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Chapter 10

Overweight and Obesity

Len Kravitz

Epidemiology of the Epidemic

Worldwide projections by the World Health Organization (WHO) indicate that 1.5 billion people age 20 years or older are overweight, with approximately 500 million of them obese (WHO, 2011). Some contributing factors to this epidemic can be credited largely to the progression from a rural lifestyle to a highly technological urban existence, and the tempting capacity of the modern environment to encourage individuals to eat more and move less. Almost all countries are experiencing this dramatic increase in overweight and obesity. The WHO further estimates that by 2015, approximately 2.3 billion adults will be overweight and more than 700 million will be obese.

Excess body weight is associated with an increased likelihood to develop heart disease, hypertension, type 2 diabetes, gallstones, breathing problems, musculoskeletal disabilities, and certain forms of cancer (endometrial, breast, and colon) [National Institutes of Health (NIH), 2007]. It is also associated with reduced life expectancy and early mortality [American College of Sports Medicine (ACSM), 2010]. In addition, obesity has a deleterious effect on the economy of all countries, as it increases the associated costs for treating the related diseases.

Overview of Overweight and Obesity—The Causes

Ultimately, the primary reason for overweight and obesity is a positive energy balance, wherein intake (via calories consumed from food and beverages) is greater than output (energy expenditure from resting metabolism, physical activity, and exercise) (ACSM, 2010). Energy balance occurs when energy intake equals energy output, while a negative energy balance exists when energy output exceeds energy intake, resulting in weight loss. The human genome has evolved from times when shelter and food were in short supply and famine was a constant threat to life (Loos & Bouchard, 2003). In addition, major amounts of physical exertion were once necessary to obtain food and cope with harsh living environments. Therefore, humans have evolved an outstanding ability to biologically function with great energy efficiency by storing large amounts of excess fat as adipose tissue. In modern society, many people spend hours every day watching TV, playing video games, using computers, doing schoolwork, and adopting other sedentary leisure behaviors. In fact, more than two hours a day of regular TV viewing has been linked to overweight and obesity (NIH, 2007). It is important to also note the existence of obesity disorders such as hypothyroidism, Prader-Willi syndrome, and Cushing’s syndrome. With these diseases, metabolic and/or hormonal dysfunctions or impairment contribute to obesity.

An abundance of food may be a by-product of the success of a society, but it clearly creates the conditions for a positive energy balance in the modern lifestyle. Other environmental factors contributing to obesity include not having enough sidewalks, trails, parks, and affordable fitness facilities for all people. Restaurants, fast-food chains, and movie theaters compete for business by offering very large food portions. In addition, healthy food choices are more expensive, making access to these foods less of an option for the financially
challenged. And food companies that encourage people of all ages to select high-calorie, high-fat snacks and sugary drinks dominate food advertising.

Overweight and obesity tend to run in families (NIH, 2007). A person’s genes may affect the amount of fat he or she stores in the body, as well as where the fat is stored (NIH, 2007). It is well established that fat-site deposition is highly linked to a person’s relative health risk. Fat deposited in the hips and thighs, referred to as gluteofemoral or gynoid fat (more often observed in females), appears to be quite benign and metabolically inactive. On the other hand, fat found in the trunk area around the internal organs of the abdomen (often observed in men) is referred to as android or visceral fat. Excess visceral fat is correlated with hypertension, diabetes, high blood triglycerides and coronary heart disease. It is interesting to observe that with exercise, it is the visceral fat that is often the first to disappear.

Familial factors also contribute to the prevalence of overweight and obesity. For example, families commonly share eating and physical-activity habits. Children tend to adopt the habits of their parents. So, a child with overweight parents who are inactive and eat high-calorie meals may become overweight like the parents. However, if a family adopts healthful food and physical-activity habits, the child’s chance of being overweight are reduced (NIH, 2007).

The Biology of Overweight and Obesity

Fat tissue, for the most part, was once understood to be an extra layer of cushioning with few metabolic responsibilities. It was viewed and described like a balloon that inflates when a person eats more food and expends fewer calories, and deflates when there is greater physical activity and less food consumption. More recent research reveals that fat tissue (composed of adipocyte cells that specialize in fat storage) functions like other endocrine organs (i.e., glands that secrete hormones) in the body, sending signals to the brain that affect several intricate physiological mechanisms of energy-expenditure regulation, insulin sensitivity, and fat and carbohydrate metabolism (Trayhurn, 2005).

Two key hormones related to energy metabolism regulation are leptin and adiponectin, while a host of other hormones are involved in immune reactions in the body.

**Leptin**

Leptin, which resides in all fat cells, communicates directly with the hypothalamus in the brain, providing information about how much energy is currently stored in the body’s fat cells. Leptin functions in what is referred to in biology as a negative feedback loop. For example, when fat cells decrease in size, leptin decreases, sending a message to the hypothalamus to direct the body to eat more. Similarly, when fat cells increase in size, leptin increases and the message sent to the hypothalamus is to instruct the body to eat less. However, it appears that the primary biological role of leptin is to facilitate energy intake when energy storage is low, as opposed to slowing down overconsumption when energy storage is high (Havel, 2002). Leptin production is chiefly regulated by insulin-induced changes in fat-cell metabolism. Havel notes that the consumption of fat (and fructose) actually results in lower circulating leptin levels, which can lead to overeating and weight gain. Thus, diet and, more specifically, intake of foods high in fat and fructose may have a direct connection with weight gain. Scientific attempts to take leptin as a pill have not shown any benefit for the overweight, possibly because the digestion process changes the synthetic form of leptin’s structure and function.

**Adiponectin**

Another specialized hormone secreted by fat is adiponectin, which is referred to as “the good-guy” hormone (Liebman, 2004). Adiponectin helps insulin by sending blood glucose into the body’s cells for storage or use as fuel, thus increasing the cells’ insulin sensitivity or glucose metabolism (Havel, 2002). It also helps decrease blood levels of triglycerides by working with insulin to stimulate fat breakdown. If a person has a lot of body fat, then he or she typically will have lower levels of adiponectin, which is predictably low in all
overweight individuals and especially low in individuals with insulin resistance.

Insulin resistance occurs when the normal amount of insulin secreted by the pancreas is not able to transport glucose into cells. To maintain a normal blood glucose level, the pancreas secretes additional insulin. In some people, when the body cells resist, or do not respond to even high levels of insulin, glucose builds up in the blood, resulting in high blood glucose, which may lead to type 2 diabetes. Even people with diabetes who take medications to control their blood glucose levels can have higher than normal blood insulin levels due to insulin resistance.

**Immune Hormones**

It is known that fat tissue produces a number of immune-system hormones, such as tumor necrosis factor-alpha, interleukin-6, plasminogen activator inhibitor 1, angiotensin II, and other cytokines (Havel, 2002). Cytokines, which are hormone-like proteins, function largely as inflammatory proteins, reacting to areas of infection or injury in the body. However, persons with excess fat appear to have an overreaction in terms of the release of these inflammatory proteins. It has been proposed that this is caused by the low oxygen content in the clusters of adipocytes, which are somewhat distant from the tissues’ vascular supply (Trayhurn, 2005). The concept of inflammation is one of the most critical in obesity biology. Both obesity and diabetes are associated with chronic low-grade inflammation (Trayhurn, 2005). In addition, inflammation is understood to be a key facet in heart disease. The release of these inflammatory proteins may inflame arterial plaque, causing the plaque to rupture and thus lead to a heart attack or stroke (Liebman, 2004). Trayhurn (2005) notes that with weight loss there is a corresponding decrease in the circulating levels of these inflammatory proteins. Trayhurn also notes that these fat tissue–derived inflammatory hormones may play a causal role in the development of insulin resistance.

**Ghrelin**

Another component of the energy reserve regulation in the body involves some of the hormones that control feeding and appetite, which are located in the gastrointestinal tract. Specific hunger signals trigger eating, while satiety messages reduce appetite. These distinctive hormones are often referred to as the “gut hormones,” one of which—ghrelin—has been proposed to be particularly associated with obesity (Druce, Small, & Bloom, 2005). Ghrelin, secreted by the stomach, plays a chief role in appetite regulation. It is recognized as the “hunger hormone” and has garnered much attention in the research due to its role in the prevalence of obesity.

Working in a positive feedback loop, high levels of ghrelin during a fasted state promote increased food intake, while lower levels of ghrelin are observed after eating a meal. However, when obese individuals lose weight, it often results in an elevation of ghrelin, thereby promoting food intake, which may be a physiological reason why dieters have so much difficulty maintaining their newfound weight. In addition, it appears that food consumption does not suppress ghrelin levels in obese individuals, again contributing to overeating.

**Peptide YY**

When the body feels that it has eaten enough, the hormone peptide YY (and other satiety hormones, such as cholecystokinin and glucagon-like peptide-1) is released from the intestines. It is particularly stimulated by lipids and carbohydrates (Druce, Small, & Bloom, 2005). This gut hormone is thought to work with the central nervous system to regulate the cessation of appetite. Thus, when released, it provides a feeling of satiety (Druce, Small, & Bloom, 2005).

**The Sleep–Obesity Connection**

It appears that less sleep is highly associated with weight gain (Taheri et al., 2004). People who report regularly sleeping less than seven hours a night, for example, are much more likely to gain weight compared to people who sleep seven to eight hours a night. Those persons who sleep less tend to eat foods that are higher in calories. Hormones, such as leptin, insulin, and ghrelin, are released during sleep to control the body’s use of foodstuffs. For example, insulin controls the rise and fall of blood sugar levels during sleep.
People who do not get enough sleep have insulin and blood sugar levels that are similar to those in people who are likely to have diabetes. Taheri and colleagues (2004) note that people who do not get enough sleep on a regular basis seem to have high levels of ghrelin (causing hunger) and low levels of leptin (increasing eating).

**Diagnostic Testing of Overweight and Obesity**

Body mass index (BMI) is a simple height–weight index that is commonly used for classifying overweight and obesity in adult populations and individuals:

\[ \text{BMI} = \frac{\text{body weight (kg)}}{\text{height}^2 \, (\text{m})} \]

However, BMI should only be considered as a useful guide, because it may not correspond to the same degree of fatness in different individuals. For example, BMI does not discriminate between lean mass and fat mass and therefore tends to overestimate body fatness in athletic, heavily muscled individuals. The WHO defines overweight as a BMI ≥25 kg/m² and obesity as a BMI ≥30 kg/m². These cutoff points provide a benchmark for individual assessment. The WHO is currently developing international growth reference charts for school-age children and adolescents. The Centers for Disease Control and Prevention (CDC) has created BMI charts broken down by age and sex and designed for children and adolescents (www.cdc.gov).

An ACE-certified Advanced Health & Fitness Specialist (ACE-AHFS) can also utilize waist circumference to establish health risk. This measurement is made at the narrowest part of the torso between the ribs and iliac crest. The National Cholesterol Education Program (NCEP, 2002) recommends using a waist circumference ≥40 inches (102 cm) for men and ≥35 inches (89 cm) for women as the risk factor threshold for obesity-related metabolic diseases (such as diabetes and insulin resistance) and coronary heart disease.

Another tool for health-risk assessment is the **waist-to-hip ratio**, which is the circumference of the waist divided by the circumference of the hips. This measurement can be taken in inches or centimeters. To determine if a client has a healthy waist-to-hip ratio, the ACE-AHFS can use a measuring tape to determine the smallest part of the waist (usually above the belly button and below the rib cage) and the largest part of the hips (Figures 10-1 and 10-2). The measuring tape must be horizontal all the way around the body when taking a measurement. When measuring the hip circumference, the ACE-AHFS should have the
client stand with his or her feet together. The standards for risk vary with age and sex (Table 10-1).

There are also a variety of assessment methods that can be used to determine a person’s body fatness, such as skinfold testing, hydrostatic weighing, bioelectrical impedance analysis (BIA), infrared interactance, computed tomography, magnetic resonance imaging (MRI), and dual-energy x-ray absorptiometry (DEXA). Women generally have a higher percentage of body fat than men (Table 10-2).

### Table 10-1
**Waist-to-Hip Ratio—High and Very High Risk Norms for Men and Women**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>High Risk</th>
<th>Very High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29</td>
<td></td>
<td>0.89–0.94</td>
<td>&gt;0.94</td>
</tr>
<tr>
<td>30–39</td>
<td></td>
<td>0.92–0.96</td>
<td>&gt;0.96</td>
</tr>
<tr>
<td>40–49</td>
<td></td>
<td>0.96–1.00</td>
<td>&gt;1.00</td>
</tr>
<tr>
<td>50–59</td>
<td></td>
<td>0.97–1.02</td>
<td>&gt;1.02</td>
</tr>
<tr>
<td>60–69</td>
<td></td>
<td>0.99–1.03</td>
<td>&gt;1.03</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29</td>
<td></td>
<td>0.78–0.82</td>
<td>&gt;0.82</td>
</tr>
<tr>
<td>30–39</td>
<td></td>
<td>0.79–0.84</td>
<td>&gt;0.84</td>
</tr>
<tr>
<td>40–49</td>
<td></td>
<td>0.80–0.87</td>
<td>&gt;0.87</td>
</tr>
<tr>
<td>50–59</td>
<td></td>
<td>0.82–0.88</td>
<td>&gt;0.88</td>
</tr>
<tr>
<td>60–69</td>
<td></td>
<td>0.84–0.90</td>
<td>&gt;0.90</td>
</tr>
</tbody>
</table>


show that a 5 to 10% loss of initial body weight is associated with meaningful improvements in cholesterol levels, hypertension, and glucose metabolism (Fabricatore & Wadden, 2003). In fact, Fabricatore and Wadden (2003) note that the Diabetes Prevention Program study showed that a four-year lifestyle intervention of physical activity and diet designed to induce a loss of 7% in body weight resulted in experimental subjects having a 58% lowered risk of developing type 2 diabetes as compared to a control group (Diabetes Prevention Program Research Group, 2002). This preventive effect was seen to hold for members of all racial, ethnic, and gender groups in this 3200-subject study. Fabricatore & Wadden (2003) affirm that the guidelines from the NHLBI and the North American Association for the Study of Obesity indicate that the three lifestyle-modification components of a successful obesity treatment program are dietary intervention, behavioral therapy, and physical activity.

### The Treatment of Obesity

Losing weight, and then maintaining the weight loss, is often very difficult due to the multifactorial nature of obesity. It is compelling to point out that small changes in body weight result in health benefits. Studies show that a 5 to 10% loss of initial body weight is associated with meaningful improvements in cholesterol levels, hypertension, and glucose metabolism (Fabricatore & Wadden, 2003). In fact, Fabricatore and Wadden (2003) note that the Diabetes Prevention Program study showed that a four-year lifestyle intervention of physical activity and diet designed to induce a loss of 7% in body weight resulted in experimental subjects having a 58% lowered risk of developing type 2 diabetes as compared to a control group (Diabetes Prevention Program Research Group, 2002). This preventive effect was seen to hold for members of all racial, ethnic, and gender groups in this 3200-subject study. Fabricatore & Wadden (2003) affirm that the guidelines from the NHLBI and the North American Association for the Study of Obesity indicate that the three lifestyle-modification components of a successful obesity treatment program are dietary intervention, behavioral therapy, and physical activity.

### Lifestyle Modification

Lifestyle modification refers to changes being made that represent an overall change in the way a person lives his or her life. All too often, individuals view a weight-loss program as an isolated period of time during which a person goes on a diet, takes exercise classes, or employs a personal...
trainer to get in shape. Others may attempt diet strategies with very unrealistic expectations for weight loss, and then give up when these hopes are not met. It is important to remind clients that they are truly establishing a new way of life, not just a temporary quick fix for some loss of weight. In addition, it is important to emphasize to clients the overall health benefits of increasing physical activity and incorporating a balanced approach to eating and meal planning. These changes can improve the quality of their lives and reduce the risks of developing coronary heart disease, hypertension, colon cancer, and diabetes, while also improving their mental well-being and musculoskeletal function in activities of daily living (ADL) (Kravitz, 2007).

**Dietary Intervention**

Over the past five decades, there has been a remarkable increase in the types of popular diets. Many clients will have tried, with no sustained success, two or more fad diets by the time they begin to work with an ACE-AHFS. The ACE-AHFS may choose to work with nutrition professionals on dietary interventions for some clients. In essence, the goal of the weight-loss dietary intervention is to keep the dietary content nutritionally adequate for health concerns, while introducing simple ways of reducing calorie intake. As acknowledged earlier, modern society has influenced food consumption so dramatically that the attainment of this goal can be easily sabotaged. Evidence suggests that low- and moderate-fat, calorie-restricted diets promote weight loss and are nutritionally sound, and that similar substantiation is lacking for high-protein, high-fat, and low-carbohydrate weight-loss approaches (Boucher, Shafer, & Chaffin, 2001). According to Jakicic and colleagues (2009), absolute dietary energy intake should be adjusted based on body weight to elicit an energy deficit of 500 to 1000 kcal per day. With this deficit, a minimum weight loss of 1 to 2 pounds (0.5 to 1.0 kg) per week is realistic. In addition, ACSM (2006) recommends reducing dietary fat intake to <30% of total energy intake. The NIH (2007) suggests a healthy eating plan that includes the following healthful foods:

- Fruits, which can be canned (in juice or water), fresh, frozen, or dried
- Vegetables, which can be canned (without salt), fresh, frozen, or dried
- Fat-free and low-fat milk and milk products such as low-fat yogurt and cheese
- Lean meat, poultry, fish, lentils, and beans
- Whole-grain foods such as oatmeal, brown rice, bagels, bread, pasta, cereal, tortillas, and crackers
- Canola or olive oils and soft margarines made from these oils in small amounts, because they are high in calories
- Unsalted nuts, like walnuts and almonds, in small amounts due to their high caloric value

**Behavioral Therapy**

The behavioral approaches to weight loss are multifaceted. Costain and Croker (2005) summarize that the behavioral-therapy evidence suggests the following techniques may be successfully incorporated to help clients attain long-term weight control:

- **Properly assess the client’s readiness to change.** Weight-loss achievement and maintenance in the long term depends on the individual being ready and able to build new attitudes and behaviors into his or her daily life.
- **Teach accurate self-monitoring of food consumption.** Fabricatore and Wadden (2003) note that obese individuals tend to underestimate how much they eat by approximately 30 to 50%. Therefore, a focus on accurate self-monitoring is vital for long-term success of the weight-management intervention.
- **Set realistic goals.** Unrealistic goal setting may set up a client for failure and cause negative self-talk—“I have no willpower”—when it may actually be the goal that is flawed (Costain & Croker, 2005). The ACE-AHFS should help clients identify modest, achievable goals and the potential barriers that need to be overcome. **SMART goals** are specific, measurable, attainable, relevant, and time-bound. This goal-setting process should be followed with a written and personalized action plan.
For enhanced motivation, the ACE-AHFS and client can together establish rewards along the way for desired outcomes.

- **Incorporate sound dietary change.** Costain and Croker (2005) highlight the following key dietary messages for adults who are seeking to manage body weight:
  - Include a variety of foods from the main food groups.
  - Control portion size.
  - Reduce the proportion of fat, particularly saturated fat.
  - Consume foods rich in omega-3 fatty acids.
  - Increase consumption of fruit and vegetables to at least five portions daily.
  - Consume low-glycemic, whole-grain, high-fiber, carbohydrate-rich foods in meals.
  - Reduce sugar intake.
  - Limit salt intake.
  - Follow a structured meal pattern, starting with breakfast.

- **Increase physical activity.** See "Physical Activity: Structured Exercise" below.

- **Utilize stimulus control.** Stimulus control involves learning how to avoid triggers such as the sight of food and dealing with cravings for food. Since food cravings are not fully understood, a few different strategies may need to be attempted. Most importantly, it is essential that clients not adopt a strict diet based on specific food deprivation. In fact, eating craved foods in moderation may quell the craving and prevent overeating. In addition, creating workable diversions to food cravings may be a viable solution.

- **Utilize cognitive restructuring.** Cognitive restructuring is a behavioral technique that involves learning how to replace unhealthy or negative thoughts and self-talk regarding weight loss with positive affirmations. Examples of cognitive traps include all-or-nothing thinking (e.g., "I blew my diet last night, so I might as well blow it again today") and discounting the positive (e.g., "I only lost one pound this week instead of two").

- **Utilize relapse management.** Relapse management attempts to makes clients aware that lapses and relapses are a normal part of behavior change. This strategy helps to relieve the stress of "being a diet failure" that some individuals experience when they miss an exercise session or overindulge in a meal.

- **Establish ongoing support.** Ongoing support involves creatively utilizing communication techniques such as email, phone, and websites that provide maintenance support to clients in an effort to sustain the lifestyle changes that have been made.

Wing and Phelan (2005) have studied and identified the key attributes of successful weight-loss maintainers from the National Weight Control Registry, the largest database in the world of persons sustaining long-term weight loss. Despite using various approaches to lose weight, the chief behavioral characteristics common to these weight-loss maintainers include the following:

- Frequent self-monitoring of body weight and food intake
- Eating a diet low in fat and higher in carbohydrate
- Eating breakfast and regular meals
- Limiting fast food
- Accepting realistic weight goals
- Performing high levels of physical activity (≥1 hour/day)
- Recognizing that weight control is an ongoing process and commitment

Wing and Phelan (2005) further suggest that once successful maintainers have sustained a weight loss for two to five years, the chances of longer-term success greatly improve.

