include ulcers, blockage of the opening from the stomach, leakage at the connection between the stomach and intestine, and pneumonia and blood clots. The incidence of gallstones and subsequent gallbladder removal is high because of the rapid weight loss that occurs following surgery. The reasons for the high complication rate include both the fact that anesthesia and surgery are risky in obese individuals and that there are a limited number of surgeons and surgical centers that have experience with these procedures.

In addition to surgical complications, there are long-term issues that affect digestion and lifestyle. Procedures that reduce the length of the small intestine reduce nutrient absorption and can lead to malnutrition if dietary supplements are not consumed for life. Some people feel very sleepy after eating and many experience chronic diarrhea, gas, foul-smelling stools, and other changes in bowel habits. Everyone who has this surgery must be willing to commit to changes in the types and amounts of food they consume. Eating too much or eating the wrong foods may induce vomiting or cause food to dump rapidly into the small intestine, leading to symptoms such as nausea, rapid pulse, and diarrhea. There are also emotional consequences to the changes in body size and eating habits that contribute to a post-bariatric surgery divorce rate that is higher than the national average.

So is bariatric surgery a good option? It is expensive and risky, but results are impressive in the first decade after the procedures. For those who have high blood pressure, diabetes, high blood cholesterol, and arthritis, all of which are helped by weight loss, recommended only in cases in which the health risks of obesity are greater than the health risks of the surgery (see Debate: Is Surgery a Good Solution to Obesity?).

Another popular surgical procedure for reducing body fat is liposuction. This procedure involves inserting a large hollow needle under the skin into a fat deposit and literally vacuuming out the fat. Liposuction is considered a cosmetic procedure. It can reduce the amount of fat in a specific location, but it does not significantly reduce overall body weight.

CONCEPT CHECK

1. Why is weight loss not recommended for everyone with a BMI above the healthy range?
2. How much weight loss per week is recommended?
3. What are some characteristics of a good weight-loss program?
4. How does gastric bypass cause weight loss?
the surgery can enhance quality of life and even be lifesaving. But we still do not understand what the consequences of rearranging the GI anatomy will be in 20 or 30 years.

Think critically: In patients who have undergone bariatric surgery, some weight gain is common after 2 to 5 years. Why might this weight gain occur?

Significant weight loss is usually achieved 18 to 24 months after weight-loss surgery. NBC’s Today Show weather anchor Al Roker lost 100 lb after undergoing gastric bypass surgery.

Eating Disorders

LEARNING OBJECTIVES

1. **Distinguish** among anorexia, bulimia, and binge-eating disorder.
2. **Describe** demographic and psychological factors associated with increased risk of developing an eating disorder.
3. **Discuss** how body ideal and the media affect the incidence of eating disorders.
4. **Explain** what is meant by the binge/purge cycle.

What and how much people eat vary, depending on social occasions, emotions, time limitations, hunger, and the availability of food, but generally people eat when they are hungry, choose foods that they enjoy, and stop eating when they are satisfied. Abnormal or disordered eating occurs when a person is overly concerned with food, eating, and body size and shape. When the emotional
aspects of food and eating overpower the role of food as nourishment, an eating disorder may develop. Eating disorders affect physical and nutritional health and psychosocial functioning. If untreated, they can be fatal.

Types of Eating Disorders
Mental health guidelines define three categories of eating disorders: anorexia nervosa, bulimia nervosa, and eating disorders not otherwise specified (ED-NOS), which includes binge-eating disorder and other abnormal eating behaviors that don’t qualify as anorexia or bulimia (Table 9.3).

What Causes Eating Disorders?
We do not completely understand what causes eating disorders, but we do know that genetic, psychological, and sociocultural factors contribute to their development (Figure 9.20). Eating disorders can be triggered by traumatic events such as sexual abuse or by day-to-day occurrences such as teasing or judgmental comments by a friend or a coach. Eating disorders occur in people of all ages, races, and socioeconomic backgrounds, but some groups are at greater risk than others. Women are more likely than men to develop eating disorders. In the United States, eating disorders affect about 3% of girls and women between ages 18 and 30. Professional dancers, models, and others who are concerned about maintaining a low body weight are most likely to develop eating disorders. Eating disorders commonly begin in adolescence, when physical, psychological, and social development is occurring rapidly.

