

# Alterations in Body Nutrition

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**N**utritional status describes the condition of the body related to the availability and use of nutrients. Nutrients provide the energy and materials necessary for performing the activities of daily living; for maintaining healthy skin, muscles, and other body tissues; for replacing and healing tissues; and for the effective functioning of all body systems, including the immune and respiratory systems. Nutrients are derived from the digestive tract through the ingestion of foods. Once inside the body, nutrients are used for energy or as the

building blocks for tissue growth and repair. When excess nutrients are available, they frequently are stored for future use. If the required nutrients are unavailable, the body adapts by conserving and using its nutrient stores.

## REGULATION OF FOOD INTAKE AND ENERGY METABOLISM

Energy is measured in heat units called *calories*. A calorie, spelled with a small c and also called a *gram calorie*, is the amount of heat or energy required to raise the temperature of 1 g of water by 1°C. A *kilocalorie* (kcal), or *large calorie*, is the amount of energy needed to raise the temperature of 1 kg of water by 1°C. Because a calorie is so small, kilocalories often are used in nutritional and physiologic studies.

*Metabolism* is the organized process through which nutrients such as carbohydrates, fats, and proteins are broken down, transformed, or otherwise converted into cellular energy. The oxidation of proteins provides 4 kcal/g; fats, 9 kcal/g; carbohydrates, 4 kcal/g; and alcohol, 7 kcal/g.

The process of metabolism is unique in that it enables the continual release of energy, and it couples this energy with physiologic functioning. For example, the energy used for muscle contraction is derived largely from energy sources that are stored in muscle cells and then released as the muscle contracts. Because most of our energy sources come from the nutrients in the food that is eaten, the ability to store energy and control its release is important. Normally, energy utilization is balanced with energy expenditure. When a person is overfed and intake of food consistently exceeds energy expenditure, the excess energy is stored as fat, and the person becomes overweight. Conversely, when food intake is less than energy expenditure, fat stores and other body tissues are broken down, and the person loses weight.

## Energy Storage

### Adipose Tissue

More than 90% of body energy is stored in the adipose tissues of the body. *Adipocytes*, or fat cells, occur singly or in small groups in loose connective tissue. In many parts of the body, they cushion body organs such as the kidneys. In addition to

**KEY CONCEPTS****ENERGY METABOLISM**

- Energy is required for all the body's activities. Food is the source of the body's energy, which is measured in kilocalories (kcal).
- Fats, which are a concentrated water-free energy source, contain 9 kcal/g. They are stored in fat cells as triglycerides, which are the main storage sites for energy.
- Carbohydrates are hydrated fuels, which supply 4 kcal/g. They are stored in limited quantities as glycogen and can be converted to fatty acids and stored in fat cells as triglycerides.
- Amino acids, which supply 4 kcal/g, are used in building body proteins. Amino acids in excess of those needed for protein synthesis are converted to fatty acids, ketones, or glucose and are stored or used as metabolic fuel.

isolated groups of fat cells, entire regions of fat tissue are committed to fat storage. Collectively, fat cells constitute a large body organ that is metabolically active in the uptake, synthesis, storage, and mobilization of lipids, which are the main source of fuel storage for the body. Some tissues, such as liver cells, are able to store small amounts of lipids, but when these lipids accumulate, they begin to interfere with cell function. Adipose tissue not only serves as a storage site for body fuels, it provides insulation for the body, fills body crevices, and protects body organs.

Studies of adipocytes in the laboratory have shown that fully differentiated cells do not divide. However, such cells have a long life span, and anyone born with large numbers of adipocytes runs the risk of becoming obese. Some immature adipocytes capable of division are present in postnatal life; these cells respond to estrogen stimulation and are the potential source of additional fat cells during postnatal life.<sup>1</sup> Fat deposition results from proliferation of these existing immature adipocytes and can occur as a consequence of excessive caloric intake when a woman is breast-feeding or during estrogen stimulation around the time of puberty. An increase in fat cells also may occur during late adolescence and in middle-aged persons who already are overweight.

There are two types of adipose tissue: white fat and brown fat. White fat, which despite its name is cream colored or yellow, is the prevalent form of adipose tissue in postnatal life. It constitutes 10% to 20% of body weight in adult males and 15% to 25% in adult females. At body temperature, the lipid content of fat cells exists as an oil. It consists of triglycerides, which are three molecules of fatty acids esterified to a glycerol molecule. Triglycerides, which contain no water, have the highest caloric content of all nutrients and are an efficient form of energy storage. Fat cells synthesize triglycerides, the major fat storage form, from dietary fats and carbohydrates. Insulin is re-

quired for transport of glucose into fat cells. When caloric intake is restricted for any reason, fat cell triglycerides are broken down, and the resultant fatty acids and glycerol are released as energy sources.

Brown fat differs from white fat in terms of its thermogenic capacity or ability to produce heat. Brown fat, the site of diet-induced thermogenesis and nonshivering thermogenesis, is found primarily in early neonatal life in humans and in animals that hibernate. In humans, brown fat decreases with age but is still detectable in the sixth decade. This small amount of brown fat has a minimal effect on energy expenditure.

**Nutritional Needs****Recommended Dietary Allowances and Dietary Reference Intakes**

The *Recommended Daily Allowances* (RDAs) define the average daily intakes that meet the nutrient needs of almost all healthy persons in a specific age and sex group.<sup>2</sup> The RDAs, which are periodically updated, have been published since 1941 by the National Academy of Sciences. The RDA is used in advising persons about the level of nutrient intake they need to decrease the risk of chronic disease.

The *Dietary Reference Intake* (DRI) includes a set of at least four nutrient-based reference values, each of which has specific uses: the RDA, the Adequate Intake, the Estimated Average Requirement, and the Tolerable Upper Intake Level.<sup>3</sup> The *United States RDA* (USRDA) was established for the purpose of labeling foods. It takes the highest recommended daily intake of each nutrient for children older than 4 years of age and for adults (excluding those pregnant or lactating); therefore, the USRDA sometimes provides a margin of nutritional safety higher than the RDA.

The *Adequate Intake* (AI) is set when there is not enough scientific evidence to estimate an average requirement. An *Estimated Average Requirement* is the intake that meets the estimated nutrient need of half of the persons in a specific group. The *Tolerable Upper Intake Level* is the maximum intake that is judged unlikely to pose a health risk in almost all healthy persons in a specific group. The DRIs are regularly reviewed and updated by the Food and Nutrition Board of the Institute of Medicine and the National Academy of Science.