**Physical Activity: Structured Exercise**

Although there are various evidence-based physical-activity and exercise approaches to weight control, such as the 10,000-steps-a-day model or the >2000 kilocalories per week target goal, the "accumulated time" approach will be highlighted here for designing weight-management programs because of its simplicity and its varied utility for all different forms of exercise.
(e.g., walking, elliptical training, water exercise, rowing, cycling). The accumulated time approach addresses the fact that energy expenditure is actually a cumulative phenomenon, including both low-intensity activities of daily life, such as walking and recreational dancing, and more vigorous exercise like swimming, elliptical training, and cycling. When pursuing weight-management goals, the evidence suggests that overweight and obese persons should gradually progress to 60 minutes per day of accumulated exercise. There appears to be an optimal dose of maintaining an average of greater than 280 minutes/week (Jakicic & Gallagher, 2003). Jakicic and Gallagher add that these greater weekly volumes of exercise tend to lead to less food consumption in individuals, and the combined exercise and decreased food consumption facilitate weight loss. The ACSM position stand for weight loss and prevention of weight regain recommends progressing to 200 to 300 minutes of accumulated exercise per week (Jakicic et al., 2009).

It is important to note that although resistance exercises are highly recommended for enhanced muscular strength, muscular endurance, physical function, and a host of other health benefits, it is cardiovascular exercise that elicits the needed energy-expenditure deficits for weight loss and the prevention of weight regain (Jakicic et al., 2009). However, research on resistance training and circuit training has shown meaningful changes in body composition (Marx et al., 2001). Thus, one of the noteworthy benefits of resistance exercise, as it relates to body composition in overweight populations, is the positive impact of maintaining or increasing fat-free body mass, while encouraging the loss of fat weight via a progressive-overload resistance-training program. Therefore, any resistance-training program designed for overweight and obese persons should be considered very meaningful to the overall health and goals of the client, and an adjunct to the cardiovascular program for weight loss. The data indicate that moderate-intensity exercise is the preferred level of exertion—approximately 60 to 70% of maximal oxygen uptake or a rating of 11 to 13 (“fairly light” to “somewhat hard”) on the Borg ratings of perceived exertion (RPE) scale (6 to 20 scale) (Jakicic & Gallagher, 2003) (Figure 10-3).

### Figure 10-3

Ratings of perceived exertion

<table>
<thead>
<tr>
<th>RPE</th>
<th>Category Ratio Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>0 Nothing at all</td>
</tr>
<tr>
<td>7</td>
<td>0.5 Very, very weak</td>
</tr>
<tr>
<td>8</td>
<td>1 Very weak</td>
</tr>
<tr>
<td>9</td>
<td>2 Weak</td>
</tr>
<tr>
<td>10</td>
<td>3 Moderate</td>
</tr>
<tr>
<td>11</td>
<td>4 Somewhat strong</td>
</tr>
<tr>
<td>12</td>
<td>5 Strong</td>
</tr>
<tr>
<td>13</td>
<td>6 Very strong</td>
</tr>
<tr>
<td>14</td>
<td>7 Fairly light</td>
</tr>
<tr>
<td>15</td>
<td>8 Strong</td>
</tr>
<tr>
<td>16</td>
<td>9</td>
</tr>
<tr>
<td>17</td>
<td>10 Very, very strong</td>
</tr>
<tr>
<td>18</td>
<td>* Maximal</td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>20</td>
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</tr>
</tbody>
</table>

What Is the Resting Metabolic Rate of Muscle Tissue?

Resting metabolic rate (RMR), which accounts for 60 to 75% of all calorie-burning processes, is the amount of energy required to keep homeostatic processes (the regulation of organ systems and body temperature) performing efficiently. Although muscle is the largest tissue in the body, its estimated RMR is below what has been publicized in the consumer media. In fact, scientific estimation of the metabolic rate of muscle is about 10 to 15 kcal/kg per day, which is approximately 4.5 to 7.0 kcal/lb per day (Elia, 1992).

In an all-inclusive research review, Donnelly and colleagues (2003) note that the majority of peer-reviewed resistance-training studies (lasting from eight to 52 weeks) show increases of 2.2 to 4.5 pounds (1.0 to 2.0 kg) of muscle mass. Therefore, the 4.5 pounds (2.0 kg) of muscle mass would increase the RMR by up to 50 kilocalories per day—far less than what is popularly promoted.
Physical Activity: Unstructured Exercise

In recent years, researchers have been investigating the impact that standing, walking, and fidgeting play on weight gain and obesity. As such, a relatively newly discovered component of energy expenditure is non-exercise activity thermogenesis (NEAT) (physiological processes that produce heat). Innovative research in this area has revealed surprising and beneficial information (Levine et al., 2005).

NEAT comprises the energy expenditure of daily activities that are not considered planned physical activity or exercise of a person’s daily life. NEAT is measured with sensitive physical-activity monitoring inclinometers and triaxial accelerometers, which are worn on the hips and legs (similar to a pedometer). These devices capture data on body position through all planes of movement 120 times a minute. The combination of this information with other laboratory measurements of energy expenditure leads to a calculation of NEAT. Findings indicate that changes in NEAT accompany changes in energy balance, which are very meaningful in affecting weight loss (Levine et al., 2005).

Levine and colleagues (2005) recruited 20 healthy, sedentary volunteers. As quoted from the article, all subjects were self-proclaimed “couch potatoes.” Of the 20 volunteers, five men and five women had BMI measurements of 23 ± 2 kg/m² (classifying them as lean) and five men and five women had BMI measurements of 33 ± 2 kg/m² (classifying them as mildly obese). A mildly obese population was selected because these individuals were less likely to have medical impediments and orthopedic troubles as compared to a morbidly obese group. With each subject wearing an inclinometer and triaxial accelerometer, the researchers collected data every half-second for 10 days.

The investigators were searching for posture and movement clues of how the 10 lean non-exercisers were different from 10 mildly obese non-exercisers. They found that the obese subjects were seated for 164 minutes longer each day than the lean participants. In addition, the lean participants were upright for 153 minutes longer per day that the obese subjects.

Importantly, sleep times between the groups did not vary at all. The lean subjects had significantly more total-body ambulatory movement, which consisted of standing and walking. In essence, the extra movement by the lean subjects averaged 352 ± 65 calories per day, which is equivalent to 36.5 pounds (16.6 kg) in one year.

In summary, a very important way to help clients achieve their weight-loss goals is to find ways for them to be more active in their daily lives (Table 10-3). Encouraging and educating clients to make small movement changes in their daily lives, in addition to their structured exercise plan, may very well contribute to profound weight-management success.

### Table 10-3
Suggestions to Help Clients Be More Active During the Day

- Walk to work.
- Walk during your lunch hour.
- Walk instead of drive whenever you can.
- Take a family walk after dinner.
- Skate to work instead of drive.
- Mow the lawn with a push mower.
- Walk to your place of worship instead of driving.
- Walk your dog.
- Replace the Sunday drive with a Sunday walk.
- Get off the bus or subway a stop early and walk.
- Work and walk around the house.
- Take your dog to the park.
- Wash the car by hand.
- Run or walk fast when doing errands.
- Pace the sidelines at your kids’ athletic games.
- Take the wheels off your luggage.
- Walk to a coworker’s desk instead of emailing or calling.
- Make time in your day for physical activity.
- Bike to the barbershop or beauty salon instead of driving.
- If you find it difficult to be active after work, try it before work.
- Take a walk break instead of a coffee break.
- Perform gardening and/or home-repair activities.
- Avoid labor-saving devices.
- Take small trips on foot to get your body moving.
- Play with your kids 30 minutes a day.
- Dance to music.
- Walk briskly in the mall.
- Take the long way to the water cooler.
- Take the stairs instead of the escalator.
- Go for a hike.

Source: www.SmallStep.gov
Obesity Medications and Physiological Responses

Between 2003 and 2007, the U.S. patent office received more than 1700 submissions with the word “obesity” in them (Hickey & Israel, 2007). Hickey and Israel (2007) also note that there are nearly 300 clinical trials currently researching some aspect of obesity. However, there are only two drugs that have been FDA-approved for long-term treatment of obesity: sibutramine (trade name is Meridia™) and orlistat (marketed under the trade name Xenical™ or over-the-counter as Alli™).

Sibutramine prevents the removal of noradrenaline and serotonin in the brain, thus prolonging some of their appetite-suppressing effects. Research on sibutramine showed that individuals who use it average approximately 10 pounds (4.5 kg) greater weight loss, as compared to those who used a placebo over the course of one-year treatments (Li et al., 2005). The research on sibutramine suggests that it is relatively safe, minimally elevating heart rate (4 bpm) and blood pressure (2 to 4 mmHg for both systolic and diastolic blood pressure). A minor increase of high-density lipoproteins (HDL) and a mild reduction in triglycerides have also been observed. No available research exists that has evaluated the use of sibutramine beyond two years.

Orlistat’s primary function is preventing the intestinal absorption of fats from the diet, thereby reducing the caloric impact of food consumed. It is intended for use in combination with a physician-supervised reduced-calorie diet. Orlistat is successful at blocking absorption of approximately 30% of dietary fat (Hickey & Israel, 2007). Over the course of a year, the use of orlistat creates approximately 6.5 pounds (2.9 kg) greater weight loss as compared to a placebo (Hickey & Israel, 2007). However, the researchers also note that orlistat has been shown to have considerable gastrointestinal side effects, including abdominal pain, diarrhea, flatulence, bloating, and upset stomach. Long-term research on orlistat has not yet been published.

Clearly, a great deal more needs to be learned about the interplay of food intake and the complex biological, neuroendocrine, and physiological mechanisms of the human body. Although much research is going on in this area of study, simple solutions do not appear to be forthcoming in the near future. In addition, Hickey and Israel (2007) note that the pathogenesis (i.e., disease development) of obesity is multifaceted and likely to vary among individuals. This suggests that the idea of one “super pill” for overweight and obesity treatment is unlikely. In addition, it is hoped that any obesity medications will be administered along with lifestyle changes that involve behavior modification, exercise, and healthy food consumption.

In June 2007, Alli became the first over-the-counter diet pill approved by the Food and Drug Administration (FDA). It is a half-strength version of the prescription weight-loss drug Xenical (orlistat). For best results, Alli should be taken before every meal that contains fat. It works by decreasing the amount of fat absorbed by the gastrointestinal tract during the digestive process. Research has shown that when individuals use Alli in combination with diet and exercise, they lose up to 50% more weight on average compared to dieting and exercising alone. As with any drug, Alli has several documented side effects, including excessive flatulence and oily, difficult-to-control bowel movements. Those individuals hailing Alli as the next “magic bullet” for weight loss should bear in mind that most weight-loss experts contend that without the contributory effects of diet and exercise, Alli’s beneficial weight-loss effects would be very limited.
Surgical Interventions for Obesity

Bariatrics is the branch of medicine that deals with the causes, prevention, and treatment of obesity. The term bariatrics comes from the Greek root baro (weight) and the suffix iatrics (a branch of medicine). Surgical treatment of obesity is suggested to be only appropriate for those individuals with a BMI ≥40 kg/m² or BMI ≥35 kg/m² in the presence of comorbidities (one or more disorders or diseases in addition to a primary disease—obesity) (Fabricatore & Wadden, 2003). The two most common surgical procedures for obesity are gastric bypass and vertical banded gastroplasty. These procedures involve separating a small pouch of stomach with a line of staples to dramatically limit food intake. Bariatric surgery results in a 30% (gastric bypass) and 25% (vertical banded gastroplasty) average reduction of initial weight. Improvements of mood, hypertension, asthma, sleep apnea, and diabetes have also been observed (Fabricatore & Wadden, 2003). Clinical trials suggest that gastric bypass surgery is associated with much better weight-loss maintenance than vertical banded gastroplasty, because patients who have undergone gastric bypass surgery and then eat high-fat or high-sugar meals tend to experience stomach cramping and gastrointestinal distress and thus avoid these foods to evade this discomfort. Naturally, before any type of bariatric procedure, individuals need to be rigorously screened to determine if there are any medical or behavioral contraindications to the surgery.

Considerations for Obesity-related Disorders and Diseases

A wide range of diseases and health problems are associated with obesity. The ACE-AHFS should be familiar with the diverse ways that overweight and obesity may be linked with the health and wellness of clients. It is important to note that the research on obesity-related disorders and diseases is very frequently correlational, as opposed to prospective, randomized research. Correlational research explores the statistical association of two or more variables to each other, and this type of study design makes it hard to prove cause and effect. Readers of research results should bear in mind the limitations imposed by the study design. Serious diseases associated with overweight and obesity include coronary heart disease, congestive heart failure, stroke, emphysema, chronic bronchitis, obstructive pulmonary disease, deep vein thrombosis, and some cancers (endometrial, breast, colon) (Patterson et al., 2004; NIH, 2007). The cardiovascular risk factors related to obesity are hypertension, hypercholesterolemia (or abnormal cholesterol levels), and type 2 diabetes. Patterson and colleagues (2004) note that the numerous medical conditions linked to obesity include depression, migraine headaches, asthma, gastroesophageal reflux disease, ulcers, diabetes, bladder infections, osteoarthritis, yeast infections, and gallbladder disease. A number of other health concerns associated with obesity include osteoporotic fractures (wrist, hip, forearm), joint pain (neck, back, knee), stress, fatigue, chronic insomnia, anxiety, indigestion, heartburn, constipation, skin problems, and allergies (to plants, trees, molds, dust, or animals) (Patterson et al., 2004). This information clearly depicts the health burden of obesity-related disorders and diseases and the challenges faced by fitness, public health, and medical professionals. It is important for an ACE-AHFS to realize that a determination of the absolute risk of morbidity and mortality of an obese client requires a comprehensive evaluation, including a complete medical history, physical examination, and appropriate laboratory tests.

Physiological Responses to Exercise Training

Regular physical activity and exercise has significant benefits in terms of risk reduction for overweight and obesity, insulin resistance, type 2 diabetes, blood lipid and lipoprotein abnormalities, hypertension, peripheral vascular disease, cerebrovascular disease, and coronary heart disease. Not everyone who is physically active on a regular basis will remain
free from these vascular and metabolic diseases, but the protective effects and the reduction in risk levels are substantial enough to justify the promotion of a physically active lifestyle in all segments of the population, especially the overweight and obese. Continued study of overweight and obese persons is needed to better understand the physiological responses to exercise training for this population. Further epidemiological research (the branch of medicine that deals with the incidence, distribution, and possible control of diseases related to health) may uncover new relationships between obesity and health, and extend the understanding of the health benefits of exercise training. Table 10-4 summarizes the physiological effects of cardiovascular and resistance training.

The Role of Exercise in Weight Loss and Weight-gain Prevention

Although it is possible to lose weight with physical activity alone, the combination of exercise with a restricted dietary intake is a more meaningful strategy (Hill & Wyatt, 2005). Hill and Wyatt (2005) also state that exercise positively alters the composition of weight loss so that a greater percentage of weight loss comes from fat, rather than from muscle. In addition, exercise, especially resistance training, helps preserve a person’s RMR in weight-loss programs by preserving muscle mass, which has a relatively high metabolic demand. Several investigations (Hill & Wyatt, 2005; Jakicic & Gallagher, 2003) have also demonstrated that persons expending high volumes of weekly exercise (one hour or more each day) have high success rates in long-term weight-loss maintenance. Hill and Wyatt (2005) state that an exertion totaling approximately 2500 to 2800 kcal/week (60 to 90 minutes per day of moderate-intensity physical activity) may be required to maintain substantial weight loss of ≥30 pounds (≥14 kg). The physiological reasons why exercise is so meaningful for long-term weight-loss success are speculative at best. However, Hill and Wyatt (2005) hypothesize that persons who maintain a high level of exercise may be much better at maintaining target food consumption goals as well. In summary, the results of several epidemiological studies consistently reveal that persons who are physically active are much less likely to gain weight over time than those who are not. Although habitual physical activity is an attainable goal, only 48% percent of all American adults currently get ≥30 minutes of moderate-intensity exercise per day on at least five days/week (Morbidity and Mortality Weekly Report, 2003).

Table 10-4
Physiological Effects of Cardiovascular and Resistance Training

<table>
<thead>
<tr>
<th></th>
<th>Cardiovascular Training</th>
<th>Resistance Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone mineral density</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Hypertension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>Decrease</td>
<td>Possible decrease</td>
</tr>
<tr>
<td>Diastolic</td>
<td>Decrease</td>
<td>Possible decrease</td>
</tr>
<tr>
<td>Resting heart rate</td>
<td>Decrease</td>
<td>Decrease</td>
</tr>
<tr>
<td>Blood lipids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triglycerides</td>
<td>Decrease*</td>
<td>Possible decrease</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>Decrease*</td>
<td>Possible decrease</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>Decrease*</td>
<td>Possible decrease</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>Increase</td>
<td>Possible increase</td>
</tr>
<tr>
<td>Glucose metabolism</td>
<td></td>
<td></td>
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<tr>
<td>Basal insulin levels</td>
<td>Decrease</td>
<td>Decrease</td>
</tr>
<tr>
<td>Insulin sensitivity</td>
<td>Increase</td>
<td>Increase</td>
</tr>
<tr>
<td>Cardiovascular endurance</td>
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</tr>
<tr>
<td>Body composition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat mass</td>
<td>Decrease</td>
<td>Decrease</td>
</tr>
<tr>
<td>Fat-free mass</td>
<td>Increase (mild)</td>
<td>Increase</td>
</tr>
<tr>
<td>Resting metabolic rate</td>
<td>No change</td>
<td>Increase (mild)</td>
</tr>
<tr>
<td>Musculoskeletal health</td>
<td>Increase (mild)</td>
<td>Increase</td>
</tr>
<tr>
<td>Functional capabilities</td>
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<td>Increase</td>
</tr>
<tr>
<td>Longevity</td>
<td>Increase</td>
<td>Unknown</td>
</tr>
</tbody>
</table>

*A decrease in triglycerides, total cholesterol, and LDL cholesterol from cardiovascular exercise occurs if there is a concurrent loss of body weight.

Programming and Progressive Exercise Guidelines for Overweight and Obesity

The foundational research for exercise guidelines for overweight and obese persons stems from the ACSM (2010) guidelines for the development and maintenance of cardiopulmonary fitness for endurance exercise (frequency of five or more days per week), using an exercise mode that involves the major muscle groups (in a rhythmic nature) for a prolonged time period. ACSM (2010) recommends an intensity of exercise of 40–60% of VO₂ R or heart-rate reserve (HRR) (progressing to 50–75% of VO₂ R or HRR) with a continuous duration of 20 to 60 minutes per session. Inherent in these guidelines is the concept of individualizing the program for each person’s fitness level, health, age, personal goals, risk-factor profile, medications, behavioral characteristics, and individual preferences.

ACSM (2010) has published the following guidelines for overweight and obese clients:

- Target adults with a body mass index (BMI) >25 kg/m² and children exceeding the 95th percentile of BMI based on age and sex.
- Target a minimal reduction in body weight of at least 5 to 10% of initial body weight over a three-to-six-month period.
- Incorporate opportunities to enhance communication between healthcare professionals, dietitians, and exercise professionals and people with overweight and obesity following the initial weight-loss period.
- Target changing eating and exercise behaviors, as sustained changes in both behaviors result in significant long-term weight loss.
- Target reducing current energy intake by 500 to 1000 kcal/day to achieve weight loss. This reduced energy intake should be combined with a reduction in dietary fat to <30% of total energy intake.
- Target progressively increasing to a minimum of 150 minutes/week of moderate-intensity physical activity to optimize health/fitness benefits.
- Progress to higher amounts of exercise (i.e., 200–300 minutes/week or >2000 kcal/week) of physical activity to promote long-term weight control.
- Consider resistance exercise as a supplement to the combination of aerobic exercise and moderate reductions in energy intake lose weight.
- Incorporate behavioral modification strategies to facilitate the adoption and maintenance of the desired changes in behavior.

The concept of periodizing aerobic-training programs is encouraged. Periodization training is based on an inverse relationship between intensity and volume of training. With aerobic exercise, intensity can be individualized using percent of heart rate maximum, percent of VO₂ max (maximal aerobic capacity), or RPE, where volume is differentiated by the duration of the session, as well as the frequency of sessions.

The following periodization suggestions can be used to individualize an exercise program to optimize weight loss during aerobic exercise:

- Incorporate frequent cardiorespiratory workouts that are low intensity and long duration.
- Include some cardiorespiratory workouts that are of higher intensity for a shorter period of time. This objective may best be realized with high-intensity continuous training or with interval training. To avoid physiological and orthopedic stress and injury, it would be prudent to complete only one higher-intensity workout per week.
- Incorporate multi-mode training. The theory of multi-mode training (i.e., employing two or more modes of cardiorespiratory exercise) implies that by doing so the body is protected from getting overly fatigued from overuse of the same muscles in the same movement patterns. This technique helps to thwart the occurrence of musculoskeletal system stress, and aids in the prevention of muscle soreness and injuries. Therefore, theoretically, a person will be able to safely do more work more frequently, which equates to higher total energy expenditure and fat utilization.
- Vary the workout designs regularly. Endeavor to find a satisfactory method for each client by which cardiorespiratory workouts vary within
each week, weekly, or bi-weekly using the three ideas just listed. Varying the workouts provides a new stimulus to the body’s cardiorespiratory system in an effort to avoid the consequences of overuse exercise fatigue.

Biomechanical Considerations for Obese Clients

Cardiorespiratory Exercise Considerations

The preferred type of cardiorespiratory exercise for overweight and obese is a combination of weightbearing (such as walking and elliptical exercise) and non-weightbearing (such as cycling and swimming) modes. Exercise choices should be based on an individual’s preferences and exercise history. Help each client find modes of exercise where he or she has a perceived comfort level with few (if any) negative barriers. The majority of the time spent exercising should be at a low-to-moderate intensity level to avoid joint stress and injury. Therefore, running, jumping, and high-impact movements are not recommended. These physical activities may lead to some musculoskeletal problems associated with body weight and impact forces from the repeated (and forceful) foot strikes on the ground surface. The emphasis of the cardiorespiratory exercise programs should be on performing longer and/or more frequent bouts of exercise. It is important to monitor muscle soreness from the exercise and always ask the client if he or she is experiencing any orthopedic problems or discomfort. Stationary cycling is preferable to road cycling, as it eliminates any balance-related challenges, while also avoiding the hazards of traffic.