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**Distinguishing among eating disorders  Table 9.3**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Anorexia nervosa</th>
<th>Bulimia nervosa</th>
<th>Binge-eating disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body weight</strong></td>
<td>Below normal (&lt; 85% of recommended)</td>
<td>Usually normal</td>
<td>Above normal</td>
</tr>
<tr>
<td><strong>Binge eating</strong></td>
<td>Possibly</td>
<td>Yes, at least twice a week for three months</td>
<td>Yes, at least twice a week for six months</td>
</tr>
<tr>
<td><strong>Purging</strong></td>
<td>Possibly</td>
<td>Yes, at least twice a week for three months</td>
<td>No</td>
</tr>
<tr>
<td><strong>Restricts food intake</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Body image</strong></td>
<td>Dissatisfaction with body and distorted image of body size</td>
<td>Dissatisfaction with body and distorted image of body size</td>
<td>Dissatisfaction with body</td>
</tr>
<tr>
<td><strong>Fear of being fat</strong></td>
<td>Yes</td>
<td>Yes</td>
<td>Not excessive</td>
</tr>
<tr>
<td><strong>Self-esteem</strong></td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Menstrual abnormalities</strong></td>
<td>Absence of at least three consecutive periods</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td><strong>Typical age of onset</strong></td>
<td>Preadolescence/adolescence</td>
<td>Adolescence/young adults</td>
<td>Adults of all ages</td>
</tr>
</tbody>
</table>

**anorexia nervosa** An eating disorder characterized by self-starvation, a distorted body image, and abnormally low body weight.

**bulimia nervosa** An eating disorder characterized by the consumption of a large amount of food at one time (binge eating) followed by purging behaviors such as self-induced vomiting to prevent weight gain.

**binge-eating disorder** An eating disorder characterized by recurrent episodes of binge eating in the absence of purging behavior.

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Eating disorders often have low self-esteem. Self-esteem refers to the judgments people make and maintain about themselves—a general attitude of approval or disapproval about worth and capability. A poor body image contributes to low self-esteem. Eating disorders are characterized not only by dissatisfaction with one’s body but also with distorted body image. Someone with a distorted body image is unable to judge the size of his or her own body. Thus, even if a young woman achieves a body weight comparable to that of a fashion model, she may continue to see herself as fat and strive to lose more weight.

People with eating disorders are often perfectionists who set very high standards for themselves and strive to be in control of their bodies and their lives. Despite their many achievements, they feel inadequate, defective, and worthless. They may use their relationship with food to gain control over their lives and boost their self-esteem. They believe that controlling their food intake and weight demonstrates their ability to control other aspects of their lives and solves other problems. Even if they feel insecure, helpless, or dissatisfied in other aspects of their lives, if they are in control of their food intake, weight, and body size, they can associate this control with success.
a. A fuller figure is still desirable in many cultures. Young women in these cultures, such as the Zulu of South Africa, may struggle to gain weight in order to achieve what is viewed as the ideal female body. As television images of very thin Western women become more accessible, the Zulu cultural view of plumpness as desirable may be changing.

b. Thinness has not always been the beauty standard in the United States. This timeline shows how the female body ideal has changed over the years. As female models, actresses, and other cultural icons have become thinner over the past several decades, the incidence of eating disorders has increased.

c. Magazine covers and advertisements emphasize thinness as a standard for female beauty. These “ideal” bodies are frequently atypical of normal, healthy women. Fashion models today weigh 23% less than the average female. Although many women strive for this thin ideal, only 1% of young women have a chance of being as thin as a supermodel.

d. The toys that children play with set a cultural standard for body ideal. Little girls playing with Barbie dolls want to be like Barbie when they grow up, and boys playing with Superman, Batman, or GI Joe action figures want to be like them. This includes looking like them. Unfortunately, Barbie’s measurements would be virtually unachievable if Barbie were life-sized. The same is true of the big chest, muscular arms and legs, and flat stomach with “six-pack” abs seen on male action figures.
Sociocultural issues What is viewed as an “ideal” body differs across cultures and has changed throughout history (Figure 9.21). Cultural ideals about body size are linked to body image and the incidence of eating disorders. Eating disorders occur in societies where food is abundant and the body ideal is thin. They do not occur in societies where food is scarce and people must worry about where their next meal is coming from.