Proteins, fats, carbohydrates, vitamins, and minerals each have their own function in providing the body with what it needs to maintain life and health. Recommended allowances have not been established for every nutrient; some are given as a safe and adequate intake, but others, such as carbohydrates and fats, are expressed as a percentage of the caloric intake.

**Calories**

Energy requirements are greater during growth periods. Infants require approximately 115 kcal/kg at birth, 105 kcal/kg at 1 year, and 80 kcal/kg of body weight between 1 to 10 years of age. During adolescence, boys require 45 kcal/kg of body weight and girls require 38 kcal/kg of body weight. During pregnancy, a woman needs an extra 300 kcal/day above her usual requirement, and during the first 3 months of breast-feeding, she requires an additional 500 kcal.<sup>2</sup> Table 29-1 can be used to predict the caloric requirements of healthy adults.

**TABLE 29-1** Caloric Requirements Based on Body Weight and Activity Level

	Sedentary	Moderate	Active
Overweight	20–25 kcal/kg	30 kcal/kg	35 kcal/kg
Normal	30 kcal/kg	35 kcal/kg	40 kcal/kg
Underweight	30 kcal/kg	40 kcal/kg	45–50 kcal/kg

(Adapted from Goodhart R.S., Shils M.E. [1980]. *Modern nutrition in health and disease* [6th ed.]. Philadelphia: Lea and Febiger)

### Proteins, Fats, and Carbohydrates

Proteins are required for growth and maintenance of body tissues, formation of enzymes and antibodies, fluid and electrolyte balance, and nutrient transport. Proteins are composed of amino acids, nine of which are essential to the body. These are leucine, isoleucine, methionine, phenylalanine, threonine, tryptophan, valine, lysine, and histidine. The foods that provide these essential amino acids in adequate amounts are milk, eggs, meat, fish, and poultry. Dried peas and beans, nuts, seeds, and grains contain all the essential amino acids but in less than adequate proportions. The proteins in these foods need to be combined with each other or with complete proteins to meet the amino acid requirements for protein synthesis.

Unlike carbohydrates and fats, which are composed of hydrogen, carbon, and oxygen, proteins contain 16% nitrogen; therefore, nitrogen excretion is an indicator of protein intake. If the amount of nitrogen taken in by way of protein is equivalent to the nitrogen excreted, the person is said to be in nitrogen balance. A person is in positive nitrogen balance when the nitrogen consumed by way of protein is greater than the amount excreted. This occurs during growth, pregnancy, or healing after surgery or injury. A negative nitrogen balance often occurs with fever, illness, infection, trauma, or burns, when more nitrogen is excreted than is consumed. It represents a state of tissue breakdown.

Dietary fats are composed primarily of triglycerides (*i.e.*, a mixture of fatty acids and glycerol). The fatty acids are saturated (*i.e.*, no double bonds), monounsaturated (*i.e.*, one double bond), or polyunsaturated (*i.e.*, two or more double bonds). The saturated fatty acids elevate blood cholesterol, whereas the monounsaturated and polyunsaturated fats lower blood cholesterol. Saturated fats usually are from animal sources and remain solid at room temperature. With the exception of coconut and palm oils (which are saturated), unsaturated fats are found in plant oils and usually are liquid at room temperature.

Dietary fats provide energy, serve as carriers for the fat-soluble vitamins, are precursors of prostaglandins, and are a source of fatty acids. The polyunsaturated fatty acid linoleic acid is the only fatty acid that is required. A deficiency of linoleic acid results in dermatitis. The daily requirement is 5 g or 1% to 2% of the total daily calories. Because vegetable oils are rich sources of linoleic acid, this level can be met by including two teaspoons of oil.

Other than the requirement for linoleic acid, there is no specific requirement for dietary fat, provided there is adequate nutrition available for energy. Fat is the most concentrated source

of energy. It is recommended that 30% or less of the calories in the diet should come from fats.

Cholesterol is the major constituent of cell membranes and is synthesized by the body. Cholesterol metabolism and transport are discussed in Chapter 15. The daily dietary recommendation for cholesterol is less than 300 mg.

Dietary carbohydrates are composed of simple sugars, complex carbohydrates, and undigested carbohydrates (*i.e.*, fiber). Within the body, carbohydrate is transformed into glucose, a six-carbon molecule. Excess glucose is stored as glycogen or converted to triglycerides for storage in fat cells. Because of their vitamin, mineral, and fiber content, it is recommended that the bulk of the carbohydrate content in the diet be in the complex form, rather than as simple sugars that contain few nutrients. Sucrose (*i.e.*, table sugar) is implicated in the development of dental caries.

There is no specific dietary requirement for carbohydrates. All of the energy requirements can be met by dietary fats and proteins. Although some tissues, such as the nervous system, require glucose as an energy source, this need can be met through the conversion of amino acids and the glycerol part of the triglyceride molecule to glucose. A carbohydrate-deficient diet usually results in the loss of tissue proteins and the development of ketosis. Because protein and fat metabolism increases the production of osmotically active metabolic wastes that must be eliminated through the kidneys, there is a danger of dehydration and electrolyte imbalances. The amount of carbohydrate needed to prevent tissue wasting and ketosis is 50 to 100 g/day. In practice, most of the daily energy requirement should be from carbohydrate. This is because protein is an expensive source of calories and because it is recommended that no more than 30% of the calories in the diet be derived from fat. The current recommendation is that the diet should provide 50% to 60% of the calories as carbohydrates.

### Vitamins and Minerals

Vitamins are a group of organic compounds that act as catalysts in various chemical reactions. A compound cannot be classified as a vitamin unless it is shown that a deficiency of it causes disease. Contrary to popular belief, vitamins do not provide energy directly. As catalysts, they are part of the enzyme systems required for the release of energy from protein, fat, and carbohydrates. Vitamins also are necessary for the formation of red blood cells, hormones, genetic materials, and the nervous system. They are essential for normal growth and development.

There are two types of vitamins: fat soluble and water soluble. The four fat-soluble vitamins are vitamins A, D, E, and K. The nine required water-soluble vitamins are thiamine, riboflavin, niacin, pyridoxine (Vitamin B<sub>6</sub>), pantothenic acid, vitamin B<sub>12</sub>, folic acid, biotin, and vitamin C. Because the water-soluble vitamins are excreted in the urine, it is less likely that they may become toxic to the body, but the fat-soluble vitamins are stored in the body, and they may reach toxic levels.