Walking is considered a very good initial exercise because it requires no extra skill. When beginning a walking or weightbearing exercise regimen with a client, it is important to keep a few things in mind. Make sure the person has quality fitness shoes with good shock-absorbing qualities. Next, and very importantly, Mattsson, Larsson, and Rossner (1996) presented some very useful data about walking with an obese female population. The most interesting finding of this study was that level walking was much harder work for obese women when compared to normal-weight women. On average, obese women used as much as 56% of \( \dot{V}\text{O}_2\text{Rmax} \) during walking, as compared to 36% \( \dot{V}\text{O}_2\text{Rmax} \) for normal-weight women. The authors noted that even though obese women do not necessarily walk with a waddle or straddled legs, they do walk with an abnormal gait pattern that increases their relative oxygen cost. The authors conclude that walking may be too exhausting (and sometimes painful) for some obese individuals due to these biomechanical differences in gait and recommend incorporating alternative training modes in the workout design. Swimming and aquatic exercise programs provide total-body exercise with little to no weightbearing due to the buoyancy of water. Buoyancy is also a benefit for overweight and obese people who may have joint problems (such as arthritis of the knee, hip, or ankle, or structural problems of these three joints).

Fitness facilities have a variety of exercise equipment. The ACE-AHFS is encouraged to help clients find exercise devices that are easy to use and that do not cause any back, hip, knee, or ankle discomfort. For example, recumbent bikes are great cycling options for obese individuals, as compared to stationary or road cycling. However, the ACE-AHFS must make sure the bike seat is comfortable for the overweight or obese client. For some obese clients, balance will be an additional challenge with some modes of exercise. If this is the case, the ACE-AHFS should select exercise devices that have handrails to provide balance support and help prevent falling.

Resistance-training Considerations

There are a few biomechanical concerns to note regarding resistance exercise and overweight and obese persons. For some overweight and obese people with mobility and/or balance challenges, seated exercises are good initial options. These types of exercises can be useful in building basic muscle strength. While seated in a chair, individuals are able to do a variety of arm raises, leg lifts, and stretches. Please note that the seats on some exercise machines were not developed for large persons, which may limit the feasibility of using some strength-training equipment. Moreover, weight
suggests following the accepted guidelines for the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness and flexibility in healthy adults (ACSM, 2010).

Body image is a complex construct that includes feelings, thoughts, and perceptions about one’s physique (Scully et al., 1998). Scully and colleagues found that females tend to have a less positive body image than males, and can become very preoccupied with losing weight. When diet and exercise become too dominant in a woman’s lifestyle, she is most susceptible to a set of disorders referred to as the female athlete triad.

In addition, females tend to focus on their body from an aesthetic viewpoint, whereas males tend to view their bodies in terms of strength, speed, and coordination (Franzoi, 1995). Franzoi (1995) suggests that women are more likely to engage in activities that are non-competitive, such as aerobics, with the goal of keeping fit. Issues such as weight control and attractiveness are bigger concerns for women than men. Misperceptions regarding body image appear to be strongly implicated in the development of eating disorders and clinical depression. The research suggests that the ACE-AHFS should be very attentive to the design of fitness facilities to make an overweight or obese client feel more comfortable with his or her body image (Scully et al., 1998). For example, having access to private changing facilities is recommended to help reduce feelings of body-image dissatisfaction. In addition, the ACE-AHFS needs to be aware that exercise participation may accentuate a person’s body-image dissatisfaction and enhance a person’s drive for leanness. Therefore, the suggestion or implication that everyone can attain a “model’s body” may perpetuate psychological disorders in some clients. Caution is necessary for all fitness professionals when guiding clients, especially overweight and obese clients, toward healthy physical activity, as opposed to leading them to a path obsessed with thinness and the development of eating disorders.

Exercise has a positive connection to improved self-esteem. This link also appears to be more potent among individuals who have lower self-esteem. At this time, available studies indicate
that aerobic exercise may have a more pronounced effect, perhaps only because there is so little research available regarding resistance training and self-esteem. However, self-esteem is quite complex and studies suggest that certain subcomponents contribute to a person’s self-esteem, including perceived sport competence, physical condition, an “attractive” body, and strength (Scully et al., 1998). Because of the many variables that influence self-esteem, it is important to note that a person may highly value his or her physical condition and yet have a negative evaluation of his or her body. The meaningful evidence suggests that aerobic exercise seems to have the most consequential influence on individuals who initially have low self-esteem. An optimal exercise design is uncertain at this time based on published research.

Case Studies

Case Study 1
Clare is a 52-year-old client who is 5’6” (1.7 m) and weighs 160 pounds (73 kg). Her blood pressure is 110/70 mmHg, her total cholesterol is 200 mg/dL, and she has 33% body fat. She was very athletic in the past and even competed as a middle-distance runner in high school. Clare takes indoor cycling class lasting 40 minutes three or four times a week and walks leisurely whenever she can. She currently performs no resistance training.

Clare drinks 1.5 liters (0.4 gallons) of water and eats between 2300 and 2500 calories each day, including a small breakfast, light snacking in the morning, a light lunch that sometimes includes protein but usually consists of a salad or just vegetables, an afternoon snack, and a dinner of fish or chicken with vegetables and some fat-free ice cream. She also drinks five cups of decaffeinated coffee during the day and has a glass of wine in the evening five days a week.

Clare reports no health conditions and does not take any medications or vitamins. She has a history of yo-yo dieting and did some fasting in her 20s and 30s. She sleeps 5.5 hours each night and has a high-stress job. Her goals are to lose weight (fat) and “firm up.”

The Program

Workout and Lifestyle Plan:
- Cardiovascular exercise (progressed to the following)
  - 40 minutes of cardiovascular exercise (cycle ergometer or stair stepping) two days a week
  - Walking for 45 minutes at a self-selected moderate intensity one day a week
  - Elliptical training for 45 minutes at a self-selected moderate intensity one day a week
  - Walking moderately for at least 90 minutes (accumulated) during the week
- Resistance training
  - Circuit resistance-training program three times a week using 10 different exercises (chest, back, biceps, triceps, deltoids, quadriceps, hamstrings, abdominals, buttocks, lower back) (one circuit)

Dietary Pattern:
- Met with a dietician, who gave her a Mediterranean-type diet of approximately 1700 calories a day

Lifestyle:
- Attempted to sleep 7 hours a night when possible
- Did extra stretching exercises on high-stress days

Three-month Outcomes:
- Weight = 148 lb (67 kg)
- Blood pressure = 110/70 mmHg
- Total cholesterol = 184 mg/dL
- Body fat = 28%

Six-month Outcomes:
- Weight = 136 lb (62 kg)
- Blood pressure = 101/70 mmHg
- Total cholesterol = 177 mg/dL
- Body fat = 24%

Case Study 2
Jen is a 19-year-old client who is 5’4” (1.6 m) and weighs 220 pounds (100 kg). Her blood pressure is 124/82 mmHg, her total cholesterol is 210 mg/dL, and she has approximately 60% body fat. Jen walks leisurely twice a week for 45 minutes each time. She currently performs no resistance training.
Jen drinks more than 1.5 liters (0.4 gallons) of water and eats more than 2800 calories of food each day. Her diet is very high in fats (particularly saturated fat) and simple carbohydrates and low in protein. She eats three big meals a day and enjoys a lot of fried and baked foods. She also snacks on sweets (e.g., cookies and cake) during the day. Jen drinks two cups of caffeinated coffee and three or four colas each day. In addition, she drinks three or four alcoholic beverages each weekend.

Jen has prehypertension and hypercholesterolemia and is currently taking no medications or vitamins. She leads what she calls an “inactive lifestyle,” sleeps seven hours a night, and has a stress level typical of a college student. Her goal is to lose weight (fat) and get in shape.

The Program

Workout and Lifestyle Plan:
• Cardiovascular exercise (progressed to the following)
  ✓ 30–60 minutes of cardiovascular exercise (stair stepping, elliptical training, or treadmill walking) four days a week
  ✓ Walking at a moderate intensity two times a week for 45 minutes each time
• Resistance training
  ✓ Four days a week using an upper- and lower-body split program; each day she does 5 different exercises, 1 to 5 sets of each (never doing more than 20 sets in a workout)

Dietary Pattern:
• Met with a dietician who gave her a heart-healthy diet as recommended by the American Dietetic Association (lowering the fats and simple sugars and replacing them with healthy fats and more fruits and vegetables and complex carbohydrates)
  • Caloric intake gradually decreased to 1500 calories per day

Lifestyle:
• Did meditation 3 or 4 times a week (20 minutes each time) to help manage stress

Three-month Outcomes:
• Weight = 185 lb (84 kg)
• Blood pressure = 110/76 mmHg
• Total cholesterol = 200 mg/dL
• Body fat = 40%

Six-month Outcomes:
• Weight = 150 lb (68 kg)
• Blood pressure = 101/74 mmHg
• Total cholesterol = 185 mg/dL
• Body fat = 32%

Summary

Client education is the framework of successful weight-loss interventions. The ACE-AHFS is encouraged to inform clients of the health risks of overweight and obesity and the benefits that accompany exercise, weight loss, and lifestyle modifications. The ACE-AHFS can help clients establish realistic weight-management goals and strategies, and provide the ongoing support for them to keep up these new behaviors. It is important to regularly remind clients that successful energy balance is a life-long process that starts with a commitment to improve the quality of their lives.
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**Suggested Reading**


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Wendy M. Miller, M.D., is a graduate of Wayne State University School of Medicine in Detroit, Michigan, and completed her Internal Medicine residency at William Beaumont Hospital in Royal Oak, Michigan. Dr. Miller is Board Certified in Internal Medicine and Bariatric Medicine, and is also certified as a Physician Nutrition Specialist. Currently she serves as medical director of the Beaumont Hospital Weight Control Center in the Division of Nutrition and Preventive Medicine. Dr. Miller is a member of the American College of Physicians and the American College of Preventive Medicine. She has published numerous pieces on obesity and its association with diabetes, inflammation, metabolic syndrome, dyslipidemia, and cardiovascular disease.

Peter A. McCullough, M.D., M.P.H., is the chief of nutrition and preventive medicine at William Beaumont Hospital in Royal Oak, Michigan. After receiving his medical degree from University of Texas Southwestern Medical School, Dr. McCullough went on to complete internal medicine residency at the University of Washington, and cardiology fellowship at William Beaumont Hospital. He holds a master's degree in Public Health from the University of Michigan. Dr. McCullough has more than 200 published scientific communications and is a nationally recognized authority on preventive medicine, chronic kidney disease, obesity, and the primary and secondary prevention of coronary artery disease.
The Metabolic Syndrome

Barry A. Franklin

Wendy M. Miller

Peter A. McCullough

Complex, mutually reinforcing interactions between obesity and insulin resistance largely account for the pathogenesis of the metabolic syndrome (Figure 11-1). Excess visceral adiposity is both necessary and sufficient for the development of this multifaceted disease state (Batsis, Nieto-Martinez, & Lopez-Jimenez, 2007). Genetically predisposed groups, including Hispanics and Asian Indians, have demonstrated a greater intolerance to excess visceral adiposity, and are known to develop the metabolic syndrome at relatively lesser degrees of adiposity (Caballero, 2005; Misra & Vikram, 2004). More than 95% of individuals with the metabolic syndrome have a body mass index (BMI) that is ≥25 kg/m²; thus, the BMI as a crude measure identifies the majority of individuals at risk for this medical condition.

Central pathophysiologic features of the metabolic syndrome as a consequence of excess visceral adiposity include the following (Rader, 2007):

- Insulin resistance at the liver and skeletal muscles
- Atherogenic dyslipidemia, chiefly manifested as a triad of low high-density lipoprotein (HDL) cholesterol, together with increases in triglycerides and small, dense low-density lipoprotein (LDL) particles with fasting and postprandial chylomicrons and glycated LDL particles prone to oxidation
- Hypertension
- A proinflammatory state, with increases in acute-phase reactants [e.g., high-sensitivity C-reactive protein (hs-CRP)]
- A prothrombotic state, with increases in plasminogen activator inhibitor (PAI-1) and fibrinogen

Both the proinflammatory and prothrombotic states of the metabolic syndrome derive largely from the secretory activity of intra-abdominal or visceral adipose tissue. Contrary to the traditional concept of fat as an inert tissue, adipocytes are clearly recognized as secretory cells. Cytokines and other inflammatory markers or signaling molecules released by adipocytes (adipokines) include tumor necrosis factor alpha (TNF-alpha), interleukin-6 (IL-6), resistin, and adiponectin. Both TNF-alpha and IL-6 are received by the liver through the portal circulation and stimulate hepatocytes to produce inflammatory proteins. Adiponectin is a local paracrine substance produced by adipocytes that is believed to have a favorable physiologic role in maintaining fat mass in homeostasis. Accordingly, adiponectin levels are characteristically reduced in the obese and those with the metabolic syndrome, thereby permitting additional growth of adipose tissue (Bodary, Iglay, & Eitzman, 2007).

Hepatic insulin resistance is triggered by resistin, hepatocyte growth factor, and free fatty acids (FFA), which are secreted by intraabdominal adipocytes and travel via the portal circulation to the liver. Visceral fat exhibits accelerated lipolytic activity. The subsequent increases in circulating FFA levels result in the development of triglyceride reservoirs in both muscle and
investigators found greater thrombotic potential in overweight and obese subjects. High-sensitivity C-reactive protein is a pivotal acute-phase reactant that is considered an index of inflammation and is associated with increased cardiovascular risk, particularly the provocation of acute coronary syndrome. Values greater than 2 mg/L may serve as a powerful predictor for future cardiovascular events. The American Heart Association/Centers for Disease Control and Prevention (CDC) Scientific Statement on Markers of Intervention and Cardiovascular Disease recommends that in persons with an intermediate Framingham coronary heart disease (CHD) 10-year risk (10 to 20%) and an LDL level below the cutoff for pharmacotherapeutic intervention, it may be appropriate to measure hs-CRP to aid in risk stratification (Pearson et al., 2003).

**Epidemiology**

The epidemiology of the metabolic syndrome directly parallels the obesity pandemic in terms of incidence and prevalence (Ford, Giles, & Dietz, 2002). The many causes for the rise in obesity are complex (see Chapter 10). Follow-up data from the Coronary Artery Risk Development in Young Adults Study (CARDIA) study of young adults followed over 15 years revealed the incidence of the metabolic syndrome as reported in their study.

Figure 11-2
Incidence of the metabolic syndrome as reported in the CARDIA study of young adults followed over 15 years.

Source: Adapted from Lloyd-Jones D.M. et al. (2007). Consistently stable or decreased body mass index in young adulthood and longitudinal changes in metabolic syndrome components: The Coronary Artery Risk Development in Young Adults Study. *Circulation*, 115, 8, 1004.
(CARDIA) (Figure 11-2) indicate that young adults are at considerable risk for the development of the metabolic syndrome if there has, over time, been a consistent increase in body weight (Lloyd-Jones et al., 2007). Although overall body weight and relative adiposity as reflected in the BMI identify the greater than two-thirds of Western populations at risk for the metabolic syndrome, those with excessive intra-abdominal adiposity are particularly susceptible. This android or male pattern of fat deposition in the abdomen is easily recognized and can be accurately quantified. If the abdomen is not scaphoid, or concave, on examination, excess visceral adiposity should be considered. Conversely, a predominately gynoid pattern of fat deposition in the buttocks and legs with a scaphoid abdomen does not indicate risk for the metabolic syndrome. One practical consideration, however, is that virtually all individuals with a BMI ≥30 kg/m² have excess visceral adiposity irrespective of body shape, with the exception of extremely muscular individuals.

Diagnostic Testing and Criteria

The association of visceral obesity and cardiovascular risk stems from the clustering of metabolic conditions, including hypertension, dyslipidemia, and type 2 diabetes mellitus mediated through insulin resistance leading to the metabolic syndrome. The purpose of this unique designation was to identify those at higher metabolic risk for cardiovascular disease and the development of diabetes and to respond with more aggressive strategies for prevention. As indicated earlier, the metabolic syndrome should be suspected in all individuals who are overweight or obese with a BMI ≥25 kg/m². The National Cholesterol Education Program Adult Treatment Panel III defines the metabolic syndrome as meeting three or more of the following criteria (Grundy et al., 2004):

- Abdominal obesity indicated by a waist circumference ≥40 inches (102 cm) in men and ≥35 inches (88 cm) in women
- Levels of triglyceride ≥150 mg/dL (1.7 mmol/L)
- HDL levels <40 and 50 mg/dL (1.0 and 1.3 mmol/L) in men and women, respectively
- Blood pressure levels ≥130/85 mmHg
- Fasting glucose levels ≥100 mg/dL (5.6 mmol/L)

Additional biomarkers that strongly support the diagnosis of the metabolic syndrome include hsCRP >2 mg/L, hyperinsulinemia (fasting C-peptide >4.6 ng/ml), and a urinary albumin:creatinine ratio >30 mg/g, which reflects kidney damage due to the vascular consequences of the disease (Table 11-1).

Table 11-1
Pathophysiologic Processes Associated With the Metabolic Syndrome

- Insulin resistance
- Abnormal fibrinolysis
- Endothelial dysfunction
- Microalbuminuria
- Inflammation
- Procoagulation


The metabolic syndrome is present in 24% of all adults in the United States and in >40% of men and women over the age of 65 (Ford, Giles, & Dietz, 2002). This proportion is expected to grow to approximately two-thirds of the adult population. Each component of the metabolic syndrome is associated with a heightened risk for developing cardiovascular disease and diabetes. Individuals with the metabolic syndrome have a one-and-a-half- to threefold increased risk for developing CHD or stroke (Isomaa et al., 2001). In the primary prevention arm of the San Antonio Heart Study, the metabolic syndrome was associated with a twofold higher risk for developing cardiovascular disease over a mean follow-up of 12.7 years (Hunt et al., 2004). This distinguishes the metabolic syndrome as a unique marker for increased cardiovascular risk, highlighting the need for aggressive risk-factor reduction and treatment.
Treatment of the Metabolic Syndrome

The cornerstone treatment of the metabolic syndrome is therapeutic lifestyle modification to reduce body weight and fat stores, increase physical activity, and transition to an anti-atherogenic diet. Reduction of abdominal adiposity, the primary underlying cause of the metabolic syndrome, is the main therapeutic target. Although lifestyle intervention is often overlooked in clinical practice (Grundy, 2006), this non-pharmacologic approach has been shown to reduce cardiovascular risk and prevent or delay progression to diabetes [National Institutes of Health (NIH), 1998; Knowler et al., 2002].

Dietary Treatment

Several dietary approaches have been advocated for cardiovascular risk reduction in overweight and obese individuals. The Third Report of the National Cholesterol Education Program Adult Treatment Panel recommends a therapeutic lifestyle change (TLC) diet. The nutrient composition includes limiting total fat to 25 to 35% of daily calories (approximately 50 to 70 grams for an 1800 kcal/day diet), saturated fat to less than 7% of daily calories (approximately 13 grams for an 1800 kcal/day diet), and total cholesterol to less than 200 mg/day (Expert Panel, 2001). The majority of fat should come from polyunsaturated and monounsaturated fatty acids, such as fish, nuts, and vegetable oils. These unsaturated fats can help reduce elevated triglycerides and raise the low HDL levels often present in individuals with the metabolic syndrome. Trans fatty acids, which can raise LDL levels, should be severely restricted. Sugar and starch (simple carbohydrates) should be eliminated or markedly reduced, since they are major sources of excess calories and promote hyperinsulinemia. Additionally, a daily fiber intake of 20 to 30 grams is recommended. Table 11-2 shows the overall composition of the TLC diet.

A modified Mediterranean-style diet, which has a similar macronutrient composition to the TLC diet, may have particular benefit for individuals with the metabolic syndrome. The diet is high in fruits, vegetables, nuts, whole grains, and olive oil. Limits for daily saturated fat and cholesterol intake of less than 10% and less than 300 mg, respectively, are slightly higher than those recommended in the TLC diet. A two-year randomized, controlled trial of subjects with the metabolic syndrome found superior weight loss with a Mediterranean-style diet as compared with a control prudent diet; moreover, the Mediterranean-style diet group experienced a concomitant reduction in markers of vascular inflammation and insulin (Esposito et al., 2004). Additionally, endothelial function improved in those on the Mediterranean-style diet, but not in the controls.

To achieve weight loss in overweight and obese individuals, a reduction in daily calorie intake of 500 to 1000 kcal is commonly recommended. This degree of caloric deficit should produce a weight loss of 1 pound (0.45 kg) or more per week. Comparisons of popular dietary approaches with unusually high restrictions of various

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Recommended Intake</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturated fat*</td>
<td>&lt;7% of total calories</td>
</tr>
<tr>
<td>Polyunsaturated fat</td>
<td>Up to 10% of total calories</td>
</tr>
<tr>
<td>Monounsaturated fat</td>
<td>Up to 20% of total calories</td>
</tr>
<tr>
<td>Total fat</td>
<td>25–35% of total calories</td>
</tr>
<tr>
<td>Carbohydrate†</td>
<td>50–60% of total calories</td>
</tr>
<tr>
<td>Fiber</td>
<td>20–30 grams/day</td>
</tr>
<tr>
<td>Protein</td>
<td>Approximately 15% of total calories</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>&lt;200 mg/day</td>
</tr>
<tr>
<td>Total calories</td>
<td>Balance energy intake and expenditure to maintain a desirable body weight/prevent weight gain</td>
</tr>
</tbody>
</table>

*Trans fatty acids are another low-density lipoprotein–raising fat that should be severely restricted.
†Carbohydrates should be derived predominantly from foods rich in complex carbohydrates, including grains, especially whole grains, fruits, and vegetables, with an avoidance of simple carbohydrates, which include sugar and most baked goods and snack foods.
macronutrients, such as very-low-carbohydrate diets, have generally failed to show significant differences in weight loss or cardiovascular risk reduction at one year (Dansinger et al., 2005). Additionally, diets advocating excessive restriction of certain macronutrients are likely to be associated with some nutritional inadequacies and typically are not adhered to over the long term. Therefore, such diet programs should not be recommended. Prevention of weight regain will ultimately depend on the maintenance of substantive lifestyle changes, including healthy dietary modifications and regular physical activity.