U.S. culture today is a culture of thinness. Messages about what society views as a perfect body—the ideal that we should strive for—are constantly delivered by television, movies, magazines, advertisements, and even toys. Tall, lean fashion models adorn billboards and magazine covers. Thinness is associated with beauty, success, intelligence, and vitality. A young woman facing a future in which she must be independent, have a prestigious job, maintain a successful love relationship, bear and nurture children, manage a household, and keep up with fashion trends can become overwhelmed. Unable to master all these roles, she may look for some aspect of her life that she can control. Food intake and body weight are natural choices because thinness is associated with success. These messages about how we should look are hard to ignore and can create pressure to achieve this ideal body. But it is a standard that is very difficult to meet—a standard that is contributing to disturbances in body image and eating behavior.

Although men currently represent a small percentage of people with eating disorders, the numbers are increasing. This is likely due to increasing pressure to achieve an ideal male body. Advertisements directed at men are showing more and more exposed skin, with a focus on well-defined abdominal and chest muscles.

Anorexia Nervosa
Anorexia means lack of appetite, but in the case of the eating disorder anorexia nervosa, it is a desire to be thin, rather than a lack of appetite, that causes individuals to decrease their food intake. Anorexia nervosa is characterized by severe weight loss, amenorrhea, constipation, and restlessness. It affects about 1% of female adolescents in the United States. The average age of onset is 17 years. There is a 5% death rate in the first two years, and the death rate can reach 20% in untreated individuals.

The psychological component of anorexia nervosa revolves around an overwhelming fear of gaining weight, even in individuals who are already underweight. It is not uncommon for individuals with anorexia to feel that they would rather be dead than fat. Anorexia is also characterized by disturbances in body image or perception of body size that prevent those with this disorder from seeing themselves as underweight even when they are dangerously thin. People with this disorder may use body weight and shape as a means of self-evaluation: “If I weren’t so fat, everyone would like and respect me, and I wouldn’t have other problems.” However, no matter how much weight they lose, they do not gain self-respect, inner assurance, or the happiness they seek. Therefore, they continue to restrict their intake and use other behaviors to lose weight.

The most obvious behaviors associated with anorexia are those that contribute to the maintenance of a body weight that is 15% or more below normal. These behaviors include restriction of food intake, binge-eating and purging episodes in some patients, strange eating rituals, and excessive activity (Figure 9.22). For some individuals

A day in the life of a person with anorexia • Figure 9.22

For individuals with anorexia, food and eating become an obsession. In addition to restricting the total amount of food they consume, people with anorexia develop personal diet rituals, limiting certain foods and eating them in specific ways. Although they do not consume very much food, they are preoccupied with food and spend an enormous amount of time thinking about it, talking about it, and preparing meals for others. Instead of eating, they move the food around the plate and cut it into tiny pieces.

Dear Diary,
For breakfast today I had a cup of tea. For lunch I ate some lettuce and a slice of tomato, but no dressing. I cooked dinner for my family. I love to cook, but it is hard not to taste. I tried a new chicken recipe and served it with rice and asparagus. I even made a chocolate cake for dessert but I didn’t even lick the bowl from the frosting. When it came time to eat, I only took a little. I told my mom I nibbled while cooking. I pushed the food around on my plate so no one would notice that I only ate a few bites. I was good today – I kept my food intake under control. The scale says I have lost 20 pounds, but I still look fat.
with anorexia, the increase in activity is surreptitious, such as going up and down stairs repeatedly or getting off the bus a few stops too early. For others, the activity takes the form of strenuous physical exercise. They may become fanatical athletes and feel guilty if they cannot exercise. They link exercise and eating, so a certain amount of exercise earns them the right to eat, and if they eat too much, they must pay the price by adding extra exercise. They do not stop when they are tired; instead, they train compulsively beyond reasonable endurance.

The first obvious physical manifestation of anorexia is weight loss. As weight loss becomes severe, symptoms of starvation begin to appear. Starvation affects mental function, causing the person to become apathetic, dull, exhausted, and depressed. Fat stores are depleted. Other symptoms that appear include muscle wasting, inflammation and swelling of the lips, flaking and peeling of the skin, growth of fine hair (called lanugo) on the body, and dry, thin, brittle hair on the head. In females, estrogen levels drop, and menstruation becomes irregular or stops. In males, testosterone levels decrease. In the final stages of starvation, the person experiences abnormalities in electrolyte and fluid balance and cardiac irregularities. Suppression of immune function leads to infection, which further increases nutritional needs.