Minerals serve many functions. They are involved in acid-base balance and in the maintenance of osmotic pressure in body compartments. Minerals are components of vitamins, hormones, and enzymes. They maintain normal hemoglobin levels, play a role in nervous system function, and are involved in muscle contraction and skeletal development and maintenance. Minerals that are present in relatively large amounts in the body are called *macrominerals*. These include calcium,

phosphorus, sodium, chloride, potassium, magnesium, and sulfur. The remainder are classified as *trace minerals*; they include iron, manganese, copper, iodine, zinc, cobalt, fluorine, and selenium.

## Regulation of Food Intake and Energy Storage

Stability of the weight and body composition over time requires that energy intake matches energy utilization. Environmental, cultural, genetic, and psychological factors all influence food intake and energy expenditure. However, powerful physiological control systems also regulate hunger and food intake.<sup>1</sup>

### Hunger, Appetite, and Food Intake

The sensation of *hunger* is associated with several sensory perceptions, such as the rhythmic contractions of the stomach and that “empty feeling” in the stomach that stimulates a person to seek food. A person’s *appetite* is the desire for a particular type of food. It is useful in helping the person determine the type of food that is eaten. Satiety is the feeling of fullness or decreased desire for food.

The hypothalamus contains centers for hunger and satiety (Fig 29-1). It receives neural input from the gastrointestinal tract that provides information about stomach filling, chemical signals from the blood about the nutrients in food, and input from the cerebral cortex regarding the smell, sight, and taste of the food. Centers in the hypothalamus also control the secretion of several hormones (*e.g.*, thyroid and adrenocortical hormones) that regulate energy balance and metabolism.

The control of food intake can be divided into short-term regulation, which is concerned with the amount of food that is consumed at a meal or snack, and intermediate and long-term regulation, which is concerned with the maintenance of energy stores over time.<sup>1</sup>

The short-term regulation of food intake provides a person with the feeling of satiety and turns off the desire for eating when adequate food has been consumed. It requires rapid feedback mechanisms that signal the adequacy of food intake be-

fore digestion has taken place and nutrients have been absorbed into the blood. These mechanisms include receptors that monitor filling of the gastrointestinal tract, gastrointestinal tract hormones, and oral receptors that monitor food intake. Stretch receptors in the gastrointestinal tract monitor gastrointestinal filling and send inhibitory impulses by way of the vagus nerve to the feeding center to suppress the desire for food. The gastrointestinal hormone cholecystokinin, which is released in response to fat in the duodenum, has a strong suppressant effect on the feeding center. The presence of food in the stomach increases the release of insulin and glucagon, both of which suppress the neurogenic feeding signals from the brain.<sup>1</sup> The act of tasting, chewing, and swallowing also appears to suppress the feeling of hunger.

The intermediate and long-term regulation of food intake is determined by the amount of nutrients that are in the blood and in storage sites. It has long been known that a decrease in blood glucose causes hunger. In contrast, an increase in breakdown products of lipids such as ketoacids produces a decrease in appetite. The ketogenic weight-loss diet relies on the appetite suppressant effects of ketones in the blood. Recent evidence suggests that the hypothalamus also senses the amount of energy that is stored in fat cells through a hormone called *leptin*. Increased amounts of leptin are released from the adipocytes when fat stores are increased. The stimulation of leptin receptors in the hypothalamus produces a decrease in appetite and food intake as well as an increase in metabolic rate and energy consumption. It also produces a decrease in insulin release from the beta cells, which decreases energy storage in fat cells.

## Assessment of Energy Stores and Nutritional Status

Anthropometric measurements provide a means for assessing body composition, particularly fat stores and skeletal muscle mass. This is done by measuring height, weight, body circumferences, and thickness of various skinfolds. These measurements commonly are used to determine growth patterns in children and appropriateness of current weight in adults.

Body weight is the most frequently used method of assessing nutritional status; it should be used in combination with measurements of body height to establish whether a person is underweight or overweight.

*Relative weight* is the actual weight divided by the desirable weight and multiplied by 100. A relative weight greater than 120% is indicative of obesity. Recent changes in weight are probably a better indication of undernutrition than a low relative weight. An unintentional loss of 10% of body weight or more within the past 6 months usually is considered predictive of a poor clinical outcome, especially if weight loss is continuing.<sup>4</sup> The body mass index (BMI) uses height and weight to determine healthy weight (Table 29-2). It is calculated by dividing the weight in kilograms by the height in meters squared ( $BMI = \text{weight [kg]} / \text{height [m}^2\text{]}$ ). A BMI between 18.5 and 25 has the lowest statistical health risk.<sup>5</sup> A BMI of 25 to 29.9 is considered overweight; a BMI of 30 or greater as obese; and a BMI greater than 40 as very or morbidly obese.<sup>6</sup>

Body weight reflects both lean body mass and adipose tissue and cannot be used as a method for describing body composition or the percentage of fat tissue present. Statistically, the best percentage of body fat for men is between 12% and

TABLE 29-2

### Classification of Overweight and Obesity by BMI, Waist Circumference, and Associated Disease Risk\*

	BMI (kg/m <sup>2</sup> )	Obesity Class	Disease Risk* Relative to Normal Weight and Waist Circumference	
			Men ≤102 cm (≤40 in) Women ≤88 cm (≤35 in)	Men >102 cm (>40 in) Women >88 cm (>35 in)
Underweight	<18.5		—	—
Normal†	18.5–24.9		—	—
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very high
	35.0–39.9	II	Very high	Very high
Extreme obesity	≥40	III	Extremely high	Extremely high

BMI, body mass index.

\*Disease risk for type 2 diabetes, hypertension, and cardiovascular disease.

†Increased waist circumference also can be a marker for increased risk, even in persons of normal weight.

(Expert Panel. [1998]. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults. National Institutes of Health. [On-line.] Available: [http://nhlbi.nih.gov/guidelines/ob\\_gdlns.htm](http://nhlbi.nih.gov/guidelines/ob_gdlns.htm).)

20%, and for women, it is between 20% and 30%.<sup>7</sup> During physical training, body fat usually decreases and lean body mass increases.

Among the methods used to estimate body fat are skinfold thickness, body circumferences, bioelectrical impedance, computed tomography (CT), and magnetic resonance imaging (MRI). The measurement of *body circumferences*, most commonly waist and hip, provides an objective measurement of body fat and supplies the information needed to calculate the waist circumference to hip circumference. The measurement of body circumference has received attention because of an interest in excess visceral or intra-abdominal fat. The waist circumference is commonly used for this purpose.<sup>6</sup>

Bioelectrical impedance involves the use of electrodes attached to the wrist and ankles to send a harmless current through the body. The flow of the current is affected by the amount of water in the body. Because fat-free tissue contains virtually all the water and current-conducting electrolytes, measurements of the resistance (*i.e.*, impedance) can be used to estimate the percentage of body fat present.<sup>8</sup>

*Computed tomography* and *MRI* can be used to provide quantitative pictures from which the thickness of fat can be determined. CT scans also can be used to provide quantitative estimates of regional fat and give a ratio of intra-abdominal to extra-abdominal fat. Because these methods are costly, they usually are reserved for research studies.