**Pharmacologic Treatment**

Permanent lifestyle changes are generally considered first-line strategies to address the cardiovascular risk factors that characterize the metabolic syndrome. However, pharmacotherapies may be indicated for individuals unable to adopt healthier lifestyle habits or those failing to reach metabolic goals despite lifestyle change. Agents that can modify the cardiovascular risk of the metabolic syndrome may target elevated blood pressure, insulin resistance, impaired glucose metabolism, dyslipidemia, or combinations thereof.

Elevated blood pressure is often a component of the metabolic syndrome and lowering it reduces the risk for both CHD and stroke. A meta-analysis of several randomized clinical trials indicates that an average reduction of 12 to 13 mmHg in systolic blood pressure (SBP) sustained over four years is associated with a 21% reduction in CHD, 37% reduction in stroke, 25% reduction in total cardiovascular mortality, and 13% reduction in all-cause mortality (He & Whelton, 1999).

Although the blood-pressure goal for individuals with the metabolic syndrome is currently unknown, it is reasonable to use the target for diabetes—that is, a value below 130/80 mmHg. There is no consensus on first-line antihypertensive medication in the metabolic syndrome. However, given the relationship between the insulin resistance of the metabolic syndrome and endothelial dysfunction, an agent that blocks the renin-angiotensin system may provide benefits beyond blood pressure reduction. This system plays a central role in endothelial dysfunction and both angiotensin receptor blockers and angiotensin-converting enzyme inhibitors can improve endothelial function (Ruilope, Redón, & Schmieder, 2007).

Insulin resistance places individuals with the metabolic syndrome but without overt type 2 diabetes in a pre-diabetic state. Progression of insulin resistance and a concomitant decline of pancreatic beta cell function ultimately leads to type 2 diabetes. This is a gradual, insidious process and the risk for cardiovascular disease begins to increase 15 years prior to the diagnosis of diabetes (Hu et al., 2002).

The Diabetes Prevention Program study demonstrated that progression to diabetes in individuals with impaired fasting glucose can be prevented or delayed with metformin, a medication that decreases hepatic glucose production, reduces intestinal glucose absorption, and increases insulin sensitivity (Knowler et al., 2002). However, metformin was less effective than intensive lifestyle modification that included a low-calorie, low-fat diet and at least 150 minutes of moderate-intensity exercise per week. Similarly, thiazolidinediones, a medication class that also enhances insulin sensitivity, may be protective against diabetes. In a large randomized, controlled trial, a thiazolidinedione medication reduced the three-year incidence of type 2 diabetes in patients with impaired fasting glucose or impaired glucose tolerance (Gerstein et al., 2006). However, use of metformin for metabolic syndrome prevention may be preferable over thiazolidinediones due to the weight gain associated with the latter.

The two metabolic syndrome criteria most highly correlated with insulin resistance/hyperinsulinemia are hypertriglyceridemia and low HDL. On the other hand, the first therapeutic target for cardiovascular risk reduction is LDL (Expert Panel, 2001). For individuals with the metabolic syndrome and cardiovascular disease or diabetes, an LDL of 70 mg/dL or less is recommended (Grundy et al., 2004). LDL targets for others are based on estimation of 10-year CHD risk via Framingham scoring (Expert Panel, 2001). The maximum LDL goal for those without risk factors is less than 160 mg/dL.
First-line pharmacologic treatment for lowering LDL is an HMG-CoA reductase inhibitor (statin), but alternatives include bile acid sequestrants or nicotinic acid. After achieving LDL goals, evaluation of triglyceride and non-HDL levels (HDL = total cholesterol – HDL) should follow. For those with a fasting triglyceride level of 200 mg/dL or greater, non-HDL should be calculated. The goal for non-HDL is 30 mg/dL higher than that of LDL. Non-HDL goals can often be achieved by increasing the dose of the LDL-lowering medication or by adding nicotinic acid or a fibrate.

**Surgical Treatment**

According to the NIH guidelines, bariatric surgery is indicated for those with a BMI of 40 kg/m² or greater, or those with a BMI between 35 and 40 kg/m² with at least one comorbid condition such as diabetes, hypertension, obstructive sleep apnea, or CHD (NIH, 1998). Bariatric surgery has shown the highest success rates for obesity management, with an average weight loss of 35 to 38% of initial total body weight (Shah, Simha, & Garg, 2006); moreover, it improves all components of the metabolic syndrome. A meta-analysis of bariatric surgery outcomes found that diabetes improved or resolved in 83%, hypercholesterolemia improved in 95%, and hypertension improved or resolved in 87% of patients who underwent gastric bypass surgery (Buchwald et al., 2004).

**Clinical Implications and Associated Disorders of the Metabolic Syndrome**

The metabolic syndrome places an individual at high risk for development of type 2 diabetes and cardiovascular disease. Compared to individuals without the metabolic syndrome, those with the diagnostic criteria have about a fivefold increased risk of developing type 2 diabetes and a one-and-a-half- to threefold relative risk of developing cardiovascular disease (Grundy, 2007).

The transition from the metabolic syndrome to overt type 2 diabetes stems from insulin resistance and a decline of pancreatic beta-cell function. Insulin resistance in muscle tissue results in decreased glucose uptake and impaired glycogen synthesis. In the liver, insulin resistance results in failure of insulin to suppress hepatic glucose production. Despite these anomalies, individuals are normoglycemic in the early stages of the disease due to a marked increase in pancreatic beta-cell insulin secretion. As the disease progresses, glucotoxicity and lipotoxicity cause beta-cell function to decline, leading to apoptosis of pancreatic islet cells (Marchetti et al., 2006). At this point, the lower level of insulin secretion can no longer compensate for the effects of insulin resistance, and serum glucose levels reach the threshold for type 2 diabetes.

A variety of pathophysiological mechanisms initiated by insulin resistance promote cardiovascular disease. Insulin resistance triggers endothelial dysfunction via glucose intolerance, hyperglycemia, and attenuated vascular production of nitric oxide, a factor involved in vasodilation and endothelial function (Peppa, Uribarri, & Vlassara, 2003; McFarlane, Banerji, & Sowers, 2001). Additionally, insulin resistance is associated with an atherogenic dyslipidemic profile, including hypertriglyceridemia; low HDL; increased proportion of small, dense LDL particles; and increased apolipoprotein B concentrations. Furthermore, insulin resistance contributes to the development of a prothrombotic and proinflammatory state via increased levels of PAI-1 and other inflammatory markers and cytokines, as well as hypertension.

There are other clinical derangements associated with the metabolic syndrome. Fatty liver disease with steatosis can ultimately lead to fibrosis and cirrhosis. Chronic kidney disease and microalbuminuria are more prevalent in those with the metabolic syndrome. There are also relationships between the metabolic syndrome and polycystic ovarian syndrome, obstructive sleep apnea, hyperuricemia, and gout.

**Exercise in the Prevention and Treatment of the Metabolic Syndrome**

There is a pathophysiological cascade by which physical inactivity predisposes to a cluster of metabolic diseases, including
the metabolic syndrome. With an increasingly hypokinetic lifestyle, skeletal muscle downregulates its capacity to convert nutritional substrates to energy [adenosine triphosphate (ATP)]. Inactive skeletal muscle’s impaired ability to oxidize glucose and fatty acids is presumably mediated by several mechanisms, including decreased mitochondrial concentration; a reduced ability to remove glucose from blood due to fewer capillaries and diminished glucose transporter; and an attenuated capacity to hydrolyze blood triglycerides to free fatty acids, secondary to decreased lipoprotein lipase activity (Chakravarthy & Booth, 2003). Collectively, these metabolic perturbations serve to reduce the capacity to burn fuel, resulting in hyperinsulinemia, hypertriglyceridemia, and ultimately increased cardiovascular risk. On the other hand, moderate-to-vigorous leisure-time physical activity diminishes the magnitude of all five risk factors that are associated with the metabolic syndrome (Rennie et al., 2003) (Table 11-3). An increase in physical activity also improves insulin action in obesity, with or without a concomitant reduction in body weight and fat stores (Kelley & Goodpaster, 1999). This is an important (and often overlooked) salutary effect, suggesting that physical activity is as efficacious in preventing insulin resistance as losing body weight.

Researchers in Finland examined the effects of moderate and vigorous physical activity over a four-year period in 612 middle-aged men without evidence of the metabolic syndrome (Laaksonen et al., 2002). Subjects who engaged in more than three hours per week of moderate-intensity leisure-time physical activity (LTPA) were half as likely as sedentary control subjects to develop the metabolic syndrome. Moreover, vigorous LTPA had an even stronger inverse association, particularly in unfit men. Men in the upper third of VO₂max were 75% less likely than unfit men to develop the metabolic syndrome. This was the first prospective study to show that low levels of leisure-time physical activity and aerobic fitness predict the development of the metabolic syndrome, even after adjustments for potential confounding variables (age, BMI, smoking habit, alcohol intake, socioeconomic status, and other coronary risk factors).

Several investigators have also examined the relationships among habitual physical activity, cardiorespiratory fitness, the metabolic syndrome, and all-cause and cardiovascular mortality. Overall, these studies suggest that higher levels of daily physical activity and/or aerobic fitness are associated with a decreased clustering of risk factors that delineate the metabolic syndrome (Carroll, Cooke, & Butterly, 2000; Farrell, Cheng, & Blair, 2004; Kullo, Hensrud, & Allison, 2002; LaMonte et al., 2005). In one widely cited report (Whaley et al., 1999), the age-adjusted cumulative odds ratio for abnormal markers of the metabolic syndrome was 3.0 for the least-fit men compared with moderately fit ones, and 10.1 when compared with the most-fit men (Figure 11-3). Among women, the age-adjusted cumulative odds ratio was 2.7 for the least-fit women when compared with moderately fit ones, and 4.9 when compared with the most-fit women (see Figure 11-3). Others have reported that higher levels of cardiorespiratory fitness are associated with a substantial reduction in health risk for a given level of visceral and subcutaneous fat (Lee et al., 2005).

### Table 11-3

<table>
<thead>
<tr>
<th>CHARACTERISTICS OF THE METABOLIC SYNDROME</th>
<th>IMPACT OF PHYSICAL ACTIVITY</th>
<th>IMPACT OF PHYSICAL INACTIVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large abdominal circumference:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women &gt;35 inches (88 cm)</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>Men &gt;40 inches (102 cm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hypertriglyceridemia:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥150 mg/dL</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>Low HDL:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women &lt;50 mg/dL</td>
<td>Increases</td>
<td>Decreases</td>
</tr>
<tr>
<td>Men &lt;40 mg/dL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High blood pressure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥130/85 mmHg</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
<tr>
<td>High fasting blood glucose:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>≥100 mg/dL</td>
<td>Decreases</td>
<td>Increases</td>
</tr>
</tbody>
</table>

and that fitness provides a strong protective effect against all-cause and cardiovascular mortality in men with the metabolic syndrome (Katzmarzyk, Church, & Blair, 2004; Katzmarzyk et al., 2005). Accordingly, these data strongly support the role of structured exercise, regular physical activity, or both, in interventions designed to prevent and treat the metabolic syndrome (Janiszewski, Saunders, & Ross, 2008).

**Physiologic Responses to Exercise**

There is considerable evidence that the metabolic syndrome is associated with an impaired exercise tolerance, especially among overweight/obese individuals and those destined to develop type 2 diabetes (Alexander, 1964). Most studies have reported a decreased aerobic capacity (approximately 10 to 20% or more), expressed as milliliters of oxygen per kilogram of body weight per minute (mL O₂/kg/min) or as metabolic equivalents (METs; 1 MET = 3.5 mL/kg/min), among individuals with insulin resistance syndrome, as compared with age- and activity-matched controls (Shahid & Schneider, 2000). Moreover, there is an inverse graded relationship between BMI and cardiorespiratory fitness (Gallagher et al., 2005). Common characteristics of overweight/obese individuals that may contribute to their reduced functional capacity include heat intolerance; hyperpnea/dyspnea; movement restriction; orthopedic pain or discomfort; localized muscular weakness; agility problems; and anxiety about loss of balance during moderate-to-vigorous physical activity.

The metabolic syndrome may also serve as a respiratory stress, especially in individuals with concomitant abdominal obesity (Buskirk, 1971; deJong et al., 2008). As adiposity develops, breathing requires increased effort, owing to the expanded mass of the chest wall, elevation of the diaphragm, and compression of a protruding abdomen. Dyspnea on exertion may result because the depth of breathing (i.e., tidal volume) is compromised, and the only way increased ventilation can occur is by increasing the individual’s breathing frequency. Varied indices of breathing economy may be adversely affected, such as the minute ventilation/oxygen consumption slope or the minute ventilation/carbon dioxide production slope (Gallagher et al., 2005), as well as associated responses, including hypoxia, hypercapnia, respiratory acidosis, somnolence, and pulmonary hypertension. Conversely, these pulmonary abnormalities may exacerbate the obesity because the breathlessness on exertion stimulates the afflicted individuals to avoid moderate-to-vigorous physical activity (Buskirk, 1971).

Individuals with the metabolic syndrome may also be susceptible to altered cardiovascular, hemodynamic, and thermoregulatory responses to exercise. During a progressive treadmill walk, obese individuals demonstrate a higher heart rate and SBP at any given work rate as compared with their leaner counterparts (Alexander, 1964). Because subcutaneous fat provides thermal insulation against cold, performance of a given submaximal workload in the cold is accomplished by the obese person with a lower body surface temperature but a higher core temperature than a lean person. On the other hand, performance of a fixed work rate involving transport of body weight in a warm environment causes greater thermal strain on the obese (Buskirk, 1971). The added heat stress results in a higher heart rate and core temperature and a greater sweat rate than in the lean individual.
Exercise Programming and Progression Guidelines

Because obesity is at the core of the metabolic syndrome, the exercise program should generally follow the guidelines published by the American College of Sports Medicine (ACSM) for the treatment of overweight and obese clients (BMI ≥25 kg/m² and ≥30 kg/m², respectively) (Jakicic et al., 2009), but other components of the cluster of risk factors associated with the condition (i.e., dyslipidemia, hypertension, and if applicable, diabetes) also should be considered. Overall, individuals with the metabolic syndrome have an increased risk of mortality and morbidity from cardiovascular disease and developing diabetes as compared to their age- and gender-matched counterparts without this syndrome. Accordingly, a careful cardiovascular assessment including peak or symptom-limited exercise testing should be considered before beginning a vigorous (≥60% V\textsubscript{O\text{2}} reserve) exercise training program.

\[ V_{O2\text{reserve}} = \text{percent intensity} \times \left( V_{O2\text{peak}} - V_{O2\text{rest}} \right) + V_{O2\text{rest}} \]

Both the American College of Cardiology/American Heart Association guidelines on exercise testing and the ACSM guidelines recommend exercise testing before vigorous training can be conducted with clients with diabetes mellitus (Thompson et al., 2007).

Type of Exercise

Aerobic (or endurance) exercise has been the most frequently studied mode of exercise, and has consistently resulted in improvements in the components of the metabolic syndrome (Shahid & Schneider, 2000). The most effective exercises for the endurance phase employ large muscle groups, are maintained continuously, and are rhythmic in nature, such as walking, jogging, elliptical training, stationary or outdoor cycling, swimming, rowing, stair climbing, and combined arm-leg ergometry. Clearly it is difficult to achieve an adequate volume of exercising muscle (and caloric expenditure) if the lower extremities are excluded. Other exercise modalities commonly used in physical-conditioning programs for clients with the metabolic syndrome include calisthenics, particularly those involving sustained total-body movement; recreational games; and resistance training. The latter is a particularly important option, since traditional aerobic-conditioning regimens often fail to accommodate participants who have an interest in improving muscular strength and endurance. Moreover, studies have shown that muscular strength is inversely associated with all-cause mortality (FitzGerald et al., 2004) and the prevalence of the metabolic syndrome (Jurca et al., 2005), independent of cardiorespiratory fitness levels.

Walking has several advantages over other forms of exercise during the initial phase of a physical-conditioning program. Brisk walking programs can result in a substantial increase in aerobic capacity and a reduction in body weight and fat stores, particularly when the walking duration exceeds 30 minutes (Pollock et al., 1971). Walking offers an easily tolerable exercise intensity and causes fewer musculoskeletal and orthopedic problems of the legs, knees, and feet than jogging or running. Moreover, it is a “companionable” activity that requires no special equipment other than a pair of well-fitted athletic shoes. Walking in water, with a backpack, or with a weighted vest are additional options for those who seek to lose body weight and fatness and improve cardiorespiratory fitness.

Because most overweight/obese clients prefer to walk at moderate intensities, it is helpful to recognize that walking on level ground at 2 and 3 mph (3.2 and 4.8 km/h) approximates 2 and 3 METs, respectively. For clients who prefer the slower walking pace (2 mph; 3.2 km/h), each 3.5% increase in treadmill grade adds approximately 1 MET to the gross energy cost. For example, if a client desires to walk at a 2 mph (3.2 km/h) pace, but requires a 4-MET workload for training, he or she would be advised to add 7% grade to this speed. For clients who can negotiate the faster walking speed (3 mph; 4.8 km/h), each 2.5% increase in treadmill grade adds an additional MET to the gross energy expenditure. Accordingly, a workload of 3.0 mph (4.8 km/h) at a 5.0% grade would approximate an aerobic requirement of 5 METs. Using this practical rule can be helpful to the ACE-certified Advanced Health & Fitness Specialist (ACE-AHFS) in
counseling clients regarding walking workloads for training.

Although resistance exercise has generally been considered to be less effective in treating individuals with the metabolic syndrome, some reviews suggest that high-volume resistance training has independent and additive effects to an aerobic exercise program for virtually the entire cluster of associated cardiovascular risk factors (Braith & Stewart, 2006; Williams et al., 2007). For example, numerous studies show that resistance training improves insulin action, significantly decreases glycosylated hemoglobin (HbA1C) and blood pressure in diabetic and hypertensive adults, respectively, and reduces total body-fat mass and visceral adipose tissue in both men and women. In addition, the maintained or enhanced muscle mass resulting from chronic resistance training is associated with a modest increase in basal metabolic rate (BMR) which, over time, may facilitate greater success at weight reduction than can be achieved with aerobic exercise alone. Weight training has been shown to attenuate the rate-pressure product when any given load is lifted (McCartney et al., 1993), which may reduce cardiac demands during daily activities such as carrying packages or lifting moderate-to-heavy objects. There are also intriguing data to suggest that strength training can increase muscular endurance capacity without an accompanying increase in cardiorespiratory fitness (Hickson, Rosenkoetter, & Brown, 1980).

Despite the widely cited CDC/ACSM exercise guidelines (Pate et al., 1995) and the much-heralded Surgeon General’s report (United States Department of Health and Human Services, 1996), the traditional model for getting people to be more physically active (i.e., a regimented or structured exercise program) has been only marginally effective. The skyrocketing prevalence of the metabolic syndrome (approximately 47 million U.S. adults, or nearly 25% of the population) suggests the need for "real world" interventions designed to circumvent and attenuate barriers to achieving an adequate daily energy expenditure. Accordingly, the ACE-AHFS should counsel clients to integrate multiple short bouts of physical activity into their daily lives. The Activity Pyramid (Figure 11-4) has been suggested as a model to combat America’s increasingly hypokinetic

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**Figure 11-4**
The Activity Pyramid

Source: Adapted from The Activity Pyramid © ParkNicolletHealthSource,® Minneapolis, U.S.A. Used with permission.
environment (Leon & Norstrom, 1995). This schematic presents a tiered set of weekly goals to promote improved aerobic fitness and health, building on a base that emphasizes the importance of accumulating at least 30 minutes of moderate-intensity activity on five or more days per week (Haskell et al., 2007).

**Intensity and Duration**

Structured exercise training sessions should include a preliminary aerobic warm-up (approximately 10 minutes) followed by stretching activities, a conditioning phase (30 minutes or more), a cool-down (five to 10 minutes), and ideally, an optional recreational game. The warm-up facilitates the transition from rest to the conditioning phase by stretching postural muscles and increasing blood flow. More important, a gradual warm-up may reduce the potential for exercise-induced ischemic responses, which can occur with sudden strenuous exertion (Barnard et al., 1973). A walking cool-down enhances venous return during recovery, reducing the possibility of post-exercise hypotension and related sequelae. In addition, it facilitates more rapid removal of lactic acid than stationary recovery and ameliorates the potential deleterious effects of the post-exercise rise in plasma catecholamines (Dimsdale et al., 1984).

There is some controversy regarding the most appropriate exercise intensity and duration that are needed to optimally train individuals with the metabolic syndrome (Shahid & Schneider, 2000). Different risk factors associated with this condition may optimally respond to different exercise dosages. For example, a randomized, controlled trial of sedentary, overweight men and women with mild-to-moderate dyslipidemia compared the effectiveness of three different exercise regimens versus controls: high-amount, high-intensity exercise; low-amount, high-intensity exercise; and low-amount, moderate-intensity exercise (Kraus et al., 2002). Although all exercise groups had better responses on a variety of lipid and lipoprotein variables than the control group, the most beneficial effect of exercise was seen most clearly with the high amount of high-intensity exercise. Because the metabolic syndrome has been associated with a sedentary lifestyle and low cardiorespiratory fitness, the initial exercise program should approximate at least 30% of the $V\text{O}_2$ reserve or 60% of maximal heart rate (Swain & Franklin, 2002) for a minimum accumulated duration of 30 minutes. Over time, the exercise intensity should be increased to 50 to 75% $V\text{O}_2$ reserve (or maximal heart-rate reserve) to provide the stimulus to improve cardiorespiratory fitness and facilitate a progressive overload (i.e., attainment of goal energy expenditure).