The goal of treatment for anorexia nervosa is to help resolve the underlying psychological and behavioral problems while providing for physical and nutritional rehabilitation. Treatment requires an interdisciplinary team of nutritional, psychological, and medical specialists and typically requires years of therapy. The goal of nutrition intervention is to promote weight gain by increasing energy intake and expanding dietary choices. In more severe cases of anorexia hospitalization is required so food intake and exercise behaviors can be controlled. Intravenous nutrition may be necessary to keep a patient with anorexia alive. Some people with anorexia make full recoveries, but about half have poor long-term outcomes—remaining irrationally concerned about weight gain and never achieving normal body weight. Some patients with anorexia also transition to bulimia nervosa.

Bulimia Nervosa

Bulimia comes from the Greek bous (“ox”) and limos (“hunger”), denoting hunger of such intensity that a person could eat an entire ox. The term bulimia nervosa was coined in 1979 by a British psychiatrist who suggested that bulimia consists of powerful urges to overeat in combination with a morbid fear of becoming fat and avoidance of the fattening effects of food by inducing vomiting and/or abusing purgatives.

Like anorexia, bulimia is characterized by an intense fear of becoming fat and a negative body image, accompanied by a distorted perception of body size. Because self-esteem is highly tied to impressions of body shape and weight, people with bulimia may blame all their problems on their appearance. They are preoccupied with the fear that once they start eating, they will not be able to stop. They may engage in continuous dieting, which leads to a preoccupation...
with food. They are often socially isolated and may avoid situations that will expose them to food, such as going to parties or out to dinner; thus they become further isolated.

Bulimia typically begins with food restriction motivated by the desire to be thin. Overwhelming hunger may finally cause the dieting to be interrupted by a period of overeating. Eventually a pattern develops that consists of semi-starvation interrupted by periods of gorging. During a binge-eating episode, a person with bulimia experiences a sense of lack of control. Binges usually last less than two hours and occur in secrecy. Eating stops when the food runs out or when pain, fatigue, or an interruption intervenes. The amount of food consumed in a binge may not always be enormous, but the individual perceives it as a binge episode (Figure 9.23).

After binge episodes, individuals with bulimia use various behaviors to eliminate the extra calories and prevent weight gain. Some use behaviors such as fasting or excessive exercise, but most use purging behaviors such as vomiting or taking laxatives, diuretics, or other medications. Self-induced vomiting does eliminate some of the food before the nutrients have been absorbed, preventing weight gain, but laxatives and diuretics cause only water loss. Nutrient absorption is almost complete before food enters the colon, where laxatives have their effect. The weight loss associated with laxative abuse is due to dehydration. Diuretics also cause water loss, but via the kidney rather than the GI tract. They do not cause fat loss.

It is the purging portion of the binge/purge cycle that is most hazardous to health. Vomiting brings stomach acid into the mouth. Frequent vomiting can cause tooth decay, sores in the mouth and on the lips, swelling of the jaw and salivary glands, irritation of the throat and esophagus, and changes in stomach capacity and the rate of stomach emptying. It also causes broken blood vessels in the face due to the force of vomiting, as well as electrolyte imbalance, dehydration, muscle weakness, and menstrual irregularities. Laxative and diuretic abuse can also lead to dehydration and electrolyte imbalance.

The overall goal of therapy for people with bulimia nervosa is to reduce or eliminate bingeing and purging behavior by separating the patients’ eating behavior from their emotions and their perceptions of success and promoting eating in response to hunger and satiety. Psychological issues related to body image and a sense of lack of control over eating must be resolved. Nutritional therapy must address physiological imbalances caused by purging episodes as well as provide education on nutrient needs and how to meet them. Treatment has been found to speed recovery, especially if it is provided soon after symptoms begin, but for some women, this disorder may remain a chronic problem throughout life.

Binge-Eating Disorder

Binge-eating disorder is the most common eating disorder. Unlike anorexia and bulimia, binge-eating disorder is not uncommon in men, who account for about 40% of cases. It is most common in overweight individuals (Figure 9.24). Individuals with binge-eating disorder engage in recurrent

A day in the life of a person with binge-eating disorder • Figure 9.24

People with binge-eating disorder often seek help for their weight rather than for their disordered eating pattern. It is estimated that 10 to 15% of people enrolled in commercial weight-loss programs suffer from this disorder.56