Various laboratory tests can aid in evaluating nutritional status. Some of the most commonly performed tests are serum albumin to assess the protein status, total lymphocyte count and delayed hypersensitivity reaction to assess cellular immunity, and creatinine-height index to assess skeletal muscle protein.

**In summary,** nutritional status describes the condition of the body related to the availability and use of nutrients.

Metabolism is the organized process whereby nutrients such as carbohydrates, fats, and proteins are broken down, transformed, or otherwise converted to cellular energy. Glucose, fats, and amino acids from proteins serve as fuel sources for

cellular metabolism. These fuel sources are ingested during meals and stored for future use. Glucose is stored as glycogen or converted to triglycerides in fat cells for storage. Fats are stored in adipose tissue as triglycerides. Amino acids are the building blocks of proteins, and most of the stored amino acids are contained in body proteins and as fuel sources for cellular metabolism. Energy is measured in heat units called *kilocalories*. The RDA is the recommended daily allowance needed to meet the known nutritional needs of healthy persons.

Nutritional status reflects the continued daily intake of nutrients over time and the deposition and use of these nutrients in the body. When a person is consistently overfed, the excess energy is stored as fat, and the person gains weight. When energy expenditure exceeds food intake, body fat and other tissues are broken down, and the person loses weight. The nutritional status of a person can be assessed by evaluation of dietary intake, anthropometric measurements, health assessment, and laboratory tests. Anthropometric measurements are used for assessing body composition; they include height and weight measurements and measurements to determine the composition of the body in relation to lean body mass and fat tissue (*e.g.*, skinfold thickness, body circumferences, bioelectrical impedance, and CT scans).

## OVERNUTRITION AND OBESITY

Obesity is defined as a condition characterized by excess body fat. Clinically, obesity and overweight have been defined in terms of the BMI. Historically, various world organizations have used different BMI cutoff points to define obesity. In 1997, the World Health Organization defined the various classifications of overweight (BMI ≥ 25) and obesity (BMI ≥ 30). This classification system was subsequently adopted by the National Institutes of Health.<sup>6</sup> The use of a BMI cutoff of 25 as a measure of overweight raised some concern that the BMI in

some men might be attributable to muscle, rather than fat, weight. However, it has been shown that a BMI cutoff of 25 can sensitively detect most overweight people and does not erroneously detect overlean people.<sup>9</sup>

Overweight and obesity have become national health problems, increasing the risk of hypertension, hyperlipidemia, type 2 diabetes, coronary heart disease, and other health problems. Fifty-five percent of the U.S. population is estimated to be overweight (BMI  $\geq 25$ ). Obesity is particularly prevalent among some minority groups, lower income groups, and people with less education. The prevalence of obesity (BMI  $\geq 30$ ) in the United States has increased from 12.0% in 1991 to 17.9% in 1998.<sup>10</sup>

## Causes of Obesity

The excess body fat of obesity often significantly impairs health. This excess body fat is generated when the calories consumed exceed those expended through exercise and activity.<sup>11</sup> The physiologic mechanisms that lead to this imbalance are poorly understood. They probably exist in different combinations among obese persons.

Although factors that lead to the development of obesity are not understood, they are thought to involve the interaction of the person's genotype with environmental influences such as social, behavioral, and cultural factors.<sup>12</sup> Obesity is known to run in families, suggesting a hereditary component. The question that surrounds this observation is whether the disorder arises because of genetic endowment or environmental influences. Studies of twin and adopted children have provided evidence that heredity contributes to the disorder.<sup>13</sup> It is now believed that the heritability of the BMI is approximately 33%.<sup>14</sup>

Although genetic factors may explain some of the individual variations in terms of excess weight, environmental influences also must be taken into account. These influences include family dietary patterns, decreased level of activity because of labor-saving devices and time spent using the computer, re-

liance on the automobile for transportation, easy access to food, energy density of food, and large food portions. The obese may be greatly influenced by the availability of food, the flavor of food, time of day, and other cues. The composition of the diet also may be a causal factor, and the percentage of dietary fat independent of total calorie intake may play a part in the development of obesity. Psychological factors include using food as a reward, comfort, or means of getting attention. Eating may be a way to cope with tension, anxiety, and mental fatigue. Some persons may overeat and use obesity as a means of avoiding emotionally threatening situations.

## Types of Obesity

Two types of obesity based on distribution of fat have been described: upper body and lower body obesity. *Upper body obesity* is also referred to as *central, abdominal, or male obesity*. Lower body obesity is known as *peripheral, gluteal-femoral, or female obesity*. The obesity type is determined by dividing the waist by the hip circumference. A waist-hip ratio greater than 1.0 in men and 0.8 in women indicates upper body obesity (Fig. 29-2).<sup>15</sup> Research suggests that fat distribution may be a more important factor for morbidity and mortality than overweight or obesity.

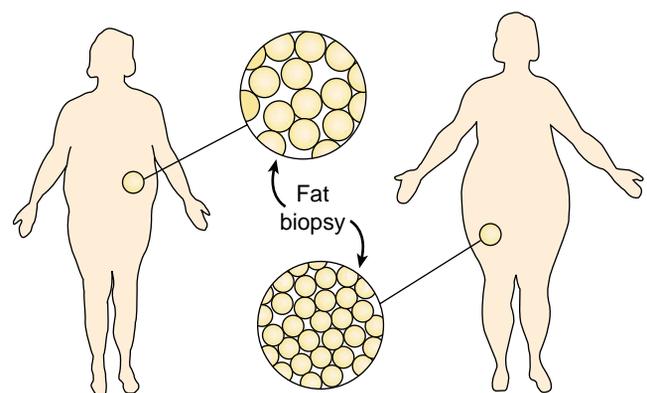
The presence of excess fat in the abdomen out of proportion to total body fat is an independent predictor of risk factors and mortality. Waist circumference is positively correlated with abdominal fat content. Waist circumference 35 inches or greater in women and 40 inches or greater in men has been associated with increased health risk<sup>6</sup> (see Table 29-2). Central obesity can be further differentiated into intra-abdominal, or visceral, fat and subcutaneous fat by the use of CT or MRI scans. However, intra-abdominal fat usually is synonymous with central fat distribution. One of the characteristics of intra-abdominal fat is that fatty acids released from the viscera go directly to the liver before entering the systemic circulation, having a potentially greater impact on hepatic function. Higher levels of circulating free fatty acids in obese persons, particularly those with upper body obesity, are thought to be associated with many of the adverse effects of obesity.<sup>11</sup>