**Frequency**

The frequency of exercise is an important consideration when structured exercise and/or increased lifestyle activity are used to treat the abnormalities associated with the metabolic syndrome, especially insulin sensitivity and glucose utilization. Because much of the benefit of exercise is related to the cumulative effects of individual bouts of exercise, exercising five or more times a week is ultimately necessary to maximize benefits.

A summary of the physical-activity recommendations for clients with the metabolic syndrome is shown in Table 11-4, with specific reference to the FITT principle (frequency, intensity, time, and type of exercise) variables required to provide a safe and effective exercise program.

**Case Study**

James, a 57-year-old asymptomatic male, is interested in starting a weight-reduction program, including exercise. His medical history reveals that he is obese, pre-diabetic, has hypertension and hyperlipidemia, is currently sedentary, does not smoke cigarettes, and has a family history of premature atherosclerotic cardiovascular disease (i.e., his father suffered his first acute myocardial infarction at 53 years of age). James is currently taking Toprol XL® (metoprolol SR) 50 mg once daily for hypertension, Lipitor® (atorvastatin) 40 mg once daily for hyperlipidemia, Niaspan® (niacin extended-release tablets) 500 mg twice daily for a reduced HDL level, and aspirin 81 mg once daily for prophylaxis of acute myocardial infarction. Because he has three or more components of the metabolic syndrome, or takes medications to control them, he is considered to have the metabolic syndrome.
Immediately prior to the exercise test, in the standing position, his heart rate was 76 bpm and blood pressure was 152/94 mmHg. During the exercise test, James demonstrated infrequent unifocal premature ventricular contractions (PVCs) and occasional premature atrial contractions (PACs) but did not develop chest discomfort, lightheadedness, or significant ST-segment depression. The test was terminated after five minutes because of volitional fatigue [ratings of perceived exertion (RPE) of 18/20, signifying “very hard” work] and increasing dyspnea (3/4, corresponding to “moderately severe” shortness of breath), indicating an estimated functional capacity of 6.6 METs. He achieved a peak heart rate and blood pressure of 136 bpm (83% of his estimated maximal heart rate) and 186/92 mmHg, respectively. His blunted peak heart rate was most likely attributed, at least in part, to his beta-blocker therapy for hypertension.

On physical examination, his height and weight are 5’7” (1.7 m) and 255 pounds (115 kg), corresponding to a body mass index of 40 kg/m². He has a waist circumference of 46 inches (117 cm); seated resting blood pressure of 146/94 mmHg; resting pulse of 64 beats per minute (regular); and a fasting plasma glucose of 122 mg/dL. With the exception of a low HDL (37 mg/dL), his serum lipids and lipoproteins are at the goal level. The remainder of the physical examination was unremarkable from an exercise programming perspective (e.g., no limiting orthopedic or musculoskeletal problems).

James performed a peak or symptom-limited exercise stress test to volitional fatigue using the conventional Bruce treadmill protocol. He intends to exercise at a health club after work and the exercise test was performed in the late afternoon. James typically takes his metoprolol SR after breakfast and was instructed to do so on the morning of the exercise test.

### Table 11-4
Physical-activity Recommendations for Clients With the Metabolic Syndrome: The FITT Principle*

<table>
<thead>
<tr>
<th>Component</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td><strong>Five days per week or daily.</strong> More frequent structured exercise bouts are desirable, but care should be taken to initially establish a regular exercise habit (3–5 days/week); 3–4 sessions per week are required to elicit beneficial metabolic effects, whereas 4–5 sessions per week (or more) may be needed to reduce body weight and fat stores.</td>
</tr>
<tr>
<td>Intensity</td>
<td><strong>30/45–75% ( \dot{V}O_2 )reserve.</strong> To avoid musculoskeletal injuries and maximize compliance, start at a light-to-moderate intensity and gradually progress over the course of several weeks or months to vigorous exercise (≥60% ( \dot{V}O_2 )reserve or heart-rate reserve) (if desired by the client). Initially emphasize increasing duration rather than intensity, with the goal of optimizing caloric expenditure.</td>
</tr>
<tr>
<td>Time</td>
<td><strong>30 to 90 minutes/day, using a gradual progression.</strong> Multiple shorter periods of exercise (10–15-minute exercise bouts) accumulated throughout the day may elicit similar (or even greater) reductions in body weight and fat stores as a single long bout of the same total duration.</td>
</tr>
<tr>
<td>Type**</td>
<td><strong>Low-impact activities (walking, low-impact aerobics, cycling).</strong> These activities are convenient, accessible, and perceived as enjoyable by the client, supplemented by adjunctive resistance training to assist in the maintenance of basal metabolic rate and an increase in daily lifestyle activities (walking breaks at work, gardening, household work).</td>
</tr>
</tbody>
</table>

*FITT: frequency, intensity, time, and type of exercise provide a framework of evidence-based recommendations for a safe and effective exercise program.

† \( \dot{V}O_2 \)reserve formula = \((\dot{V}O_2 \text{peak} – \dot{V}O_2 \text{rest}) \times 30–75\% \text{ intensity} + \dot{V}O_2 \text{rest}\), where \( \dot{V}O_2 \) values are expressed as metabolic equivalents (METs).

‡ A light-to-moderate intensity workout approximates 50–76% of the maximal heart rate or a rating of perceived exertion of 11–13 (“fairly light” to “somewhat hard”) on the 6–20 category exertion scale.

**Aerobic exercise should be preceded by a warm-up (approximately 10 minutes) and followed by a cool-down (5–10 minutes) at a reduced exercise intensity (e.g., slow walking). Stretching (5–10 minutes) may be incorporated before or after the endurance exercise phase.
Based on James’ medical history, physical examination, and graded exercise test results, the following exercise program was formulated.

**Aerobic exercise program:**
- Type: Treadmill walking and combined arm-leg ergometry
- Frequency: Initially three days/week; increase gradually to five to seven days/week
- Duration: Initially 15 to 20 minutes/session, which may be accumulated in two 10-minute exercise bouts; to build up gradually to 45 to 60 or more minutes/session by adding approximately five minutes each week as tolerated
- Intensity: Target heart rate set at 40–75% heart-rate reserve = 100–121 bpm and target RPE (6–20 scale) set at 11–14; target MET range initially set at 40–75% VO2 reserve = 3.2–5.2 METs). Estimated treadmill workloads at the lower end of this intensity range (approximately 3.2 METs) might be 2.0 mph, 3.5% grade or, for clients who prefer a faster walking pace, 3.0 mph, 0% grade.

James was informed that the time interval between his taking metoprolol SR and exercise training could modify his heart-rate response to exercise, since the effects of beta-blocker therapy are not necessarily uniform over time. Moreover, he was counseled about the importance of warming up and cooling down, as well as the significance of warning signs and symptoms (e.g., heart rhythm irregularities, exertional chest pain or pressure, lightheadedness, unusual shortness of breath) that require the cessation of exercise and immediate medical review.

**Resistance exercise program:**
James was counseled to complement his aerobic exercise regimen with resistance training. Initially, he was advised to perform one set of 10 to 15 repetitions of eight to 10 different exercises that condition the major muscle groups on two or three days/week. He was advised regarding appropriate lifting and breathing techniques (e.g., avoid the Valsalva maneuver), and encouraged to increase the weight/resistance gradually

[approximately 2 to 5 pounds/week (0.9 to 2.25 kg/week) for arms and 5 to 10 pounds/week (2.25 to 4.5 kg/week) for legs] as tolerated.

**Lifestyle activity:**
James was also counseled to integrate multiple short bouts of walking into his daily routine. To this end, he purchased a quality pedometer to enhance his awareness of daily physical activity by progressively increasing step totals. Baseline ambulatory studies conducted over one week revealed that he took approximately 3000 steps/day on average. He was advised to add at least an additional 500 steps/day each week, to ultimately increase his daily step totals to 8000 to 10,000 steps/day. Moreover, he was provided a “log” to document and track his progress in this regard.

**Summary**
Obesity and insulin resistance largely account for the pathogenesis of the metabolic syndrome. Although overall body weight and relative adiposity as reflected in the BMI identify the greater than two-thirds of Western populations at risk for the metabolic syndrome, those with excessive intra-abdominal adiposity are particularly susceptible.

The cornerstone treatment of the metabolic syndrome is therapeutic lifestyle modification to reduce body weight and fat stores, increase physical activity, and transition to an anti-atherogenic diet. Although lifestyle intervention is often overlooked in clinical practice, this non-pharmacologic approach has been shown to reduce cardiovascular risk and prevent or delay progression to diabetes. The ACE-AHFS can play an important role in providing a safe and effective exercise program that corresponds with the lifestyle-intervention component of metabolic syndrome treatment. Because obesity is at the core of the metabolic syndrome, the ACE-AHFS should generally follow the guidelines published by ACSM for the treatment of overweight and obese clients when designing exercise programs for this population. Aerobic exercise, resistance training, and increased lifestyle activity are recommended for individuals with the metabolic syndrome.
References


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Hunt, K.J. et al. (2004). National Cholesterol Education Program versus World Health Organization


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**Suggested Reading**


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About The Author
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Chapter 12

Diabetes Mellitus

Larry S. Verity

Only three decades ago, physical exercise for persons with diabetes—also called diabetes mellitus—was frowned upon. In fact, diabetes was seen as an excuse to avoid exercise. Questions continue to be asked regarding whether a person with diabetes can safely participate in exercise or physical activity.

Questions that an ACE-certified Advanced Health & Fitness Specialist (ACE-AHFS) may be asked include the following:

- Does exercise actually help a person with diabetes or does it hamper his or her condition?
- Can exercise actually control diabetes?
- Is it safe for persons with diabetes to exercise at any time?
- Do diabetes complications affect the ability to regularly and safely participate in exercise?

To answer these questions, the ACE-AHFS must have a solid understanding of the different types of diabetes to recommended exercise interventions for individuals with this disease, identify practical aspects of physical activity for diabetics, and design and modify exercise programs to improve disease management and health outcomes. This chapter provides a thorough overview of the different types of diabetes, the benefits and risks of exercise for this disease, and assessments that may be performed by the ACE-AHFS that could aid in the design of a safe and effective exercise program.

Epidemiology

According to the Centers for Disease Control and Prevention (CDC, 2011), an estimated 26 million people in the United States have diabetes, with more than 6 million undiagnosed cases, while prevalence is approximately 8.3% of the population. Type 2 diabetes mellitus (T2DM) accounts for 90 to 95% of all cases of diabetes mellitus, and there is a slightly greater prevalence in men (11.8%) versus women (10.8%) (CDC, 2011). The burden of diabetes disproportionately affects minorities. The prevalence rates are about twofold greater in Hispanic Americans, African Americans, Native Americans, Asians, and Pacific Islanders when compared with non-Hispanic whites. Type 1 diabetes mellitus (T1DM) accounts for 5 to 10% of all cases of diabetes (CDC, 2011). Although T1DM is one of the most commonly diagnosed chronic diseases in children, diagnosis of T2DM in youth has risen dramatically over the past decade (American Diabetes Association [ADA], 2000).

The ACE-AHFS should realize that diabetes mellitus is a heterogeneous disease composed of three primary categories: T1DM, T2DM, and gestational diabetes mellitus (GDM) (ADA, 2004a). Diagnostic and classification criteria of diabetes focus on cause and pathogenesis (ADA, 2007a). The two major etiopathogenetic categories of diabetes are T1DM and T2DM, each of which has distinguishing characteristics (Table 12-1). All persons with diabetes have elevated blood glucose levels, or hyperglycemia, caused by either an absolute or relative lack of insulin, along with abnormal protein and fat metabolism (ADA, 2007b). Low blood glucose, or hypoglycemia, occurs most often in T1DM, but persons with T2DM and GDM can also experience episodes of hypoglycemia, although these are infrequent (ADA, 2004b; 2004a; 2007b). Acute complications can occur when hypoglycemia or hyperglycemia are present for relatively short periods of time.
Table 12-1
Distinguishing Characteristics of Type 1 and Type 2 Diabetes Mellitus

<table>
<thead>
<tr>
<th></th>
<th>T1DM</th>
<th>T2DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synonyms</td>
<td>Insulin requiring (formerly: juvenile onset)</td>
<td>Non-insulin requiring (formerly: adult onset)</td>
</tr>
<tr>
<td>Former Abbreviation</td>
<td>IDDM</td>
<td>NIDDM</td>
</tr>
<tr>
<td>Age of Onset</td>
<td>&lt;30 years</td>
<td>&gt;30 Years</td>
</tr>
<tr>
<td>Cases of Diabetes in U.S.</td>
<td>5–10%</td>
<td>90–95%</td>
</tr>
<tr>
<td>Pathological Factor</td>
<td>Auto-immune deficiency</td>
<td>Family history</td>
</tr>
<tr>
<td>Insulin Use</td>
<td>100%</td>
<td>~27%</td>
</tr>
<tr>
<td>Body Weight History</td>
<td>Recent weight loss</td>
<td>Weight gain</td>
</tr>
<tr>
<td>Obese at Diagnosis</td>
<td>Uncommon</td>
<td>Common (~80% obese)</td>
</tr>
<tr>
<td>Insulin Production</td>
<td>None</td>
<td>Deficient</td>
</tr>
<tr>
<td>Ketoadicodic Episodes</td>
<td>Common</td>
<td>Uncommon</td>
</tr>
<tr>
<td>Response to Diet Alone</td>
<td>Absent</td>
<td>In some mild forms</td>
</tr>
<tr>
<td>Insulin Resistance</td>
<td>Uncommon; may be present</td>
<td>Common</td>
</tr>
</tbody>
</table>

Diabetes mellitus increases the risk for cardiovascular disease, along with other complications. Most notably, macrovascular, microvascular, and nerve disease complications are commonly linked to hyperglycemia and diabetes. An ACE-AHFS should know whether a client has complications, which reflect the severity and duration of the disease and may contribute to accelerated morbidity and excessive mortality.

Diabetes mellitus afflicts 11.3% of American adults over the age of 20 years (CDC, 2011). Interestingly, 20.9% of people from 60 years and older have diabetes, while one in three people born in the United States in the year 2000 are projected to develop diabetes in their lifetime (Narayan et al., 2003). Overall, diabetes contributes to more than 230,000 deaths in the U.S. each year (CDC, 2011), with heart disease being the leading cause of diabetes-related deaths. The presence of diabetes-related complications (DRCs) exacerbates morbidity and increases the likelihood of physical limitation or disability (ADA, 2007a). Hyperglycemia for extended periods is linked with chronic abnormalities that worsen macrovascular, microvascular, and neural disease processes. As shown in Table 12-2, DRCs can be quite serious. Because of the daily fluctuations in blood glucose that occur in diabetes, therapeutic interventions are focused on the effective management and control of blood glucose and heart disease risk factors, along with prevention of DRCs (ADA, 2007a; Buse et al., 2007; Grundy et al., 1999).

Table 12-2
Diabetes-related Complications

- Coronary heart disease death rates in adults with diabetes are two to four times higher than in adults without diabetes.
- Stroke risk is two to four times higher among adults with diabetes.
- Hypertension is present in approximately 73% of adults with diabetes.
- Retinopathy is the leading cause of new cases of blindness among adults 20 to 74 years old.
- Diabetic nephropathy is a leading cause of end-stage renal disease, accounting for 43% of new cases.
- Neuropathy, mild to severe forms of nervous system damage involving peripheral motor sensory nerves and autonomic nerves, affects approximately 65% of people with T1DM or T2DM.
- Severe forms of diabetic nerve disease are major contributing causes of lower-extremity amputations; more than 60% of non-traumatic lower-limb amputations in the United States occur among people with diabetes.

Etiology of Type 1 Diabetes Mellitus

T1DM usually afflicts persons younger than 30 years old, and is an immune-mediated disease that selectively destroys
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the pancreatic beta cells, leading to a “central defect” in insulin release upon stimulation, or hypoinsulinemia (waning of the insulin dose), and resultant hyperglycemia (ADA, 2007a).

Serologic markers of pancreatic beta-cell destruction [(e.g., islet cell autoantibodies, insulin autoantibodies, glutamic acid decarboxylase (GAD), and human leukocyte antigens (HLA)] are common at diagnosis and provide evidence for its autoimmune nature (ADA, 2004a).

Onset of T1DM is usually abrupt and accompanied by “classic” signs of diabetes, including frequent urination (polyuria), constant hunger (polyphagia), excessive thirst (polydipsia), and unexplained weight loss (ADA, 2004a). An absolute lack of insulin production in T1DM requires exogenous insulin administration (e.g., injections, pump, or inhalation) to maintain normal glucose levels, minimize complications, and prevent excessive use of fatty acids for energy, resulting in ketoacidosis.

Ketoacidosis occurs when a high level of ketones (beta hydroxybutyrate, acetoacetate) are produced as a by-product of fatty-acid metabolism. In T1DM, the combination of deficient insulin and increased counter-regulatory hormones (e.g., catecholamines, cortisol, glucagon) results in excessive ketone production and metabolic acidosis. Diabetic ketoacidosis (DKA) can result from an infection, but is more commonly linked to a lack of insulin, dehydration, and failure to manage glucose levels. Signs and symptoms of DKA include confusion, gastrointestinal (GI) upset, extreme thirst, lethargy, and a fruity breath odor (ADA 2004c; 2007a). DKA is a serious health issue for individuals with T1DM and, if left untreated, can result in coma or death.

Etiology of Type 2 Diabetes Mellitus

T2DM usually afflicts persons older than 30 years of age, and is directly related to insulin resistance (ADA, 2007a). In 2007, the American Heart Association put forth an educational program entitled The Heart of Diabetes: Understanding Insulin Resistance to help individuals with T2DM reduce their risk for heart disease and stroke. For those with T2DM, insulin resistance creates a health burden that worsens the ability to manage blood glucose, and significantly increases morbidity and mortality associated with vascular complications of diabetes (ADA, 2007a; Cerosimo & DeFronzo, 2006). The pathology and natural history of T2DM onset is illustrated in Figure 12-1. Interestingly, onset of T2DM may actually be present approximately 10 years prior to diagnosis.

The role of diabetes and insulin resistance in advancing heart disease and DRCs, or disorders of the eyes, kidneys, heart, blood vessels, and nerves, is well established (ADA, 2007a; AHA, 2007). T2DM is highly linked with typical cardiovascular disease (CVD) risk factors, such as obesity, hypertension, and dyslipidemia (ADA, 2007b). Alarmingly, the incidence of T2DM in children and adolescents has increased in recent years, to the point where approximately 85% of children diagnosed with T2DM are overweight or obese at diagnosis, presumably related to increased levels of obesity secondary to excess caloric intake and too little caloric expenditure (ADA, 2000). To this end, the ACE-AHFS must have a solid understanding of T2DM onset to develop an effective exercise program that can aid in managing T2DM and countering the common coexisting conditions of this disease.

Varying degrees of endogenous insulin production (e.g., normal or elevated) are present in T2DM, which is characterized by insulin resistance or a relative lack of activity in insulin-sensitive tissues to maintain normoglycemia (i.e., normal glucose levels) (ADA, 2007a). Insulin resistance is considered a “peripheral defect” because of a decrease in insulin-mediated uptake and storage of glucose in the liver and skeletal muscle. Reduced insulin receptor binding at target tissues and impaired post-receptor activities related to insulin function manifest as insulin resistance. Central to postreceptor deficiencies are abnormal translocation of muscle glucose transporters (GLUT-4) and insulin receptor substrates (IRS) that perform important intermediary phosphorylation processes (ADA, 2004a). Interestingly, these
abnormalities are reversible through weight loss, proper diet, and physical activity (Albright et al., 2000; ADA, 2007a). The hyperglycemia present in T2DM suggests that insulin release is inadequate to compensate for the insulin resistance. Over time, the pancreas loses its ability to produce insulin, and the need for exogenous insulin to control blood glucose increases (ADA, 2007a).

Control of glucose levels in T2DM is essential to prevent hyperosmolar hyperglycemic nonketotic syndrome (HHNS), an emergency condition in which elevated glucose levels are accompanied by dehydration without ketones in the blood or urine (ADA, 2004c). Usually, HHNS affects individuals with T2DM and, if not treated over several days to weeks, can lead to coma or death.

Onset of T2DM is associated with genetic, environmental, and cultural factors (ADA, 2004a; 2007a). The risk of T2DM rises with family history, age, obesity, and inactivity. About 80% of adults and 85% of adolescents with T2DM are obese and physically inactive, both of which are related to increased insulin resistance (CDC, 2011). Lifestyle interventions focusing on weight loss and physical activity are essential strategies to manage diabetes (ADA, 2007a), lessen the onset of DRCs (Acilio et al., 2002; Vinik & Erbas, 2002; Waxman & Nesto, 2002), prevent the onset of T2DM [Ruderman, 2002; Diabetes Prevention Program Research Group (DPP), 2005], and prevent the onset of CVD (Buse et al., 2007; Cerosimo & DeFronzo, 2006; Grundy et al., 1999).

Etiology of Gestational Diabetes Mellitus

The ACE-AHFS should have a sound understanding of all types of diabetes, including the type that occurs during pregnancy. In essence, GDM is an inability to maintain normal glucose or any degree of glucose intolerance during pregnancy, despite being treated with either diet or insulin. GDM occurs in about 7% of all pregnancies (ADA, 2004b). High-risk factors for developing GDM include obesity, personal or family history of GDM, and glycosuria (an excretion of glucose in the urine) (ADA, 2004a; 2007b; 2007a). GDM is usually diagnosed by an oral glucose tolerance test between 24 and 28 weeks of gestation. If GDM is diagnosed, therapeutic strategies are used to monitor and manage maternal blood glucose to prevent fetal macrosomia and maternal
complications (ADA, 2004b). GDM resolves postpartum, yet many women who experience GDM eventually develop T2DM. Although not identical in pathophysiology, GDM resembles etiologic features of T2DM, including obesity, insulin resistance, family history, and physical inactivity (ADA, 2004b; 2007a). As in T2DM, GDM onset is related to genetic predisposition, insulin resistance, and subsequent deficient insulin release (ADA, 2004a; 2007b). Management of GDM focuses on interventions similar to those that are commonly recommended in T2DM. However, insulin therapy, not oral agent therapy, is usually initiated when glucose control is not achieved (ADA, 2004). Referring women with GDM to an exercise setting that can provide heart-rate monitoring of both mother and fetus is the most appropriate action for the ACE-AHFS, as women with GDM typically require close medical supervision during exercise.