Dear Diary,
I got on the scale today. What a mistake! My weight is up to 250 pounds. I hate myself for being so fat. Just seeing that I gained more weight made me feel ashamed – all I wanted to do was bury my feelings in a box of cookies or a carton of ice cream. Why do I always think the food will help? Once I started eating I couldn’t stop. When I finally did I felt even more disgusted, depressed, and guilty. I am always on a diet but it is never long before I lose control and pig out. I know my eating and my weight are not healthy but I just can’t seem to stop.
### Table 9.4: Other Eating Disorders

<table>
<thead>
<tr>
<th>Eating disorder</th>
<th>Who is affected</th>
<th>Characteristics and consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anorexia athletica</strong></td>
<td>Athletes in weight-dependent sports such as dance, figure skating, gymnastics,</td>
<td>Engaging in compulsive exercise to lose weight or maintain a very low body weight. Can lead to more serious eating disorders and serious health problems, including kidney failure, heart attack, and death.</td>
</tr>
<tr>
<td></td>
<td>track and field, cycling, wrestling, and horse racing</td>
<td></td>
</tr>
<tr>
<td><strong>Female athlete triad</strong></td>
<td>Female athletes in weight-dependent sports</td>
<td>A triad of disordered eating, amenorrhea, and osteoporosis. The energy restriction, along with high levels of exercise, causes amenorrhea. Low estrogen levels then interfere with calcium balance, eventually causing reductions in bone mass and an increased risk of bone fractures (discussed further in Chapter 10).</td>
</tr>
<tr>
<td><strong>Bigorexia (muscle dysmorphia or reverse anorexia)</strong></td>
<td>Bodybuilders and avid gym-goers; more common in men than in women</td>
<td>An obsession with being small and underdeveloped. Those affected believe that their muscles are inadequate, even when they have good muscle mass. They become avid weight lifters and may experiment with steroids or other muscle-enhancing drugs.</td>
</tr>
<tr>
<td><strong>Avoidance emotional disorder</strong></td>
<td>Children</td>
<td>Similar to anorexia nervosa in that the child avoids eating and experiences weight loss and the other physical symptoms of anorexia. However, there is no distorted body image or fear of weight gain.</td>
</tr>
<tr>
<td><strong>Selective eating disorder</strong></td>
<td>Children</td>
<td>Children with this disorder will eat only a few foods, mostly those high in carbohydrate. If the disorder continues for long periods, it increases the risk of malnutrition.</td>
</tr>
<tr>
<td><strong>Night-eating syndrome</strong></td>
<td>Obese adults and those experiencing stress</td>
<td>A disorder that involves consuming most of the day's calories late in the day or at night. People with this disorder—which contributes to weight gain—are tense, anxious, upset, or guilty while eating. A similar disorder, in which a person may eat while asleep and have no memory of the events, is called nocturnal sleep-related eating disorder (NS-RED) and is considered a sleep disorder, not an eating disorder.</td>
</tr>
<tr>
<td><strong>Pica</strong></td>
<td>Pregnant women, children, people with psychiatric disturbances and developmental</td>
<td>Craving and eating nonfood items such as dirt, clay, paint chips, plaster, chalk, laundry starch, coffee grounds, and ashes. Depending on the items consumed, pica can cause perforated intestines and contribute to mineral deficiencies or intestinal infections (discussed further in Chapter 11).</td>
</tr>
<tr>
<td></td>
<td>disabilities, people whose family or ethnic customs include eating certain nonfood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>substances, people who are hungry and try to ease hunger and cravings with nonfood</td>
<td></td>
</tr>
<tr>
<td></td>
<td>substances</td>
<td></td>
</tr>
<tr>
<td><strong>Diabulimia (insulin misuse)</strong></td>
<td>People with type 1 diabetes</td>
<td>Type 1 diabetes is a disease that forces patients to focus on food portions and body weight. This may cause some to become preoccupied with their weight and to control it by withholding insulin. Without insulin, glucose cannot enter cells to provide fuel, blood levels rise, and weight drops. Uncontrolled blood sugar can lead to blindness, kidney disease, heart disease, nerve damage, and amputations.</td>
</tr>
</tbody>
</table>

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episodes of binge eating but do not regularly engage in purging behaviors.

The major complications of binge-eating disorder are the health problems associated with obesity, which include diabetes, high blood pressure, high blood cholesterol levels, gallbladder disease, heart disease, and certain types of cancer. Treatment of binge-eating disorder involves counseling to improve body image and self-acceptance; a healthy, nutritious diet; increased exercise to promote weight loss; and behavior therapy to reduce bingeing.