In general, men have more intra-abdominal fat and women more subcutaneous fat. As men age, the proportion of intra-

### KEY CONCEPTS

#### OBESITY

- Obesity results from an imbalance between energy intake and energy consumption. Because fat is the main storage form of energy, obesity represents an excess of body fat.
- Overweight and obesity are determined by measurements of body mass index (BMI; weight [kg]/height [m<sup>2</sup>]) and waist circumference. A BMI of 25 to 29.9 is considered overweight; a BMI of 30 or greater, obese; and a BMI greater than 40, very or morbidly obese.
- Waist circumference is used to determine the distribution of body fat. Central, or abdominal, obesity is an independent predictor of morbidity and mortality associated with obesity.



■ **FIGURE 29-2** ■ Distribution of body fat and size of fat cells in persons with upper and lower body obesity. (Courtesy of Ahmed Kissebah, M.D., Ph.D., Medical College of Wisconsin, Milwaukee)

abdominal fat to subcutaneous fat increases. After menopause, women tend to acquire more central fat distribution. Increasing weight gain, alcohol, and low levels of activity are associated with upper body obesity. These changes place persons with upper body obesity at greater risk for ischemic heart disease, stroke, and death independent of total body fat. They also tend to exhibit hypertension, elevated levels of triglycerides and decreased levels of high-density lipoproteins, hyperinsulinemia and diabetes mellitus, breast and endometrial cancer, gallbladder disease, menstrual irregularities, and infertility. Visceral fat also is associated with abnormalities of metabolic and sex hormone levels.<sup>15</sup>

Weight reduction causes a loss of intra-abdominal fat and has resulted in improvements in metabolic and hormonal abnormalities.<sup>16</sup> In terms of weight reduction, some studies have shown that persons with upper body obesity are easier to treat than those with lower body obesity. Other studies have shown no difference in terms of success with weight reduction programs between the two types of obesity.

Weight cycling (the losing and gaining of weight) has been found to have little or no effect on metabolic variables, central obesity, or cardiovascular risk factors or future amount of weight loss.<sup>17</sup> More research is needed to determine its effect on dietary preference for fat, psychological adjustment, disordered eating, and mortality.

## Health Risks Associated With Obesity

Obese persons are more likely to have high blood pressure, hyperlipidemia, cardiovascular disease, glucose intolerance, insulin resistance, type 2 diabetes, stroke, gallbladder disease, infertility, and cancer of the endometrium, prostate, colon, and in postmenopausal women, the breast.<sup>6</sup> The increased weight associated with obesity stresses the bones and joints, increasing the likelihood of arthritis. Other conditions associated with obesity include sleep apnea and pulmonary dysfunction, nonalcoholic steatohepatitis, carpal tunnel syndrome, venous insufficiency and deep vein thrombosis, and poor wound healing.<sup>6</sup> Because some drugs are lipophilic and exhibit increased distribution in fat tissue, the administration of these drugs, including some anesthetic agents, can be more dangerous in obese persons. If surgery is required, the obese person tends to heal more slowly than a nonobese person of the same age.

Massive obesity, because of its close association with so many health problems, can be regarded as a disease in its own right.<sup>18</sup> It is the second leading cause of preventable death. In men who have never smoked, the risk of death increases from 1.06 at a BMI of 24.5 to 1.67 at a BMI higher than 26.<sup>19</sup>

## Prevention and Treatment

It has been theorized that obesity is preventable because the effect of hereditary factors is no more than moderate. A more active lifestyle together with a low-fat diet (<30% of calories) is seen as the strategy for prevention. The target audience should be young children, adolescents, and young adults.<sup>20</sup> Tools needed to achieve this goal include promotion of regular low-fat meals, avoidance of snacking, substitution of water for calorie-containing beverages, reduction of time spent in sedentary activities, such as television viewing, and an increase in ac-

tivity. Other high-risk periods are from 25 to 35 years, at menopause,<sup>20</sup> and the year after successful weight loss.

The goals for weight loss are, at a minimum, prevention of further weight gain, reduction of current weight, and maintenance of a lowered body weight indefinitely. An algorithm has been designed for use in treating overweight and obesity. The initial goal in treatment is to lower body weight by 10% from baseline during a 6-month period. This degree of weight loss requires a calorie reduction of 300 to 500 kcal/day in individuals with a BMI of 27 to 35. For those persons with a BMI greater than 35, the calorie intake needs to be reduced by 500 to 1000 kcal/day. After 6 months, the person should be given strategies for maintaining the new weight. The person who is unable to achieve significant weight loss should be enrolled in a weight management program to prevent further weight gain.

There are many ways to treat obesity. It is currently recommended that treatment should focus on lifestyle modification through a combination of a low-calorie diet, increased physical activity, and behavior therapy.<sup>6</sup>

Dietary therapy should be individually prescribed based on the person's overweight status and risk profile. The diet should be a personalized plan that is 300 to 1000 kcal/day less than the current dietary intake. If the patient's risk status warrants it, the diet also should be decreased in saturated fat and contain 30% or less of total calories from fat. Reduction of dietary fat without a calorie deficit will not result in weight loss.

Physical activity is important in the prevention of weight gain. In addition, it reduces cardiovascular and diabetes risk beyond that achieved by weight loss alone. Although physical activity is an important part of weight loss therapy, it does not lead to a significant weight loss. Exercise should be started slowly, with the duration and intensity increased independent of each other. The goal should be 30 minutes or more of moderate-intensity activity on most days of the week. The activity can be performed at one time or intermittently over the day.

Techniques for changing behavior include self-monitoring of eating habits and physical activity, stress management, stimulus control, problem solving, contingency management, cognitive restructuring, and social support.

Pharmacotherapy and surgery are available as an adjunct to lifestyle changes in individuals who meet specific criteria.<sup>21</sup> Pharmacotherapy is usually considered only after combined diet, exercise, and behavioral therapy has been in effect for a minimum of 6 months. Weight loss surgery is limited to persons with a BMI greater than 40; those with a BMI greater than 35 who have comorbid conditions and in whom efforts at medical therapy have failed; and those who have complications of extreme obesity.