Clinical Features of Diabetes Mellitus

The diagnosis of diabetes mellitus is based on established criteria (ADA, 2004a; 2007b) (Table 12-3). After diagnosis, clinical emphasis is placed on frequent blood glucose monitoring (i.e., three to six glucose checks per day) in conjunction with diet and physical activity to control glucose levels and reduce the risk of complications (ADA, 2007a). Glycemic control is assessed using glycosylated hemoglobin (HbA1C), which reflects a time-averaged blood glucose concentration over the previous two to three months. The recommended A1C goal is set at less than 7.0%, which is approximately 1% above the non-diabetic range (A1C <6.0%), and it is recommended that it be assessed every three to four months (ADA, 2007b; 2007a).

Assessment of overall health, especially identification of coexisting CVD risk factors and DRCs, is an essential component of effective diabetes care (ADA, 2007b; 2007a). A relatively new term has been used to address the complex relationship between diabetes and cardiac risk—cardiometabolic risk. The existence of multiple risk factors for CVD, along with metabolic- and diabetes-specific factors, creates an unusually increased likelihood for those with diabetes to develop CVD (Figure 12-2). Recommendations focus on aggressive management of CVD risk factors (ADA, 2007a; Buse et al., 2007). Glucose-lowering agents are the primary medications used in diabetes management, supplemented by drugs to prevent CVD, such as antihypertensive drugs, lipid-lowering agents, and antiplatelet medications (ADA, 2007a; CDC, 2011).

Whereas body weight is usually normal in T1DM, obesity prevails in T2DM and GDM. Body mass index (BMI) often exceeds 30 kg/m² and abdominal girth is often large [men ≥40 inches (102 cm); women ≥35 inches (88 cm)] in those with T2DM, placing many patients at high risk for CVD and cancer [ADA, 2007b; National Institutes of Health (NIH) and National Heart, Lung, and Blood Institute (NHLBI), 1998]. Therefore, weight loss is a primary treatment goal to improve insulin action in persons with T2DM (ADA, 2007a).

The Metabolic Syndrome

The metabolic syndrome (MetS), also called insulin-resistance syndrome or syndrome X, is commonly seen in T2DM (Grundy et al., 1999) and is linked to physical inactivity, diet, and genetic factors [Joint National Committee (JNC) on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, 2003]. The MetS is characterized by a constellation of disorders, including insulin resistance, obesity, central adiposity, glucose intolerance,
dyslipidemia, and hypertension (Table 12-4) (NIH/NHLBI, 1998). The presence of the MetS substantially increases the risk of developing both T2DM and cardiovascular disease. Insulin resistance is a cornerstone in diagnosing MetS and appears to worsen the risk for CVD and hasten the onset of T2DM. Insulin resistance is also commonly present in most individuals with T2DM.

Table 12-4
Criteria for the Diagnosis of the Metabolic Syndrome (MetS)

At least three of the following factors must be present for MetS to be confirmed:
- SBP ≥ 130 mmHg or DBP ≥ 85 mmHg
- Fasting glucose ≥ 110 mg/dL
- HDL cholesterol < 40 mg/dL for men and < 50 mg/dL for women
- Triglycerides ≥ 150 mg/dL
- Waist circumference ≥ 40 inches (102 cm) for men and ≥ 35 inches (88 cm) for women

Note: SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL = high-density lipoprotein


Pathological Consequences of Diabetes Mellitus

Diabetes leads to a variety of metabolic, physiologic, vascular, and neural problems. The pathology of this disease results in DRCs that primarily affect the macrovascular (e.g., cardiovascular disease, peripheral vasculature, cerebral vasculature), microvascular (e.g., small vessels of the retina and kidney), and neural (e.g., peripheral motor and sensory nerves, and autonomic nerves) systems. It is important to note that these DRCs are not always present in clients with diabetes. Diabetes self-management principles suggest maintaining near-normal glucose levels and managing CVD risk factors to reduce the risk for complications. In essence, good metabolic control is associated with a significant reduction in vascular and neural diabetes complications.

Macrovascular, microvascular, and nerve disease complications are commonly linked to hyperglycemia and diabetes (ADA, 2007a; AHA, 2007; Buse et al., 2007). DRCs reflect the severity
and duration of the disease and contribute to accelerated morbidity and excessive mortality in diabetics. Diabetes increases mortality risk from CVD. Thus, the ACE-AHFS must know the health profile of any client with diabetes to ensure safe and effective exercise participation, while also minimizing risks for untoward outcomes.

**Macrovascular Disease**

Large-vessel disease, or macrovascular disease, is common in persons with diabetes. One type of macrovascular disease, **coronary heart disease**, is accelerated in people with diabetes and leads to premature morbidity and mortality. Additionally, diabetes contributes to an accelerated atherogenic process in other large vessels, including those in the lower extremities (peripheral vasculature) and in the brain (cerebral vasculature). Lower-extremity complications usually limit the weightbearing tolerance of afflicted individuals and contribute to a greater risk of non-traumatic amputations. **Cerebral vascular disease** is another serious complication worsened by high blood pressure that increases the risk of stroke in people with diabetes. Consequently, knowing whether a client with diabetes has macrovascular disease is a crucial part of the pre-activity screening process. If macrovascular disease is present, obtaining physician approval of exercise and modifying the assessment, programming, and leadership accordingly is prudent.

Multiple, coexisting risk factors for macrovascular disease are commonly present in T1DM and T2DM, as indicated by the cardiometabolic risk profile in diabetes (Buse et al., Grundy et al. 1999). As in non-diabetic populations, modification of CVD risk factors (e.g., smoking, elevated lipid levels, high blood pressure, and physical inactivity) aid in minimizing the risk of macrovascular disease (ADA, 2007a). Additionally, T2DM is the most common form of diabetes among individuals of older age or with obesity, visceral fat, **insulin resistance**, hypertension, dyslipidemia, and inactivity, which commonly coexist, and thus, increase the risk for macrovascular disease (ADA, 2007a; AHA, 2007; Buse et al., 2007; Grundy et al., 1999).

Physiological and metabolic abnormalities of diabetes that are believed to exacerbate the macrovascular atherogenic process are glucose intolerance, hyperglycemia, and insulin resistance (Cerosimo & DeFronzo, 2006). Though there may be different mechanisms responsible for the pathogenesis of atherosclerosis in T1DM and T2DM, modification of CVD risk factors (ADA, 2007a; Buse et al., 2007; Grundy et al., 1999) and improvement of glucose control (ADA, 2003a; 2003b) and insulin sensitivity (Cerosimo & DeFronzo, 2006) are keys to lessening the risk of atherosclerotic vascular disease.

**Microvascular and Neural Complications**

Small-vessel diseases, or microvascular complications, and nerve diseases are common outcomes of long-standing diabetes. Usually, the onset of **microvascular disease** progressively contributes to failure of the target tissue involved. The three different types of microvascular and neural complications are **retinopathy** (eye disease), **nephropathy** (kidney disease), and **neuropathy** (nerve disease). These complications of diabetes are the leading causes of new blindness, end-stage renal disease and kidney failure in adults, and nervous system damage leading to numerous amputations, respectively (see Table 12-2). Moreover, these complications affect work performance and tolerance, as well as the mode and intensity of work performed. The ACE-AHFS must know whether microvascular complications exist to safely and effectively devise an exercise program for a client with diabetes.

Interestingly, near-normalization of blood glucose reduced the risk for onset and/or progression of microvascular disease in T1DM by over 50% (ADA, 2003a), and similar outcomes for T2DM have been published (ADA, 2003b). Compelling data link diabetes complications with poor blood glucose control, and provide diabetes healthcare professionals with persuasive evidence about the importance of vigilant management of metabolic factors through **self–blood glucose monitoring** [SBGM] to prevent or delay the progression of complications. Thus, an ACE-AHFS can help in diabetes management by encouraging clients to
maximize glucose control and regulation, while lessening the progression of small-vessel complications in these clients.

**Glucose Regulation**

Precise hormonal and metabolic events that normally regulate glucose homeostasis are disrupted in diabetes because of defects in insulin release, action, or both, and result in an excess release of counter-regulatory hormones. Glucose control requires near-normal balance between hepatic glucose production and peripheral glucose uptake, combined with effective insulin responses. In diabetes, an inability to precisely match glucose production with glucose use results in daily glucose excursions that require regular glucose monitoring and adjustments in the dosage of exogenous insulin or oral agent, combined with adjustments in dietary intake, particularly when anticipating exercise or physical activity.

The ACE-AHFS should have a general understanding of common medications that are prescribed for individuals with diabetes mellitus, their action(s), and the impact of exercise with respect to the medication. Classically, there are different diabetes medications that aid in controlling blood glucose. The ACE-AHFS should recognize that medication is taken by injection/infusion or orally.

**Insulin Injections or Continuous Subcutaneous Insulin Infusion**

Individuals with T1DM require multiple daily insulin injections or must use an insulin pump—also called continuous subcutaneous insulin infusion (CSII)—to facilitate glucose uptake and control glucose levels (ADA, 2007a). An insulin pump can be used by some individuals to manage T2DM and GDM. Insulin administered by syringe is injected into subcutaneous tissue using a rotation of sites, including the abdomen (fastest absorption rate), upper arms, lateral thigh, and buttocks (Berger, 2002). CSII is subcutaneously delivered only in the abdominal area.

Insulin administered by syringe can be rapid-acting (peak action: 30 minutes to one hour) (Humalog®), short-acting (peak action: two to three hours) (Regular), intermediate-acting (peak action: four to 10 hours) (Humulin L or N), or long-acting (peak action: sustained for 20 to 24 hours) (Humulin U). A mixed dose of different types of insulin produces a more normal glucose response and is used most commonly in T1DM. Usually, rapid-acting insulin is used with CSII. Exercise can accelerate the mobilization of insulin if the injection site is in the exercising muscle. Therefore, it is essential that the ACE-AHFS understands the importance of avoiding injection of insulin into working muscle. Also, insulin dosage (pump or injection) can be reduced prior to exercise to avoid hypoglycemia. Frequent adjustments in insulin administration are generally needed to effectively manage diabetes. These insulin adjustments involve a trial-and-error process that requires an understanding of insulin action and the impact of exercise, food intake, and medication on glucose excursions, combined with frequent routine SBGM (Berger, 2002; Toni et al., 2006).

There are also two injectable medications that aid glucose management and are used by individuals with T1DM and/or T2DM: Byetta® (exenatide or exendin-4) and Symlin® (pramlintide), a synthetic form of amylin, which is a hormone co-released from pancreatic beta cells with insulin (Joy, Rogers, & Scates, 2005; Ryan, Jobe, & Martin, 2005). For the ACE-AHFS, the main exercise-related concern with these medications is that they both delay the emptying of food from the gut after a meal and could slow the release of ingested carbohydrates taken to prevent or treat low blood glucose levels during a bout of exercise. Consequently, to err on the side of safety, neither Byetta nor Symlin should be injected within two hours prior to scheduled physical activity.

**Oral Hypoglycemic Agents**

Oral agents are widely prescribed for individuals with T2DM when onset is recent and little or no insulin is taken (e.g., <20 units) (ADA, 2007a). As with insulin injections, oral agents are prescribed individually or in combination to optimize glucose control in T2DM. Four major groups of oral agents are used to control glucose:
beta-cell stimulants for insulin release, drugs to improve insulin sensitivity, drugs to abate intestinal absorption of carbohydrates, and drugs to extend the action of insulin. Their mechanisms of action and effects on exercise are discussed in the following sections.

**Beta-cell Stimulants for Insulin Release**

Sulfonylurea and meglitinide drugs are taken at mealtime to stimulate insulin release and manage *postprandial glycemia*. Because of insulin stimulation, these oral agents can lead to hypoglycemia with or without exercise. The prolonged length of action in these oral agents increases the risk for low blood glucose and requires more frequent monitoring during exercise. Sulfonylureas include the following:

- Chlorpropamide (Diabinese®)
- Glipizide (Glucotrol® and Glucotrol XL®)
- Glyburide (Micronase®, Glynase®, and Diabeta®)
- Glimepiride (Amaryl®)
- Repaglinide (Prandin®) and nateglinide (Starlix®) are the only meglitinides currently on the market (ACSM, 2010). The ACE-AHFS should recognize that individuals taking these types of longer-lasting oral hypoglycemic medications will need to check their blood glucose levels more often when exercising (and afterward). When exercise becomes a habit, it is a good idea to encourage these clients to check with their healthcare providers about lowering their medication doses, particularly if they are experiencing more frequent low glucose readings with exercise.

**Drugs to Improve Insulin Sensitivity**

The thiazolidinediones [rosiglitazone (Avandia®) and pioglitazone (Actos®)] improve insulin sensitivity at muscle and adipose tissue, and the biguanides [e.g., metformin (Glucophage® and Glucophage XR®)] promote muscle glucose uptake and inhibit hepatic glucose output overnight. Consequently, these types of medications have little effect on exercise responses. Insulin sensitizers mainly improve the action of insulin at rest, not during exercise, so the risk of them causing exercise-associated hypoglycemia is very low (ACSM, 2010).

**Drugs to Abate Intestinal Absorption of Carbohydrates**

*Alpha-glucosidase inhibitors* [acarbose (Precose®) and miglitol (Glyset®)] decrease the carbohydrate absorption rate and slow the increase in postprandial blood glucose level. These medications do not directly affect exercise, but can delay effective treatment of hypoglycemia during activities by slowing the absorption of carbohydrates ingested to treat this condition (ACSM, 2010).

**Drugs to Extend the Action of Insulin**

Dipeptidyl peptidase-4 inhibitors (DDP-4 inhibitors) are the newest class of oral diabetic drugs. The primary action of these drugs is to extend the action of insulin, but they may not increase the risk of exercise-induced hypoglycemia in individuals with type 2 diabetes who are already being treated with metformin (Charbonnel et al., 2006).

**Diabetes Management**

Exercise intervention for persons with diabetes involves a multidisciplinary team of specialists that includes the diabetes physician, diabetes nurse educator, registered dietician, and exercise specialist to facilitate patient education and necessary lifestyle changes to manage this disease (ADA, 2007a). Intensive SBGM, combined with balancing diet, oral drugs or exogenous insulin (or both), and exercise are the established cornerstones of therapy to facilitate near-normal to normal metabolic function (ADA, 2007a). In general, management of blood glucose level in diabetes involves a planned regimen of insulin or oral medication (or both), frequent SBGM, an individualized medical nutrition therapy (MNT) plan, and participation in a regular physical-activity program. Self-management skills are essential to the successful management of diabetes. The use of diabetes self-management education (DSME) is also an important tool to improve control (ADA, 2007a). The use of a continuous glucose monitoring system (CGMS) has been shown to improve the management of diabetes, but remains a limited therapeutic intervention due to third-party reimbursement issues.
The primary goal of therapy for all diabetics focuses on SBGM to achieve acceptable blood glucose control (A1C <7.0%), thereby limiting the development and progression of DRCs (ADA, 2007a). Both T1DM (ADA, 2003a) and T2DM (ADA, 2003b) show reduced risk for retinopathy, nephropathy, and neuropathy with intensive therapy and the potential for a reduction of cardiovascular disease with improved glycemic control. Glycemic control is best achieved through SBGM combined with nutrition, adjustment of medications, and physical activity.

The ACE-AHFs should address the ABC’s of diabetes with respect to clients’ health (AHA, 2007):
- A1C% (glycosylated hemoglobin): <7%; checked at least twice a year
- Blood pressure: <130/80 mmHg; checked at every doctor’s visit
- Cholesterol: LDL <100 mg/dL; checked at least once a year

Managing the ABC’s of diabetes aids in reducing cardiometabolic risk and managing risk for CVD onset. Cardiovascular risk factors, along with symptomatic and asymptomatic CVD, are common in diabetes (ADA, 2007b; Buse et al., 2007; Cerosimo & DeFronzo, 2006). Identification of macrovascular disease and comorbidities of diabetes and aggressive intervention are crucial in minimizing their progression, particularly factors linked with the MetS (Buse et al., 2007; Grundy et al., 1999). CVD morbidity and mortality in diabetes can be favorably affected through lifestyle interventions. Prudent lifestyle interventions in diabetes care focus on minimizing progression of CVD through the management of CVD risk factors. Lifestyle strategies lower CVD risk factors by favorably modifying blood pressure, blood lipids, glucose tolerance, and body weight. Lifestyle strategies for managing CVD risk in diabetes include the following (ADA, 2007a):
- Dietary intervention where calories and fat intake are restricted
- Weight management and/or weight loss
- Regular physical activity
- Smoking cessation
- DSME

The coexistence of multiple CVD risk factors and hyperglycemia requires a vigilant risk factors intervention to lessen risk and prevent CVD (Buse et al., 2007).

**Therapeutic Interventions for Diabetes Mellitus**

The cornerstones of diabetes therapy for self-management of this disease include insulin (or oral drugs), diet, and exercise, as well as a focus on blood glucose regulation. The primary goal of treating diabetes is not only to normalize glucose metabolism, but also to delay or prevent disease complications common to diabetes. Therapeutic strategies for diabetes treatment encompass various allied health professionals in conjunction with the physician to enhance self-care management of the disease (Figure 12-3). The ACE-AHFs is part of the diabetes management team and can help in motivating clients to safely and regularly participate in physical activity. Also, proactive communication with other members of the diabetes treatment team (e.g., personal physician, nurse educator) to ensure the safety and effectiveness of a physical-activity program is an essential responsibility of the ACE-AHFS.

**The Role of Exercise in Diabetes Management**

Regular physical activity and exercise offer multiple well-known health benefits for both T1DM and T2DM (Table 12-5). Mild-to-moderate intensity exercise may assist with daily glucose regulation on a short-term basis for both T1DM and T2DM, which may explain the role of regular exercise to favorably alter metabolic functions related to glucose metabolism. Regular exercise helps lessen CVD and cardiometabolic risk factors, such as mild to moderate hypertension, insulin action and resistance, glucose metabolism, vascular inflammation and altered vascular reactivity, impaired fibrinolysis, and abnormal lipid profiles. Also, regular exercise favorably affects not only cardiovascular and metabolic health, but also the psychological and cognitive health of individuals with T1DM and T2DM. Clearly, the ACE-AHFS should understand the benefits of chronic exercise and its adaptations in clients with diabetes.
Long-term Benefits of Exercise in T1DM

Current knowledge about the long-term benefits of regular exercise on various health aspects offers a persuasive rationale for persons with T1DM to participate in physical activities. While effective exercise programming is based upon an understanding of short-term benefits, it is the benefits of chronic exercise that help to maximize health and manage risks for CVD and DRCs.

A single session of exercise acutely lowers blood glucose in individuals with T1DM for a variable amount of time, as long as the pre-exercise blood glucose level is approximately 250 mg/dL or less. The synergistic effect of exercise and insulin on lowering blood glucose is well established, and is the typical focus regarding the role of exercise as part of diabetes management. As the pre-exercise blood glucose increases beyond 250 to 300 mg/dL (with or without ketones), exercise causes skeletal muscle to increase blood glucose utilization; however, the relative amount of glucose use is countered with an excessive amount of glucose production from the liver. Thus,
the ACE-AHFS should understand that the pre-exercise blood glucose has an effect on the exercise-related blood glucose response. Requiring blood glucose checks for all individuals with T1DM before and after exercise is a safe and effective strategy to minimize untoward outcomes of exercise.

In T1DM, aerobic capacity has been suggested to be lower than that of non-diabetic, healthy individuals (Riddell & Iscoe, 2006). Nonetheless, physical training through aerobic workouts and/or resistance training is commonly recommended for individuals with T1DM who are without complications. Such individuals tend to exhibit chronic exercise benefits similar to those observed in non-diabetics (ADA, 2004d). However, regular exercise is not effective for improving blood glucose control of T1DM and should not be the sole means of controlling blood glucose (ACSM, 2010; ADA, 2004d; Verity, 2010). Adjusting therapeutic medication and nutritional regimens is an important management strategy for individuals with T1DM, along with SBGM (ADA, 2004d). Although regular exercise improves metabolism in individuals with T1DM, it does not facilitate the desired level of metabolic control. The ACE-AHFS should help educate clients on daily use of SBGM, insulin adjustment, and nutritional needs combined with regular exercise to facilitate the management of glucose.

The ACE-AHFS should recommend regular physical exercise for cardiovascular conditioning and modification of cardiovascular risk factors in individuals with T1DM, rather than only as a means for better glucose control. Research suggests that cardiovascular training in T1DM favorably alters common CVD risk factors, including blood lipids, blood pressure, insulin resistance, and glucose control (ADA, 2004d; Giannini, Mohn, & Chiarelli, 2006; Herbst et al., 2005). Therefore, improving aerobic fitness and muscular fitness in individuals with T1DM is central to improving cardiovascular health and lessening CVD risk.

The ACE-AHFS must understand that physical training (e.g., cardiorespiratory or resistance training) enhances the sensitivity of peripheral tissue to insulin action in T1DM, as is commonly reflected by reduced daily insulin dosage (Berger, 2002; Giannini, Mohn, & Chiarelli, 2006; Riddell & Iscoe, 2006). While physical activity augments insulin-mediated glucose disposal into skeletal muscle and improves insulin action, physical inactivity independently improves glucose uptake through important glucose transport activities (e.g., GLUT-4) (Zierath, 2002). Physical activity has a short-term, or transient, effect on glucose transport because insulin sensitivity begins to decline within days after physical activity ceases.