**Eating Disorders in Special Groups**

Although anorexia and bulimia are most common in women in their teens and 20s, eating disorders occur in both genders and all age groups. Both male and female athletes are at high risk for eating disorders, with an incidence of 10 to 20%. Eating disorders occur during pregnancy and are becoming more frequent among younger children due to social values about food and body weight. They also occur in individuals with diabetes. A number of less common eating disorders appear in special groups in the general population (Table 9.4).

**Preventing and Getting Treatment for Eating Disorders**

Because eating disorders are often triggered by weight-related criticism, elimination of this type of behavior can help prevent them. Another important target for reducing the incidence of eating disorders is the media. If the unrealistically thin body ideal presented by the media could be altered, the incidence of eating disorders would likely decrease. Even with these interventions, however, eating disorders are unlikely to go away entirely. Education through schools and communities about the symptoms and complications of eating disorders can help people identify friends and family members who are at risk and persuade those with early symptoms to seek help.

The first step in preventing individuals from developing eating disorders is to recognize those who are at risk. Early intervention can help prevent at-risk individuals from developing serious eating disorders. Excessive concerns about body weight, having friends who are preoccupied with weight, being teased by peers about weight, and family problems all predispose a person to developing an eating disorder.

Once an eating disorder has developed, the person usually does not get better on his or her own. The actions of family members and friends can help people suffering from eating disorders get help before their health is impaired. But it is not always easy to persuade a friend or relative with an eating disorder to agree to seek help. People with eating disorders are good at hiding their behaviors and denying the problem, and often they do not want help. When confronted, one person might be relieved that you are concerned and willing to help, whereas another might be angry and defensive. When approaching someone about an eating disorder, it is important to make it clear that you are not forcing the person to do anything he or she doesn’t want to do. Continued encouragement can help some people agree to seek professional help.

**CONCEPT CHECK**

1. **Which** eating disorder is characterized by extreme weight loss? Which is characterized by excess weight?
2. **What** factors contribute to the higher incidence of eating disorders among women than among men?
3. **What** is meant by body image?
4. **How** does a food binge differ from “normal” overeating?
Summary

1 Body Weight and Health 310

- More Americans today are overweight and obese than ever before, as seen in this obesity map. Excess body fat increases the risk of chronic diseases such as diabetes, heart disease, high blood pressure, and certain types of cancer.

Obesity on the rise • Figure 9.1

- Body mass index (BMI) can be used to evaluate the health risks of a particular body weight and height. Measures of body composition can be used to determine the proportion of a person’s weight that is due to fat. Excess visceral fat is a greater health risk than excess subcutaneous fat.

2 Energy Balance 315

- Americans are getting fatter because they are consuming more calories due to poor food choices and larger portion sizes, as illustrated in the photo, and moving less due to modern lifestyles in which computers, cars, and other conveniences reduce the amount of energy expended in work and play.

Portion distortion • Figure 9.6

- The principle of energy balance states that if energy intake equals energy expenditure, body weight will remain constant. Energy is provided to the body by the carbohydrate, fat, and protein in the food we eat. This energy is used to maintain basal metabolic rate (BMR), to support activity, and for the thermic effect of food (TEF). When excess energy is consumed, it is stored, primarily as fat in adipocytes, causing weight gain. When energy in the diet does not meet needs, energy stores in the body are used, and weight is lost.

- The energy needs of healthy people can be predicted by calculating their Estimated Energy Requirements (EER). A person’s EER depends on gender, age, life stage, height, weight, and level of physical activity.

3 What Determines Body Size and Shape? 322

- The genes people inherit affect their body size and shape, as illustrated by the father and son shown here, but environmental factors and personal choices concerning the amount and type of food consumed and the amount and intensity of exercise performed also affect body weight.

Genes and body shape • Figure 9.11
Hunger and satiety from meal to meal are regulated by signals from the gastrointestinal tract, hormones, and levels of circulating nutrients. Signals from fat cells, such as the release of leptin, regulate long-term energy intake and expenditure.

Inheriting an efficient metabolism or expending less energy through nonexercise activity thermogenesis (NEAT) may contribute to obesity.

Managing Body Weight 327

Weight loss is recommended for those with a BMI above the healthy range who have excess body fat and a large waist circumference or who have health conditions associated with obesity.