## Childhood Obesity

Obesity is the most prevalent nutritional disorder affecting the pediatric population in the United States. The findings from the third National Health and Nutrition Examination Survey (NHANES III), conducted between 1988 and 1994, showed that 14% of children and 12% of adolescents were overweight.<sup>22</sup> The definition for overweight for the NHANES III study was a BMI at or above the sex- and age-specific 95th percentile. Another definition of overweight in children is a weight for height greater than 120% of ideal when controlled for age and sex.<sup>23</sup> Children who are 120% of weight expected for their

height are overweight, but they are only considered to have excess fat when the triceps skinfold thickness is greater than the 85th percentile. This distinction is important in preventing misdiagnosis of obesity and creating anxiety for the parents and the child.

The major concern of childhood obesity is that obese children will grow up to become obese adults. Health care providers are beginning to see hypertension, dyslipidemia, and type 2 diabetes in obese children and adolescents.<sup>24</sup> In addition, there is a growing concern that childhood and adolescent obesity may be associated with negative psychosocial consequences, such as low self-esteem and discrimination by adults and peers.<sup>25</sup>

Childhood obesity is determined by a combination of hereditary and environmental factors. It is associated with obese parents, higher socioeconomic status, increased parental education, small family size, and sedentary lifestyle.<sup>26</sup> Children with overweight parents are at highest risk; the risk for those with two overweight parents is much higher than for children in families in which neither parent is obese. One of the trends leading to childhood obesity is the increase in inactivity. Increasing perceptions that neighborhoods are unsafe has resulted in less time spent outside playing and walking and more time spent indoors engaging in sedentary activities, such as television viewing. Television viewing is associated with consumption of calorie-dense snacks and decreased indoor activity. Obese children also may have a deficit in recognizing hunger sensations, stemming perhaps from parents who use food as gratification.

Because adolescent obesity is predictive of adult obesity, treatment of childhood obesity is desirable. Weight loss without adverse health effects and maintenance of that loss are the goals. Each child should be assessed and treated individually. In young children who have mild to moderate weight problems, weight maintenance or a reduced rate of weight gain is sufficient. Studies indicate that physical activity in combination with diet therapy is more effective than diet therapy alone.

When weight loss is required, a loss of 1 pound per month is reasonable together with permanent changes in food consumption and activity. However, the focus should be on normalizing food intake, particularly fat intake, and increasing physical activity. If weight gain can be slowed or maintained during growth, lean body mass increases, and some of the abnormal metabolic effects of obesity may be reversed. Family members need to be involved so they can learn to provide appropriate support and assist the child in taking responsibility for his or her own actions. Highly restrictive diets should be limited to the rare child or adolescent who has morbid complications. They should not be used for children or adolescents with renal, liver, or cardiac disease. These diets should contain a minimum of 2 g protein/kg body weight.<sup>22</sup> There should be close monitoring for sustained nitrogen losses, cardiac dysrhythmias, and cholelithiasis. Commercial diets are not recommended.

**In summary,** obesity is defined as excess body fat resulting from the consumption of calories in excess of those expended for exercise and activities. Heredity, socioeconomic, cultural, and environmental factors, psychological influences, and activity levels have been implicated as causative factors in

the development of obesity. The health risks associated with obesity include hypertension and cardiovascular disease, hyperlipidemia, insulin resistance and type 2 diabetes mellitus, menstrual irregularities and infertility, cancer of the endometrium, breast, prostate, and colon, and gallbladder disease. There are two types of obesity—upper body and lower body obesity. Upper body obesity is associated with a higher incidence of complications. The treatment of obesity focuses on nutritionally adequate weight-loss diets, behavior modification, exercise, social support, and in situations of marked obesity, surgical methods. Obesity is the most prevalent nutritional disorder affecting the pediatric population in the United States.

## UNDERNUTRITION

Undernutrition ranges from the selective deficiency of a single nutrient to starvation in which there is deprivation of all ingested nutrients. Undernutrition can result from eating disorders; lack of food availability; or health problems that impair food intake and decrease its absorption and use. Weight loss and malnutrition are common during illness, recovery from trauma, and hospitalization.

The prevalence of malnutrition in children is substantial. Globally, nearly 195 million children younger than 5 years of age are undernourished.<sup>27</sup> Malnutrition is most obvious in developing countries of the world, where the condition takes severe forms. Even in developed nations, malnutrition remains a problem. In 1992, it was estimated that 12 million American children consumed diets that were significantly below the recommended allowances of the National Academy of Sciences.<sup>27</sup>

## Protein and Calorie Malnutrition

Malnutrition and starvation are conditions in which a person does not receive or is unable to use an adequate amount of calories and nutrients for body function. Among the many causes of starvation, some are willful, such as the person with anorexia nervosa who does not consume enough food to maintain weight and health, and some are medical, such as persons with Crohn's disease who are unable to absorb their food. Most cases of food deprivation result in semistarvation with protein and calorie malnutrition.

Protein-calorie malnutrition, also referred to as *marasmus*, is characterized by loss of muscle and fat stores. Marasmus is characterized by progressive wasting from inadequate food intake that is equally deficient in calories and protein. The person appears emaciated, with sparse, dry, and dull hair and depressed heart rate, blood pressure, and body temperature. The female experiences anovulation and amenorrhea, and the male experiences decreased testicular function. The child with marasmus has a wasted appearance, with stunted growth and loss of subcutaneous fat, but with relatively normal skin, hair, liver function, and affect.

Kwashiorkor is caused by protein deficiency. The term *kwashiorkor* comes from the African word meaning "the disease suffered by the displaced child," because the condition devel-

ops soon after a child is displaced from the breast after the arrival of a new infant and placed on a starchy gruel feeding. The child with kwashiorkor is characterized by edema, desquamating skin, discolored hair, enlarged abdomen, anorexia, and extreme apathy. The serum albumin level is less than 3.0 g/dL, and there is pitting edema of the extremities. There is less weight loss and wasting of skeletal muscles than in marasmus. Other manifestations include skin lesions, easily pluckable hair, enlarged liver and distended abdomen, cold extremities, and decreased cardiac output and tachycardia.

Marasmus-kwashiorkor is an advanced protein-calorie deficit together with increased protein requirement or loss. This results in a rapid decrease in anthropometric measurements with obvious edema and wasting and loss of organ mass.