To minimize insulin needs and maximize insulin action, regular exercise participation is strongly recommended for individuals with T1DM.

Beyond the physiological and metabolic benefits of chronic exercise, the psychological benefits of regular exercise for those with T1DM are beginning to receive attention. The rigors of diabetes management are emotionally stressful, particularly for young children and adolescents. Depression is common in people with T1DM and can adversely influence adherence to diabetes self-management regimens and result in poor glycemic control (Lustman & Clouse, 2005; Lustman et al., 2000; Van Tillburg et al., 2001). Because of poor glycemic control, T1DM can also increase the risk for diabetes complications (de Groot et al., 2001). Given that regular exercise may help lessen physiological reactivity to mental stressors, it may help reduce stress, thereby enhancing psychological well-being, lessening depressed feelings, and improving the quality of life for individuals with T1DM (Zacker, 2004). Chronic exercise is a powerful tool for those with T1DM to empower themselves to keep control of their lives. The ACE-AHFS must continually promote the mind-body value of exercise for individuals with T1DM.

**Long-term Benefits of Exercise in T2DM**

Of the many coexisting conditions presented in T2DM, insulin resistance is central to muscle glucose metabolism and numerous health-related problems that only worsen the health profile. Consequently, the strategic focus of therapeutic interventions in waging war against these combined health risks is to manage glucose levels and reverse insulin resistance, or improve insulin sensitivity, which favorably affect glucose metabolism,
glucose control, lipid metabolism, inflammatory reactions, and vascular wall functions—all while focusing on the reduction of cardiometabolic risk. Individuals with T2DM may also suffer from abnormal insulin secretion and hepatic and peripheral insulin resistance. Obesity, hyperglycemia, hyperinsulinemia, dyslipidemia, and physical inactivity also contribute to insulin resistance. Presently, diabetes management includes strategies to not only control blood glucose levels, but also to lessen morbidity and mortality in T2DM via aggressive lifestyle interventions.

In addition to glucose control through self-management skills, T2DM interventions also include nutritional changes, weight loss, CVD risk-factor management, and physical activity. These strategies are recommended based on results of the Diabetes Prevention Program (2005), where modest lifestyle changes—including dietary changes in line with current recommendations, weight loss between 5 and 7%, and increased physical activity—reduced the risk of T2DM onset by 58% in those with impaired glucose tolerance. Just as these lifestyle strategies are used to prevent the onset of T2DM, the same strategies can be implemented secondarily to lessen the progression of cardiometabolic risks associated with T2DM (Buse et al., 2007).

The favorable effects of regular exercise have been reported for insulin signaling (Zierath, 2002), insulin resistance (Praet & van Loon, 2007), and T2DM (Albright et al., 2000; Sigal et al., 2004). It can be stated that the more that individuals with T2DM engage in physical activity throughout each week, the lower the insulin levels and the greater the insulin sensitivity or the lower the insulin resistance. To maximize health benefits, regular aerobic and resistance exercise, combined with individualized nutrition therapy, are the key weapons used to combat T2DM and insulin resistance (Buse et al., 2007; Sigal et al., 2007; Stewart, 2002). The combined therapeutic interventions promote myriad beneficial health outcomes, including improved cardiovascular and metabolic functions (Cerosimo & DeFronzo, 2006), reduced risk of cardiac morbidity and mortality (Buse et al., 2007), and favorable changes in lipids and lipoproteins (increased HDL; decreased triglycerides and LDL), blood pressure, body weight, fat-free mass (maintained or decreased), fat mass, body-fat distribution and morphology, insulin sensitivity and insulin concentrations, and glucose metabolism (ADA, 2004d; Albright et al., 2000; Sigal et al., 2004). Also, strength training has been shown to improve muscle function and quality, while increasing insulin sensitivity in individuals with T2DM (Castenada et al., 2002; Cheng et al., 2007; Dunstan et al., 2002; Sigal et al., 2007). Most importantly, the glucose metabolic defects found in previously sedentary individuals with T2DM are reversed with exercise, while both insulin signaling and exercise signaling of glucose transport are markedly improved with moderate-intensity exercise performed consistently over time (Zierath, 2002). Consequently, regular exercise training improves glucose control (e.g., A1C) in T2DM, primarily through improved insulin signaling and insulin sensitivity. These combined physiological changes can actually lower daily medication dose (e.g., insulin and/or oral agent) for individuals with T2DM.

Interestingly, increased energy expenditure through aerobic exercise and/or strength training is independently linked with reducing insulin resistance, while improving insulin sensitivity. Both physical activity/aerobic exercise and muscle-strengthening activities have been shown to improve insulin-mediated glucose uptake, GLUT-4 transporters, insulin signaling capabilities, and insulin sensitivity—all of which are essential in glucose metabolism and management. In general, exercise training appears to reverse inflammatory markers and postreceptor insulin signaling defects, and encourage intramuscular and abdominal fat use, while simultaneously lowering the metabolic and atherosclerotic risks associated with T2DM (ACSM, 2010; ADA, 2007a; Grundy et al., 1999; Stewart, 2002; Zierath, 2002).

Additionally, regular exercise may favorably alter stress-related psychological factors and cognitive function in diabetes. Depression is common in people with diabetes (de Groot et al., 2001; Engum et al., 2005; Lustman & Clouse, 2005; Lustman et al., 2000). Unfortunately, depression can interfere with the management of diabetes and

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worsen glucose control in T2DM. Because glucose control plays a pivotal role in minimizing the risk for complications, individuals with T2DM are at increased risk for diabetes complications. Thus, regular exercise may assist in countering depression/anxiety, while improving glucose control and lessening the risk for complications. Moreover, non-traditional exercise modalities in which mind-body interventions are the focus have become more popular and have been integrated into the overall programs of clients with diabetes (Rice, 2001). For example, tai chi, yoga, and Pilates are becoming more common as alternative exercises for clients with T2DM. These types of exercise not only improve functional fitness and flexibility, but also aid in glucose management. Because the mind-body interventions aid in self-care and self-knowledge, there is a psychological outcome that has important outcomes for those with T2DM. Furthermore, regular exercise may enhance psychological well-being and quality of life for individuals with T2DM when other therapies fail (Zacker, 2004). The ACE-AHFS must recognize the value of traditional and non-traditional exercise to facilitate improved diabetes management and health outcomes in individuals with T2DM.

Pre-exercise Screening and Client Assessment

The diabetes management team must encourage clients to participate in physical activity. While regular exercise carries significant benefits, the risks are also undeniable. It is best to proceed cautiously. Before initiating exercise with clients who have diabetes, the ACE-AHFS must acquire information about his or her client to ensure safe and effective participation in physical activity. By implementing the pre-activity questionnaires (e.g., PAR-Q and PARmed-X), the ACE-AHFS will have crucial information about the client’s current health and risk factors, evidence of any DRCs and physical limitations, and exercise-intensity recommendations from the physician. Thus, the pre-activity questionnaires provide an excellent opportunity for the ACE-AHFS to obtain important health information about a client with diabetes. Assessment of clients with diabetes includes the following key areas related to diabetes:

- Medical information
- Physician approval
- Lifestyle and habits questionnaire
  - ✓ PAR-Q (see Figure 1-3; page 14)
  - ✓ PARmed-X (see Figure 1-4; page 15)
- Pre-test screening
- Health-related fitness assessment

Medical Information and Physician Approval

For most clients with diabetes, physician approval is the first step to safely beginning an exercise program. Due to the high prevalence of asymptomatic coronary heart disease, there may be a need for the client with diabetes to undergo an exercise test before initiating a modest exercise program (Buse et al., 2007). The ACE-AHFS should know the health of his or her client and whether vascular and/or neural complications exist. Therefore, learning about a client’s health and clinical status is essential for the ACE-AHFS to effectively engage a client with diabetes in an exercise program. Additionally, identifying questions that reflect the potential needs of the client is encouraged, including the following:

- How long has the client suffered from diabetes?
- How long has he or she taken medication?
- Are other coexisting conditions present (e.g., hypertension, elevated lipids, smoking habits, obesity)?

Because diabetes is a disease that increases the risk for coexisting conditions, the ACE-AHFS should develop a continuing-care plan that requires clients to have periodic medical evaluations (e.g., at least one physician visit per year). These follow-up visits may identify the onset or progression of complications.

Depending on the client’s age, duration of diabetes, and presence of additional CVD risk factors or microvascular and/or nerve disease, a stress test may be advisable before the start of an exercise program (Sigal et al., 2004). Stress tests are advisable for all persons with diabetes who are older than 35 years of age, and for people who are older than 25 years of age who have had T1DM.
should ask clients to identify the daily dosage of oral medications. Oral agents to lower blood glucose for T2DM include:

- Glucotrol XL® (glipizide extended release)
- Prandin® (repaglinide)
- Amaryl® (glimepiride)
- Rezulin® (troglitazone)
- Glucophage® (metformin)
- Micronase® (glyburide)

Medication dosage can be reduced following a period of weight loss and/or physical activity. However, only the client’s physician should make changes in oral medications. The ACE-AHFS should encourage clients who are taking oral medications to regularly monitor and record their blood glucose and then provide this information to a physician, which may help the physician in determining dosage.

About 73% of all persons with diabetes develop hypertension (CDC, 2011). Hypertensive medications are outlined in Chapter 8. Drugs commonly prescribed to treat high blood pressure can adversely elevate blood glucose. These include diuretics, beta blockers, and calcium-channel blockers. Furthermore, beta blockers are known to mask the symptoms related to low blood glucose. Other hypertensive medications may actually lower blood glucose, including ACE inhibitors and alpha-adrenergic antagonists (JNC, 2003). The varying effect of hypertensive medications is further reason to monitor blood glucose.

The ACE-AHFS should follow standard fitness screening procedures (ACSM, 2010; 2009). Using a questionnaire (e.g., PAR-Q and PARmed-X) is appropriate. If the client responds positively to a question, its significance must be ascertained through a follow-up with the client’s physician. Also, if any client with diabetes has been diagnosed with CVD, or has suffered a heart attack, he or she requires medical approval to exercise. Whenever a client with diabetes presents a history of heart disease, the ACE-AHFS should refer the client to a clinical setting for supervised exercise.

**Lifestyle and Habits Questionnaire**

The ACE-AHFS should consider a number of factors before developing an exercise program for clients with diabetes. Based on current...
health profile, fitness assessment outcomes, and limitations identified by the physician, a safe and effective individualized exercise program can be devised. Central to the safety of an exercise program is ensuring the client with diabetes monitor and manage his or her blood glucose to minimize risks of exercise and onset of diabetes complications. To motivate the client, the ACE-AHFS should devise an exercise program that considers personal interests, past and/or present exercise habits, and short- and long-term goals that are achievable, as doing so is central to the client’s successful adherence to the exercise program. Because more than 70% of diabetics do not engage in regular physical activity (Ford & Herman, 1995), developing an activity program that is motivational, develops long-term habits, and addresses each client’s personal goals is key to a successful program.

Identifying the personal goals and needs in a physical-activity program is crucial to maintain the interest and focus of a client with T2DM. Additionally, past exercise habits can provide important insight regarding present exercise interests, commitments, and/or habits. Previous habits and interests can also provide information about the client’s awareness and knowledge of his or her disease, and about his or her effort in trying to control blood glucose. Glucose control is a life-long habit and helps ensure that exercise is safe and effective.

Education about the role of SBGM before and after each exercise session is usually presented in diabetes education classes. If a client with diabetes has not participated in a series of diabetes education classes, the ACE-AHFS should encourage him or her to do so. These classes will increase the client’s understanding of the disease and reemphasize the importance of regular glucose monitoring. Also, the ACE-AHFS may provide the client with a list of diabetes educators and other resources.

**Screening**

The ACE-AHFS should administer the PAR-Q, PARmed-X, informed consent, and possibly release forms, and then measure resting heart rate and blood pressure. From his or her most recent physician visit, the client with diabetes should know his or her A1C (%) and inform the ACE-AHFS of this value for baseline information. Also, the client with diabetes should bring his or her glucose meter on the day of the health-related fitness assessment and on subsequent exercise days for glucose monitoring before and after each exercise session.

Resting heart rate and blood pressure assessment are commonly used as screening aids for apparently healthy persons who wish to partake in physical activity. About 73% of persons with diabetes have hypertension. Some medications used to treat hypertension may actually lower the resting heart rate; however, resting blood pressure may remain elevated. Consequently, a client with diabetes may have a normal resting heart rate but elevated blood pressure.

A resting heart rate above 120 bpm and resting blood pressure exceeding 180/105 mmHg are contraindications to exercise (Gordon, 2002). Other contraindications to exercise follow previously established guidelines (ACSM, 2010).

**Health-related Fitness Assessment**

Fitness assessments are integral to effective exercise programming. The ACE-AHFS can chart client progression and set goals to motivate clients. Fitness evaluations may include body morphology and/or composition, cardiorespiratory fitness, and musculoskeletal fitness tests. Although fitness assessments can be administered, the ACE-AHFS may have to adapt the procedure for some clients with diabetes. Whenever testing procedures are changed, the ACE-AHFS should record the modifications of the client’s initial test so that subsequent evaluations are consistent.

**Body Morphology and/or Composition**

Excessive body weight and/or body fat is common in individuals with T2DM, while those with T1DM are commonly normal weight. Most persons with T2DM are overweight or obese (ADA, 2007b), while the distribution of body fat is predominantly in the abdominal region. This type of body morphology, or body-fat distribution, increases the risk for CVD, insulin resistance, and abnormal lipids. The preferred method to determine
body composition is by using skinfold thickness measures. The use of circumferential measures aids the ACE-AHFS in understanding the distribution of body fat, or the client’s morphology (ACSM, 2009). Normally, it is acceptable to use the same generalized equations that have established norms for age and gender of apparently healthy persons for those with T1DM. When working with individuals with T2DM, the determination of body fat is difficult and may not be very useful, as most of these individuals are obese. However, the ACE-AHFS can measure and record skinfold thickness to observe subtle changes over time. Also, circumference measures (e.g., abdominal, waist, hip) can be obtained and recorded for clients with T2DM to derive a baseline from which program goals may be targeted. Overall, these types of morphologic measures have far greater practical outcomes and can be easily compared with previous assessments.

Cardiorespiratory Fitness

Clients with diabetes tend to participate less frequently in regular physical activity than non-diabetics (Ford & Herman, 1995). Low cardiorespiratory fitness is strongly linked with cardiac mortality in individuals with diabetes (Boulé et al., 2003). Moreover, research suggests that people with T2DM consume a lower amount of oxygen than non-diabetics across different intensity levels of work (Regensteimer et al., 1995). Therefore, improving cardiorespiratory fitness is an extremely important health outcome that can be accomplished through regular participation in exercise (Boulé et al., 2003; Buse et al., 2007; Stewart, 2002). The ACE-AHFS is encouraged to use standard submaximal testing protocols to assess cardiorespiratory fitness in persons with diabetes. Also, heart-rate data and ratings of perceived exertion (RPE) should be obtained during cardiorespiratory assessments. However, administering a valid submaximal test can be difficult with diabetics.

Many persons with diabetes are hypertensive and take heart-rate-altering medications, which make a submaximal test to assess cardiorespiratory fitness invalid. In some clients, a bicycle protocol may be appropriate (e.g., YMCA protocol). To ensure the validity of submaximal outcomes, the ACE-AHFS must know whether a client has a neural condition called cardiac autonomic neuropathy, because this DRC slows the heart rate and limits the validity of submaximal protocols that assess heart-rate responses to submaximal work.

The ACE-AHFS may find field tests (e.g., 12-minute walk/run test) to be suitable for clients with T1DM, but not for those with T2DM. Performance in this type of test requires motivation to achieve a near-maximal effort and knowledge of pacing oneself. The use of a field test of this type may only be useful for those who have a recent history of regular exercise.

For those clients who undergo a stress test with their physicians, it is always a good idea to obtain a copy of this report through client consent. In cases where the cardiorespiratory fitness assessment cannot be administered, the information from a stress test can be used to aid in developing an aerobic program for a client.

Musculoskeletal Fitness

Administration of tests to assess muscle endurance, muscle strength, and joint flexibility in clients with diabetes is appropriate only in those who are not limited by diagnosed complications, especially microvascular complications (Aiello et al., 2002; Albright et al., 2000). Prior to initiating any portion of the muscular-strength and/or endurance assessments, the ACE-AHFS should ensure an appropriate medical health status, especially the absence of microvascular complications. The ACE-AHFS is encouraged to use standard testing protocols that do not use one-repetition maximum (1 RM) to assess musculoskeletal fitness in persons with diabetes (e.g., YMCA).

Guidelines for Exercise Programming

The ACE-AHFS must have a solid understanding of the client with diabetes. Some of the more distinguishing factors
to keep in mind when devising an exercise plan for diabetes clients are as follows:

- Diabetics are less active than non-diabetics. Approximately 70% of persons with diabetes are sedentary (Ford & Herman, 1995).
- Diabetics are older, perceive their health more poorly, and identify physical or orthopedic limitations four times more frequently than their non-diabetic counterparts (Ford & Herman, 1995).

Developing an exercise plan by using the FITT acronym is commonplace. Incorporating RPE to identify exercise intensity is prudent, as disease progression and complications (e.g., autonomic and peripheral neuropathy) can limit the ability to accurately assess heart rate. Additionally, the FITT program differs for those with T1DM and T2DM (Table 12-6), in that a T1DM program can emphasize exercise at a moderate to high intensity for shorter durations, while a program for individuals with T2DM can emphasize caloric expenditure where lower-intensity and longer-duration exercise is strongly encouraged. In those with T1DM without complications, exercise recommendations are closely aligned with apparently healthy persons (Wasserman & Zinman, 1994), while recommendations for those with T2DM are more closely aligned with obesity and hypertension guidelines (Sigal et al., 2004; Stewart, 2002) due to the prevalence of these comorbidities in T2DM. Also, individuals with T2DM are encouraged to engage in at least 150 minutes of moderate-intensity exercise each week (or 90 minutes of vigorous exercise each week), primarily focusing on caloric expenditure and weight-management issues (ADA, 2004d). The ACE-AHFS must consider the risk for muscular injury whenever he or she recommends higher-intensity exercise, especially for clients with T2DM. For long-term weight-loss maintenance, larger volumes of exercise (seven hours/week of moderate or vigorous activity, with an expenditure of more than 2000 kcals/week) are recommended for clients with T2DM (ADA, 2004d; Sigal et al., 2004). Consideration of personal interests, past and/or present activity habits, and the goals and needs of a physical-activity program is critical for successful participation, especially in those with T2DM (Albright et al., 2000; Praet & van Loon, 2007). Individuals who use insulin may prefer to engage in daily physical activity to improve the balance between insulin dose and caloric needs (Albright et al., 2000; ADA, 2004b; Berger, 2002).

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1DM</th>
<th>T2DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>3–7 days/week</td>
<td>3–7 days/week</td>
</tr>
<tr>
<td>Intensity</td>
<td>50–80% HRR RPE = 12–16 (6–20 scale)</td>
<td>50–80% HRR* RPE = 12–16 (6–20 scale)</td>
</tr>
<tr>
<td>Time</td>
<td>Moderate ~50–70% HRmax</td>
<td>Vigorous &gt;70% HRmax</td>
</tr>
<tr>
<td></td>
<td>20–60 minutes/session</td>
<td>At least 150 minutes/week</td>
</tr>
<tr>
<td></td>
<td>At least 90 minutes/week</td>
<td>At least 90 minutes/week</td>
</tr>
<tr>
<td>Type*</td>
<td>Walking, cycling, jogging, aquatic exercise</td>
<td>Walking, cycling, aquatic exercise, leisure activities, house- and yardwork</td>
</tr>
</tbody>
</table>

*Some individuals may need to perform non-weightbearing activity or alternate with weightbearing activities due to orthopedic limitations and/or peripheral vascular disease.

Note: HRR = heart-rate reserve; RPE = ratings of perceived exertion; HRmax = maximum heart rate

Resistance training is recommended for persons with diabetes who have no contraindications (Albright et al., 2000; ADA, 2004d) and follows apparently healthy guidelines, with age and experience as prime considerations in program development (Table 12-7). When working with clients who have diabetes complications, the ACE-AHFS must either obtain specific instructions from the physician for safe and effective participation, or refer the client to an appropriately monitored setting. Strength or resistance training appears to offer specific improvements in insulin sensitivity (Cheng et al., 2007) and glucose control in those with T2DM (Castenada et al., 2002; Dunstan et al., 2002; Sigal et al., 2007). Therefore, the ACE-AHFS is strongly encouraged to have all appropriate diabetes clients engage in resistance training to accrue its many potential benefits. Appropriate attention to modifying the intensity of the resistance-training session may lessen the risk for elevations in blood pressure and glucose, and for the onset of musculoskeletal injury (Albright et al., 2000; ADA, 2004d). Research suggests that higher-intensity resistance exercise is safe and effective in lowering A1C (Castenada et al., 2002; Dunstan et al., 2002). Caution should be reserved when recommending higher-intensity resistance exercise for those with diabetes. For safe and effective exercise participation, it is imperative that glucose levels be carefully managed. Moreover, initiation of a resistance-exercise program requires that clients do not have complications that might prevent safe and effective outcomes. To lessen exercise-induced blood pressure elevations, modifications may need to be made, including lowering the intensity of each lift, requiring higher repetitions, foregoing lifting to exhaustion, and limiting isometric contractions.

Flexibility exercises are strongly recommended for those with diabetes (Albright et al., 2000; Gordon, 2002; Verity, 2010) and aid in maintaining normal joint function. Balancing the selection of exercises between the upper and lower body, as well as for the core area, is important. Essentially, the flexibility-exercise recommendations are very similar between T1DM and T2DM (Table 12-8). The ACE-AHFS must ensure that clients do not hold their breath for the entire range of motion of any movement, even when statically holding a given stretch. Proper breathing will limit the Valsalva maneuver, which causes elevated SBP and may be detrimental to individuals with CVD or to those who have DRCs (Gordon, 2002).