Weight management involves adjusting energy intake and expenditure to lose or maintain weight and behavior modification to keep weight in a healthy range over the long term. To lose a pound of adipose tissue, energy expenditure must be increased or intake decreased by approximately 3500 Calories. Slow, steady weight loss of 1/2 to 2 lb/week is more likely to be maintained than rapid weight loss.

If being underweight is not due to a medical condition, weight gain can be accomplished by increasing energy intake and lifting weights to increase muscle mass.

A good weight-loss program is one that promotes physical activity and a wide variety of nutrient-dense food choices, does not require the purchase and consumption of special foods or combinations of foods, and can be followed for life.

Drug therapy and surgery are recommended only for those whose health is seriously compromised by their body weight. Currently, the most popular surgical approaches to treating obesity are gastric bypass, shown here, and adjustable gastric banding.

Drug therapy and surgery are recommended only for those whose health is seriously compromised by their body weight. Currently, the most popular surgical approaches to treating obesity are gastric bypass, shown here, and adjustable gastric banding.

Eating Disorders 337

Eating disorders are psychological disorders that involve dissatisfaction with body weight. Anorexia nervosa involves self-starvation, resulting in an abnormally low body weight as shown here. Bulimia nervosa is characterized by repeated cycles of binge eating followed by purging and other behaviors to prevent weight gain. Binge-eating disorder is characterized by bingeing without purging. People with this disorder are typically overweight.

A day in the life of a person with anorexia • Figure 9.22

Eating disorders are caused by a combination of genetic, psychological, and sociocultural factors. The lean body ideal in the United States is believed to contribute to disturbances in body image that lead to eating disorders. Treatment involves medical, psychological, and nutritional intervention to stabilize health, change attitudes about body size, and improve eating habits while supplying an adequate diet.
Key Terms

- adipocyte 320
- adjustable gastric banding 335
- amenorrhea 341
- anorexia nervosa 338
- appetite 315
- basal metabolic rate (BMR) 317
- basal metabolism 317
- behavior modification 330
- binge-eating disorder 338
- body composition 313
- body image 339
- body mass index (BMI) 311
- bulimia nervosa 338
- eating disorder 338
- eating disorders not otherwise specified (EDNOS) 338
- energy balance 315
- extreme obesity or morbid obesity 312
- gastric bypass 335
- ghrelin 325
- hunger 316
- lean body mass 311
- leptin 326
- liposuction 336
- nonexercise activity thermogenesis (NEAT) 317
- obese 310
- obesity genes 322
- overweight 310
- resting metabolic rate (RMR) 319
- satiety 324
- set point 324
- subcutaneous fat 315
- thermic effect of food (TEF) or diet-induced thermogenesis 317
- total energy expenditure 317
- underweight 312
- visceral fat 315

Online Resources

- For more information on controlling the global obesity crisis, go to www.who.int/nutrition/topics/obesity/en/index.html.
- For more information on preventing obesity in children, go to the 2010 Dietary Guidelines, at www.health.gov/dietaryguidelines/.
- For more information on healthy weight control, go to http://win.niddk.nih.gov.
- For more information on nutrition and eating disorders, go to www.nutrition.gov/ and click on Nutrition and Health Issues.
- Visit your WileyPLUS site for videos, animations, podcasts, self-study, and other media that will aid you in studying and understanding this chapter.

Critical and Creative Thinking Questions

1. Stephanie wants to lose 10 lb. She finds an app for her cell phone that allows her to track her calories in and calories out. The program says she can lose a pound a week by limiting her Calories to 1500/day and adding enough exercise to burn 300 Calories/day. Her intake and exercise Calories for three days are shown here. Is she meeting her goals? Is her current energy balance realistic and healthy for the long term?

2. Beth is 22 years old and has a BMI in the healthy range. Discuss the steps she can take to prevent weight gain as she gets older.

3. If a race of humans evolved on an island where food was always abundant, how might this have affected the frequency of different types of genes that affect the regulation of body weight?

4. Use your knowledge of food intake regulation to explain why drinking a large glass of water would make you feel less hungry for a short time but not for more than an hour or so.

5. If you were invited to offer advice to your town’s planning committee, what recommendations would you make to help promote physical activity among members of your community? What recommendations would you make for the middle school in order to encourage physical activity and healthy eating among the students and staff?