### Malnutrition and Wasting in Illness

Malnutrition and wasting are common in persons with trauma, sepsis, and serious illnesses such as cancer and acquired immunodeficiency syndrome. Approximately half of all persons with cancer experience tissue wasting in which the tumor induces metabolic changes, leading to a loss of adipose tissue and muscle mass.<sup>28</sup> In healthy adults, body protein homeostasis is maintained by a cycle in which the net loss of protein in the postabsorptive state is matched by a net postprandial gain of protein.<sup>29</sup> In persons with severe injury or illness, net protein breakdown is accelerated and protein rebuilding disrupted. Consequently, these persons may lose up to 20% of body protein, much of which originates in skeletal muscle.<sup>29</sup> Protein mass is lost from the liver, gastrointestinal tract, kidneys, and heart. As protein is lost from the liver, hepatic synthesis of serum proteins decreases and decreased levels of serum proteins are observed. There is a decrease in immune cells and those needed for wound healing. The lungs are affected primarily by weakness and atrophy of the respiratory muscles. The gastrointestinal tract undergoes mucosal atrophy with loss of villi in the small intestine, resulting in malabsorption. The loss of protein from cardiac muscle leads to a decrease in myocardial contractility and cardiac output.

In hospitalized patients, malnutrition increases morbidity and mortality rates, incidence of complications, and length of stay. Malnutrition may present at the time of admission or develop during hospitalization. The hospitalized patient often finds eating a healthful diet difficult and commonly has restrictions on food and water intake in preparation for tests and surgery. Pain, medications, special diets, and stress can decrease appetite. Even when the patient is well enough to eat, being alone in a room where unpleasant treatments may be given is not conducive to eating. Although hospitalized patients may appear to need fewer calories because they are on bed rest, their actual need for caloric intake may be higher because of other energy expenditures. For example, more calories are expended during fever, when the metabolic rate is increased. There also may be an increased need for protein to support tissue repair after trauma or surgery.

### Treatment

The treatment of severe protein-calorie malnutrition involves the use of measures to correct fluid and electrolyte abnormalities and replenish proteins, calories, and micronutrients.<sup>30</sup> Treatment is started with modest quantities of proteins and calories based on the person's actual weight. Concurrent ad-

ministration of vitamins and minerals is needed. Either the enteral or parenteral route can be used. The treatment should be undertaken slowly to avoid complications. The administration of water and sodium with carbohydrates can overload a heart that has been weakened by malnutrition and result in congestive failure. Enteral feedings can result in malabsorptive symptoms caused by abnormalities in the gastrointestinal tract. Refeeding edema is benign dependent edema that results from renal sodium reabsorption and poor skin and blood vessel integrity. It is treated by elevation of the dependent area and modest sodium restrictions. Diuretics are ineffective and may aggravate electrolyte deficiencies.

### Eating Disorders

Eating disorders affect an estimated 5 million Americans each year.<sup>31</sup> These illnesses, which include anorexia nervosa, bulimia nervosa, and binge-eating disorder and their variants, incorporate serious disturbances in eating, such as restriction of intake and bingeing, with an excessive concern over body shape or body weight. Eating disorders typically occur in adolescent girls and young women, although 5% to 15% of cases of anorexia nervosa and 40% of cases of binge-eating disorder occur in boys and men.<sup>31</sup> The mortality rate associated with anorexia nervosa, 0.56% per year, is more than 12 times the mortality rate among young women in the general population.<sup>31</sup>

Eating disorders are more prevalent in industrialized societies and occur in all socioeconomic and major ethnic groups. A combination of genetic, neurochemical, developmental, and sociocultural factors is thought to contribute to the development of the disorders. The American Psychiatric Society's

#### KEY CONCEPTS

##### EATING DISORDERS

- Eating disorders are serious disturbances in eating, such as willful restriction of intake and binge eating, as well as excessive concern over body weight and shape.
- Anorexia nervosa is characterized by a refusal to maintain a minimally normal body weight (*e.g.*, at least 85% of minimal expected weight); an excessive concern over gaining weight and how the body is perceived in terms of size and shape; and amenorrhea (in girls and women after menarche).
- Bulimia nervosa is characterized by recurrent binge eating; inappropriate compensatory behaviors, such as self-induced vomiting, fasting, or excessive exercise that follow the binge-eating episode; and extreme concern over body shape and weight.
- Binge eating consists of consuming unusually large quantities of food during a discrete period (*e.g.*, within any 2-hour period) along with a lack of control over the binge-eating episode.

*Diagnostic and Statistical Manual of Mental Disorders, Text Revision* (DSM-IV-TR) has established criteria for the diagnosis of anorexia nervosa and bulimia nervosa.<sup>32</sup> Although these criteria allow clinicians to make a diagnosis in persons with a specific eating disorder, the symptoms often occur along a continuum between those of anorexia nervosa and bulimia nervosa. Preoccupation with weight and excessive self-evaluation of weight and shape are common to both disorders, and persons with eating disorders may demonstrate a mixture of both disorders.<sup>32</sup> The female athlete triad, which includes disordered eating, amenorrhea, and osteoporosis, does not meet the strict DSM-IV-TR criteria for anorexia nervosa or bulimia nervosa but shares many of the characteristics and therapeutic concerns of the two disorders (see Chapter 43). Persons with eating disorders may require concomitant evaluation for psychiatric illness because eating disorders often are accompanied by mood, anxiety, and personality disorders. Suicidal behavior may accompany anorexia nervosa and bulimia nervosa and should be excluded.<sup>31</sup>

### Anorexia Nervosa

Anorexia nervosa was first described in the scientific literature more than 100 years ago by Sir William Gull.<sup>33</sup> The DSM-IV-TR diagnostic criteria for anorexia nervosa are (1) a refusal to maintain a minimally normal body weight for age and height (*e.g.*,  $\leq 85\%$  of minimal expected weight or  $\text{BMI} \geq 17.5$ ); (2) an intense fear of gaining weight or becoming fat; (3) a disturbance in the way one's body size, weight, or shape is perceived; and (4) amenorrhea (in girls and women after menarche).<sup>32</sup> Anorexia nervosa is more prevalent among young women than men. The disorder typically begins in teenage girls who are obese or perceive themselves as being obese. An interest in weight reduction becomes an obsession, with severely restricted caloric intake and frequently with excessive physical exercise. The term *anorexia*, meaning "loss of appetite," is a misnomer because hunger is felt but in this case is denied.

Many organ systems are affected by the malnutrition that occurs in persons with anorexia nervosa. The severity of the abnormalities tends to be related to the degree of malnutrition and is reversed by refeeding. The most frequently occurring complication of anorexia is amenorrhea and loss of secondary sex characteristics with decreased levels of estrogen, which can eventually lead to osteoporosis. Bone loss can occur in young women after as short a period of illness as 6 months.<sup>31</sup> Symptomatic compression fractures and kyphosis have been reported. Constipation, cold intolerance and failure to shiver in cold, bradycardia, hypotension, decreased heart size, electrocardiographic changes, blood and electrolyte abnormalities, and skin with lanugo (*i.e.*, increased amounts of fine hair) are common. Unexpected sudden deaths have been reported; the risk appears to increase as weight drops to less than 35% to 40% of ideal weight. It is believed that these deaths are caused by myocardial degeneration and heart failure, rather than dysrhythmias.

The most exasperating aspect of the treatment of anorexia is the inability of the person with anorexia to recognize there is a problem. Because anorexia is a form of starvation, it can lead to death if left untreated. A multidisciplinary approach appears to be the most effective method of treating persons with the disorder.<sup>34,35</sup> The goals of treatment are eating and weight gain,

resolution of issues with the family, healing of pain from the past, and efforts to work on psychological, relationship, and emotional issues.

### Bulimia Nervosa and Binge Eating

Bulimia nervosa and binge eating are eating disorders that encompass an array of distinctive behaviors, feelings, and thoughts. Binge eating is characterized by the consumption of an unusually large quantity of food during a discrete time along with lack of control over the binge-eating episode. Bulimia nervosa is a condition of recurrent binge eating that is accompanied by purging, excessive exercise, or fasting.

**Bulimia Nervosa.** Bulimia nervosa is 10 times more common in women than men; it usually begins between 13 and 20 years of age, and affects as many as 3% of young women.<sup>36</sup> The DSM-IV-TR criteria for bulimia nervosa are (1) recurrent binge eating (at least two times per week for 3 months); (2) inappropriate compensatory behaviors, such as self-induced vomiting, abuse of laxatives or diuretics, fasting, or excessive exercise that follow the binge-eating episode; (3) self-evaluation that is unduly influenced by body shape and weight; and (4) a determination that the eating disorder does not occur exclusively during episodes of anorexia nervosa.<sup>32</sup> The diagnostic criteria for bulimia nervosa now include subtypes to distinguish patients who compensate by purging (*e.g.*, vomiting or abuse of laxatives or diuretics) and those who use non-purging behaviors (*e.g.*, fasting or excessive exercise). The disorder may be associated with other psychiatric disorders, such as substance abuse.<sup>31,36</sup>

The complications of bulimia nervosa include those resulting from overeating, self-induced vomiting, and cathartic and diuretic abuse. Among the complications of self-induced vomiting are dental disorders, parotitis, and fluid and electrolyte disorders. Dental abnormalities, such as sensitive teeth, increased dental caries, and periodontal disease, occur with frequent vomiting because the high acid content of the vomitus causes tooth enamel to dissolve. Esophagitis, dysphagia, and esophageal stricture are common. With frequent vomiting, there often is reflux of gastric contents into the lower esophagus because of relaxation of the lower esophageal sphincter. Vomiting may lead to aspiration pneumonia, especially in intoxicated or debilitated persons. Potassium, chloride, and hydrogen are lost in the vomitus, and frequent vomiting predisposes to metabolic alkalosis with hypokalemia (see Chapter 6). An unexplained physical response to vomiting is the development of benign, painless parotid gland enlargement.

The weights of persons with bulimia nervosa may fluctuate, although not to the dangerously low levels seen in anorexia nervosa. Their thoughts and feelings range from fear of not being able to stop eating to a concern about gaining too much weight. They also experience feelings of sadness, anger, guilt, shame, and low self-esteem.

Treatment strategies include psychological and pharmacologic treatments. Unlike persons with anorexia nervosa, persons with bulimia nervosa or binge eating are upset by the behaviors practiced and the thoughts and feelings experienced, and they are more willing to accept help. Pharmacotherapeutic agents include the tricyclic antidepressants (*e.g.*, desipramine, imipramine), the selective serotonin re-

uptake inhibitors (e.g., fluoxetine), and other antidepressant medications.<sup>36</sup>

**Binge Eating.** Binge eating is characterized by recurrent episodes of binge eating at least 2 days per week for 6 months and at least three of the following: (1) eating rapidly; (2) eating until becoming uncomfortably full; (3) eating large amounts when not hungry; (4) eating alone because of embarrassment; and (5) disgust, depression, or guilt because of eating episodes.<sup>31,34,36</sup>

The primary goal of therapy for binge-eating disorders is to establish a regular, healthful eating pattern. Persons with binge-eating disorders who have been successfully treated for their eating disorder have reported that making meal plans, eating a balanced diet at three regular meals a day, avoiding high-sugar foods and other binge foods, recording food intake and binge-eating episodes, exercising regularly, finding alternative activities, and avoiding alcohol and drugs are helpful in maintaining their more healthful eating behaviors after treatment.

**In summary,** undernutrition can range from a selective deficiency of a single nutrient to starvation in which there is deprivation of all ingested nutrients. Malnutrition and starvation are among the most widespread causes of morbidity and mortality in the world. Malnutrition is common during illness, recovery from trauma, and hospitalization. The effects of malnutrition and starvation on body function are widespread. They include loss of muscle mass, impaired wound healing, impaired immunologic function, decreased appetite, loss of calcium and phosphate from bone, anovulation and amenorrhea in women, and decreased testicular function in men.

Anorexia nervosa, bulimia nervosa, and binge eating are eating disorders that result in malnutrition. In anorexia nervosa, distorted attitudes about eating lead to serious weight loss and malnutrition. Bulimia nervosa is characterized by secretive episodes or binges of eating large quantities of easily consumed, high-caloric foods, followed by compensatory behaviors such as fasting, self-induced vomiting, or abuse of laxatives or diuretics. Binge-eating disorder is characterized by eating large quantities of food but is not accompanied by purging and other inappropriate compensatory behaviors seen in persons with bulimia nervosa.

## REVIEW QUESTIONS

- Define *calorie* and state the number of calories derived from the oxidation of 1 g of protein, fat, or carbohydrate.
- State the purpose of the Recommended Dietary Allowance of calories, proteins, fats, carbohydrates, vitamins, and minerals.
- State the factors used in determining body mass index and explain its use in evaluating body weight in terms of undernutrition and overnutrition.
- Define and discuss the causes of obesity and health risks associated with obesity.
- Explain the effect of malnutrition on muscle mass, respiratory function, acid-base balance, wound healing, immune function,

bone mineralization, the menstrual cycle, and testicular function.

- Compare the eating disorders and complications associated with anorexia nervosa and the binge-purge syndrome.



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