6. Why is leptin sometimes referred to as a lipid thermostat?

7. Discuss how bulimia might affect each side of the energy balance equation.
8. A late-night TV advertisement promotes a diet pill that is supposed to cause a weight loss of 10 lb in the first week. Assuming that you did not change your activity, how many Calories would you have to eliminate from your diet each day to lose 10 lb of adipose tissue in a week? Based on your calculation, do you think it is possible to lose 10 lb of fat in one week? Why or why not?

9. Design a weight-loss plan for someone who is 20 years old, eats in the dorm cafeteria, and is 40 lb overweight.

What is happening in this picture?

Sumo wrestlers train for many hours each day and eat huge amounts of food. The result is a high BMI and a large waist but surprisingly little visceral fat.

Think Critically

1. Why do these individuals have a low level of visceral fat?
2. Do you think they are at risk for diabetes and heart disease?
3. What type of fat is hanging over the belt of this wrestler?
4. What may happen if this wrestler retires and stops exercising but keeps eating large amounts of food?
1. Basal metabolic rate (BMR) ____________.
   a. is a small component of energy expenditure.
   b. includes the energy needed for kidney function and heartbeat.
   c. includes the energy needed for exercise.
   d. is measured after 2 hours without food or exercise.
   e. is the energy needed to maintain body weight.

2. Excess body fat increases the risk of ____________.
   a. diabetes
   b. high blood cholesterol
   c. certain cancers
   d. high blood pressure
   e. all of the above

3. In order to calculate a person's BMI, you need to know the person's ____________.
   a. height and weight
   b. age and activity level
   c. lean body mass and waist circumference
   d. gender and weight
   e. gender and body composition

4. Which of the following has not contributed to the rising incidence of overweight and obesity in the United States?
   a. Americans use less energy in the activities of their daily lives than they used to.
   b. Portion sizes of our food have increased.
   c. We have ready access to food 24 hours a day.
   d. Our genetics have changed.
   e. The number of people who work at jobs requiring strenuous physical labor has decreased.

5. Which group is least likely to develop an eating disorder?
   a. ballet dancers     d. actresses
   b. fashion models     e. middle-aged men
   c. female gymnasts

6. Which eating disorder is characteristic of people who are overweight?
   a. anorexia
   b. bigorexia
   c. bulimia
   d. binge-eating disorder

7. The method of determining body composition shown here relies on what principle to determine the amount of body fat?
   a. Fat is less dense than water.
   b. Fat does not conduct electricity.
   c. The amount of subcutaneous fat is representative of total body fat.
   d. The extent to which X-rays penetrate fat is different from the extent to which they penetrate other tissues.

8. EER ____________.
   a. is the amount of energy needed to reduce body weight to a healthy level
   b. is the amount of energy you expend daily
   c. increases if you lose weight
   d. increases in adults as they get older
   e. decreases if you exercise more
9. Which statement about leptin is true?
   a. Someone with a defective leptin gene will most likely be obese.
   b. More leptin is released as adipocytes shrink.
   c. High leptin levels stimulate food intake and reduce energy expenditure.
   d. Most human obesity is due to abnormalities in the leptin gene.
   e. Leptin is better at defending against weight gain than against weight loss.

10. Long-term healthy weight loss is based on all of the following principles except ____________.
    a. increasing physical activity
    b. adopting lifelong changes in eating habits
    c. eating specific combinations of foods that increase the number of calories burned
    d. keeping portion sizes moderate
    e. making nutrient-dense choices

11. Which statement about the type of body fat labeled by the letter A is false?
    a. This type of fat storage increases the risk of heart disease, diabetes, and high blood pressure.
    b. This type of fat storage can be reduced by eating grapefruit.
    c. This type of fat storage increases after menopause.
    d. This type of fat storage is more common in men than women.
    e. This type of fat storage can be reduced through exercise.

12. This chart most likely shows the distribution of energy expenditure in which of the following people?
    a. a cyclist who trains for 6 hours a day
    b. an office worker who gets no exercise other than gardening
    c. a young adult who works out for 90 minutes a day
    d. an elderly man who is bedridden

13. True or false: It is possible for someone who is 50 lb overweight to be in energy balance.
    a. True  b. False

14. True or false: Everyone with a BMI in the overweight or obese range is at risk for weight-related health problems.
    a. True  b. False

15. Which of the following is not a characteristic of anorexia nervosa?
    a. a fear of gaining weight
    b. a normal body weight
    c. a preoccupation with food
    d. an abnormal menstrual cycle
    e. a distorted body image

Review your Chapter Planner on the chapter opener and check off you completed work.