### Exercise Programming in T1DM

Daily aerobic exercise has been recommended for individuals with T1DM to better

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**Table 12-7**

Recommended FITT Program for Resistance Training in Individuals With Diabetes

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1DM</th>
<th>T2DM</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Frequency</strong></td>
<td>2–3 days/week</td>
<td>2–3 days/week*</td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td>60–80% 1 RM Low-to-moderate intensity RPE ~13–16 (6–20 scale)</td>
<td>60–80% 1 RM Low intensity RPE ~11–15 (6–20 scale)</td>
</tr>
<tr>
<td><strong>Time</strong></td>
<td>8–12 reps/exercise 2–3 sets/exercise</td>
<td>8–12 reps/exercise reps (up to 20) 2–3 sets/exercise</td>
</tr>
<tr>
<td><strong>Type of exercise</strong></td>
<td>8–10 muscle groups Upper body: 4–5 exercises Lower body: 4–5 exercises</td>
<td>8–10 muscle groups Upper body: 4–5 exercises Lower body: 4–5 exercises</td>
</tr>
</tbody>
</table>

*3 days/week is strongly encouraged

*Note: T1DM = Type 1 diabetes mellitus; T2DM = Type 2 diabetes mellitus; 1 RM = One-repetition maximum; RPE = Ratings of perceived exertion*

regulate insulin dosage and diet needs for glucose control (ADA, 2003a; 2003b). Improving glucose control for individuals with T1DM is best achieved through intensive insulin therapy combined with SBGM (ADA, 2007a). Therefore, clients with T1DM are best served to follow the FITT principle in Table 12-6 and exercise three to five days per week to improve aerobic capacity and accrue other health-related benefits. The ACE-AHFS should know that exercise is not recommended for glucose control in T1DM, and that daily exercise may be unrealistic. Moreover, high-intensity activity can increase the risk of elevating blood glucose and suffering musculoskeletal injuries (Gordon, 2002; Hornsby & Albright, 2009). Clients with T1DM who do not have complications can comfortably exercise between 55 and 75% of functional capacity, or at an RPE of 11 to 14 (using the 6 to 20 scale) or 3 to 5 (using the 0 to 10 scale). Each activity session should last about 30 minutes to spur improved aerobic fitness and health-related benefits.

Finally, strength training for clients with T1DM may increase aerobic capacity, as well as increase muscle mass and improve glucose control, by increasing insulin sensitivity (Riddell & Iscoe, 2006). Clients with T1DM who do not have complications can participate in a moderate-intensity strength-training program that mimics a program non-diabetics would use (see Table 12-7). Clients with a longer history of T1DM should seek physician approval and heed limits on participation.

### Exercise Programming in T2DM

Exercise programming for individuals with T2DM follows the FITT principle (see Table 12-6). The focus of such programming is to burn calories and lose weight (ACSM, 2010; ADA, 2004d; Sigal et al., 2004). Physical activity of 40 to 60 minutes in duration at a low intensity of 40 to 60% of functional capacity (or 50 to 70% of HRmax) is appropriate for overweight/obese persons to burn an adequate number of calories. Lower-intensity walking improves aerobic capacity, insulin action, and glucose control (Boulé et al., 2001; 2003) and aids in weight management for individuals with T2DM (Yamanouchi et al., 1995). Overall, the therapeutic effects of regular exercise have enormous health benefits for those with T2DM (Praet & van Loon, 2007; Sigal et al., 2004; Stewart, 2002). Because obesity is a problem for individuals with T2DM, more moderate exercise reduces the likelihood of foot irritation and/or musculoskeletal injury (Gordon, 2002; Verity, 2010).

Exercising five to six days per week maximizes the caloric expenditure necessary for weight management. Although walking is the most convenient activity, persons with claudication pain may have to perform low- or non-weightbearing activity (e.g., swimming, aquatic exercise, stationary cycling), or alternate between weightbearing and non-weightbearing activities. Moreover, peripheral neuropathy, which may lead to foot irritation, may

### Table 12-8

**Recommended FITT Program for Flexibility Training in Individuals With Diabetes**

<table>
<thead>
<tr>
<th>Variable</th>
<th>T1DM</th>
<th>T2DM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency</td>
<td>2–3 days/week</td>
<td>2–3 days/week</td>
</tr>
<tr>
<td>Intensity</td>
<td>Stretch to ROM tightness</td>
<td>Stretch to ROM tightness</td>
</tr>
<tr>
<td>Time</td>
<td>15–30 seconds/stretch 2–4 reps/stretch</td>
<td>15–30 seconds/stretch 2–4 reps/stretch</td>
</tr>
<tr>
<td>Type of stretching exercise</td>
<td>Upper body: 4–5 exercises Lower body: 4–5 exercises</td>
<td>Upper body: 4–5 exercises Lower body: 4–5 exercises</td>
</tr>
</tbody>
</table>

*Note: ROM = Range of motion*

preclude weightbearing activities due to the possibility of foot irritation.

Finally, it may also benefit individuals with T2DM to engage in moderate-intensity resistance training (see Table 12-7), which increases muscle mass, lowers basal insulin levels, improves insulin action and sensitivity, and aids in glucose control. Resistance training is a safe, effective, and highly recommended component of a comprehensive exercise program that provides cardiovascular and metabolic benefits for those with T2DM (Hornsby & Albright, 2009). However, it is important for clients with T2DM to participate regularly in an aerobic-training program before the start of a resistance-training program. Most of these clients are severely deconditioned. Dynamic, whole-body activity in the aerobic exercise program will enhance their abilities to accommodate the muscular strength, endurance, and flexibility requirements.

**Guidelines for Exercise Leadership**

Clients with diabetes should consider numerous factors before starting an exercise program. Safety before, during, and after exercise is of paramount importance. Ensuring that clients learn certain practical information before exercising is central to safe and effective exercise participation, and providing practical exercise advice for clients with diabetes is a strong asset for an ACE-AHFS (Table 12-9).

Documenting each exercise session helps when communicating with a client’s physician about cardiovascular adaptations and metabolic changes resulting from regular exercise. A daily log may be a particularly efficient way to record vital information—both quantitative and qualitative.

In fact, a qualitative assessment of the client’s ability and performance is essential. Additionally, evaluating the client’s self-concept, self-esteem, motivation to exercise regularly, and other quality-of-life issues is important for the ACE-AHFS to understand. Any noticeable dysfunctional changes should immediately be reported to the client’s physician. These changes may include:

- An inability to accurately palpate and obtain a heart rate
- A loss of sensation in the feet or toes during weightbearing activities
- Increasing pain in the legs during weightbearing activities
- Difficulty reading the RPE chart
- Unusual forgetfulness or memory problems
- Persistent fatigue

The ACE-AHFS must evaluate the client on a daily basis and report both quantitative and qualitative information regarding the exercise session. Barring more immediate problems, written documentation can be submitted to the client’s physician on an annual basis. This documentation may compare various fitness assessments to those from the previous year. They may include the frequency and amount of daily submaximal work and heart rate, medication doses, glucose levels before and after sessions (averaged weekly or monthly), and any qualitative assessments previously described.

**Risks of Exercise in Clients With T1DM and Clients With T2DM Who Require Insulin**

Although individuals with T1DM and some individuals with T2DM require exogenous insulin derived from an injection site, or through a continuous infusion pump, exogenous insulin absorption does not mimic the normal insulin secretory pattern, especially during physical exercise. Consequently, insulin administration poses a potential problem for these individuals as they work to sustain near-normal glucose levels while exercising (Toni et al., 2006). In non-diabetics, metabolic responses to most exercise are balanced between adequate insulin release and an intricately matched glucose utilization and glucose production (Figure 12-4a). The maintenance of a normal glucose response, or euglycemia, during exercise is always achieved in normal clientele. Because of the need for exogenous insulin for diabetics, it is important
Table 12-9
Practical Tips for Clients With T1DM and T2DM When Engaging in Exercise

Check with your physician.
- Clients may need to limit the intensity of physical activity, especially if disease complications are present.
- Clients may need to join a supervised program for guidance and assistance, especially if they have not been physically active for a long period of time.

Utilize self-blood glucose monitoring (SBGM).
- Clients should perform SBGM before and after each physical-activity session. SBGM is excellent cognitive training for diabetics to understand individual glucose response to physical activity. It is important to ensure that blood glucose is in relatively good control before engaging in purposeful exercise. If blood glucose is:
  - >250 mg/dL with ketones, physical activity should be postponed
  - <100 mg/dL, the client should eat a snack consisting of carbohydrates and recheck blood glucose before exercising
  - Between 100 and 250 mg/dL, physical activity can be safely performed

Keep a daily log.
- Clients should record the value and the time of day the SBGM is performed and the amount/timing of any pharmacologic agent (e.g., oral drugs or insulin). Also, they should include approximate time (minutes), intensity (heart rate), and distance (miles or meters) of each activity session. This information will aid the diabetic in understanding the type of response to possibly expect from specific physical-activity bouts.

Plan for an exercise session.
- How much activity is anticipated (e.g., time and intensity)?
- If needed, clients should carry extra carbohydrate feedings (~20–30 g of carbohydrate per 30 minutes of exercise).

Exercise with a partner.
- Exercising with a partner affords a “support system” for the physical-activity habit. Initially, diabetics should exercise with a partner until glucose response is known. Ideally, a partner who accompanies the physically active diabetic will be a source of social support and encourage continued participation in this healthy lifestyle.

Wear a diabetes I.D.
- Never leave home without it. Hypoglycemia or other problems can arise that require an understanding of the condition.

Wear good shoes.
- Proper-fitting and comfortable footwear can minimize foot irritations and sores, and reduce the occurrence of orthopedic injuries to the foot and lower leg.

Practice good hygiene.
- Clients should always take extra care to inspect their feet for any irritation spots to prevent possible infection. They should tend to all sores immediately and report hard-to-heal sores to a physician. Clients can prevent irritations when physically active by using Vaseline™ on the feet and wearing socks inside-out.

Modify caloric intake accordingly.
- Through frequent SBGM, caloric intake can be regulated more carefully on days of, and following, physical activity. For those clients requiring insulin, blood glucose can drop significantly after physical activity and latent post-exercise hypoglycemia can be prevented via SBGM. Also, in consultation with the client’s physician, a decrease in insulin dosage may be necessary.

for the ACE-AHFS to identify the risks for individuals with T1DM and T2DM who wish to safely participate in exercise.

Insulin injection therapy for most individuals with T1DM typically consists of multiple-dose insulin injections, while those who use CSII infuse a single type of fast-acting insulin (Toni et al., 2006). In some clients with T2DM, insulin is commonly introduced into an existing treatment regimen of oral medications as a single evening or bedtime dose of basal insulin. Because of this regimen, those with T2DM are less likely to experience the common risks of insulin injections/infusions observed in those with T1DM. Exogenous insulin absorption is not well regulated and results in varying degrees of insulin excess or deficiency in the peripheral blood. Insulin levels are very important during the increased metabolic demands of physical exercise. In T1DM, several factors influence the
blood glucose response to exercise, including the time of the insulin injection; the location of insulin injection (e.g., active vs. non-active muscle); pre-exercise glucose; pre-exercise nutrition; intensity and duration of the exercise session; and the novelty of the exercise performed (Toni et al., 2006).

Given so many factors to regulate, it is not surprising that physical exercise brings about unpredictable blood glucose responses in individuals with T1DM. Because of the dependency on exogenous insulin and an inability to regulate the absorption of insulin, people with T1DM commonly oscillate between insulin excess and insulin deficiency. Hence, the degree of “insulinization” and the level of blood glucose before the start of exercise determine the blood glucose response during and after exercise for those with T1DM. In well-controlled or well-insulinized T1DM clients, a single session of moderate exercise brings about normal metabolic responses. Under certain conditions, blood glucose may increase or decrease, depending on insulin levels (Figure 12-4).

**Hypoinsulinemia**

Hypoinsulinemia, or insulin deficiency, results in elevated blood glucose and ketone bodies before exercise (Figure 12-4c). Insulin-deficient diabetics rely heavily upon free fatty acids (FFA) as a primary energy source, which leads to elevated ketones in the blood and urine.

What happens when an insulin-deficient client exercises? As work increases, there is an increase in metabolic functions to provide adequate fuel for the body. Unfortunately, a person with inadequate insulin is not able to adequately regulate blood glucose levels, and therefore experiences an increase in blood glucose, along with an increase in FFA use and ketone production. Exercise seems to worsen hyperglycemia in an insulin-deficient state because insulin action does not promote normal metabolic functions. Clients with diabetes should use SBGM before exercise, as this is the safest way to determine whether exercise will help improve insulin action and lower glucose levels.

**Figure 12-4**

Schematic illustration of the blood glucose response to exercise. (A) Non-diabetic response or ideally controlled T1DM where hepatic glucose production matches skeletal muscle glucose utilization and blood glucose does not change. (B) Hyperinsulinemia, or excessive insulin, results in low hepatic glucose production and enhanced skeletal muscle glucose uptake, yielding a low blood glucose, or hypoglycemia. (C) Hypoinsulinemia, or insulin deficiency, results in elevated counter-regulatory hormones, causing an imbalance between excessive hepatic blood glucose production and an inadequate skeletal muscle glucose uptake, thereby yielding an increase in blood glucose. (D) The stress of high-intensity exercise, competition, or heat can dramatically increase counter-regulatory hormones that increase hepatic glucose output with diminished skeletal muscle glucose uptake resulting in hyperglycemia.

*Note: ↑= Increase; ↓= Decrease; ↔ = No change; ↑↑= Large increase*

Exercise-induced Hyperglycemia

During heavy, or high-intensity, exercise in clients with T1DM, glucose levels increase because of stress responses to the intensity of work that result in excessive release of glucose from the liver and limit skeletal muscle glucose use. Typically, the T1DM is in good control prior to exercise and the elevation of blood glucose is singularly due to the stressors of high-intensity exercise. Therefore, the ACE-AHFS should always have his or her T1DM clients check their blood glucose to enhance effective management of their exercise-induced responses.

Hyperinsulinemia

Hyperinsulinemia, or high insulin levels, usually occurs when exogenous insulin is accelerated by increased muscle contraction and blood flow (Figure 12-4b). This situation can cause exercise-induced hypoglycemia. Insulin injection into non-active muscle is recommended on exercising days, although the strict use of non-active muscle as an injection site may not prevent hypoglycemia during exercise in those with T1DM (Toni et al., 2006).

Elevated insulin levels suppress hepatic glucose production, which causes an imbalance between the rate of peripheral glucose use and production, and results in the lowering of blood glucose. Although a decrease in blood glucose is a beneficial short-term effect of exercise, prolonged exercise can bring about hypoglycemia. Consequently, blood glucose lowering is dependent upon such factors as pre-exercise levels of blood glucose and insulin, antecedent nutrition, and exercise duration and intensity. Regular SBGM and modifying food intake and insulin dose on exercise days are useful strategies to prevent hypoglycemia in clients with T1DM.

Post-exercise Hypoglycemia

Although hypoglycemia can occur during exercise, low blood glucose can develop many hours after an acute exercise bout in those with T1DM. Although short-lived, post-exercise metabolic adjustments increase the risk for hypoglycemia in the first few hours following an exercise bout. To prevent acute and late-onset hypoglycemia, strategies should combine aggressive post-exercise SBGM with the adjustment of pre- and post-exercise insulin and caloric intake, as changes in insulin dose and caloric intake are not totally effective.

Postprandial Exercise Responses

The majority of individuals with T1DM exercise after a meal, rather than in a post-absorptive, or fasted, state. Usually, persons with T1DM have glucose fluctuations with each meal, due to the relative timing of insulin injection or infusion and the rate of insulin absorption from the injection/infusion site. Mild exercise after breakfast blunts glucose elevations throughout the course of a day in those with T1DM. Exercise performed after breakfast may also prove valuable because of a reduced risk for hypoglycemia during and following exercise. However, the postprandial (i.e., after-meal) response to exercise in those with T1DM is quite variable, and is dependent upon the pre-exercise glucose level, the timing of the insulin injection and food consumption before activity, and exercise intensity and duration.

Management of Exercise Risks in Clients With Diabetes

As a client with diabetes engages in regular physical activity, are there risks associated with participation? Will he or she develop problems? If so, what are the signs and symptoms of these problems?

The ACE-AHFS should know that the most common problem encountered by exercising clients with T1DM (and some T2DM) is low blood glucose, or hypoglycemia. Hypoglycemia can occur at any time (e.g., before, during, or after exercise) and is defined as blood glucose less than 80 mg/dL. Clients may be experiencing hypoglycemia or an insulin reaction when they:

- Sweat profusely
- Are clammy and look pale
- Get shaky
- Have difficulty answering specific questions
breakfast, or at least in the morning hours. For some with T1DM, postprandial exercise aids in mitigating glucose excursions throughout the day, and leaves them less susceptible to dramatic decrements in blood glucose (Toni et al., 2006). It is also important to individualize an exercise regimen. A program must fit into a client’s schedule.

SBGM is essential for clients with T1DM and is strongly recommended for those with T2DM. Glucose monitoring is appropriate before and after exercising. Given the understanding of glucose levels, those with diabetes can minimize severe glucose shifts, especially after exercise.

Elevated blood glucose occurs in clients with diabetes who are not well insulinized because of excessive caloric intake and/or not enough insulin. Exercise will only worsen the hyperglycemia and ketone levels when pre-exercise glucose levels are elevated. Pre-exercise glucose levels exceeding 250 mg/dL with ketones indicate poor control and necessitate postponement of exercise. A log enables a management team to evaluate glucose excursions and prevent a reoccurrence. When blood glucose is high, clients with T1DM need an appropriate dosage of insulin, while those with T2DM may be able to engage in low-intensity physical activity without medication adjustment. For those with T1DM, exercise is not recommended until blood glucose is below 250 mg/dL.

High-intensity exercise has been found to elevate blood glucose from a normal to hyperglycemic level. It is believed that the role of counter-regulatory hormones on glucose production plays a major part in this type of glycemic excursion. Moderate-intensity exercise is recommended to facilitate more normal glucose levels and lessen the likelihood of musculoskeletal injury.

Progression of the Program

The progression of the aerobic and musculoskeletal programs is determined by several factors, including age, functional capacity, medical and disease complications, and personal preferences and goals (Albright et al., 2000; ADA, 2004d; Gordon, 2002). Initial changes in FITT programming for clients with diabetes should focus on the duration
of the exercise session rather than the intensity, particularly for those with T2DM. This programming adjustment can prevent blood glucose increases, provide a safe and effective workout that is not unduly taxing, and increase the likelihood that the program will be sustained.

For clients without complications, initial ability levels are quite different between types of diabetes. For example, individuals with T1DM follow a similar FITT program to that of apparently healthy persons. They can initially engage in continuous, moderate-intensity physical activity for 20 minutes, while those with T2DM may only be able to engage in low-intensity physical activity for five to 10 minutes before fatiguing. The initial phase of FITT programming for clients with T2DM requires low-intensity and short-duration (e.g., less than 15 minutes) activity at least three times per week, and preferably five times per week (Albright et al., 2000; ADA, 2004d; Sigal et al., 2004). But individuals with T1DM may not require significant modifications in the initial phase of FITT programming. By closely observing client response to a program and modifying it to prevent fatigue, the ACE-AHFS will enhance the client’s enjoyment and commitment to such a lifestyle change.

Progression of the program after the initial phase should be approached with caution, especially when working with clients with T2DM. For both types of diabetes, the duration of an activity should be increased before the intensity. The duration should be gradually increased to accommodate the ability and clinical status of each client. Because clients with T2DM are more likely to be obese and older, they may require a longer period of time to adapt to program changes. Once the client is able to exercise for a desired amount of time, programmatic changes should be small and be approached with caution to lessen the risk of undue fatigue, musculoskeletal injuries, and/or relapse.

Some clients with well-controlled T1DM may set a goal to participate in competitive athletics (e.g., 10Ks, marathons, triathlons, biathlons). A small number of these clients may require higher-intensity, longer-duration workouts. Successful participation in competitive athletics by an individual with T1DM is dependent upon rigorous SBGM, appropriate insulinization, proper nutrient intake, and regular medical visits. Still, most diabetics will not strive to compete in athletics. Instead, they will need to improve functional aspects that relate to quality of life. Because T2DM onset is related to older age, obesity, and dysfunction of physiologic and neurologic processes, the most valuable aspect of any program should relate to functional outcomes specific to each client and his or her abilities and limitations.

Medical Concerns and Disease Complications

Although complications are common in diabetes (ADA, 2007a), their existence does not preclude physical activity. Rather, there are physical-activity precautions and limitations for clients with diabetes who have one or more types of microvascular and/or neural complications. The options for diabetics with disease complications are discussed in the following sections. The ACE-AHFS should familiarize him- or herself with the many diabetic complications. Clients with diabetes-related complications should often be referred to a clinical setting where close supervision and monitoring of exercise can safely occur.

Retinopathy

Although exercise increases systemic and retinal blood pressure, there is no evidence that physical activity acutely worsens the retinopathy present in diabetes (Aiello et al., 2002). Diabetics with proliferative retinopathy who engage in low-intensity exercise can significantly improve cardiovascular function. However, systolic blood pressure should be monitored during each exercise session and limited to 20 to 30 mmHg above resting. Clients with retinopathy may exercise safely when they are properly supervised.

Clients with retinopathy should not engage in activities that require them to raise their arms over their heads, such as with certain strength-
training movements. These activities may cause systolic blood pressure to rise dramatically. Under such circumstances, increased blood pressure may increase the likelihood of retinal hemorrhaging when proliferative retinopathy is present (Aiello et al., 2002).

Nephropathy

Approximately one-third of individuals with T1DM develop nephropathy, while some clients with T2DM develop nephropathy (Mogensen, 2002). Increased blood pressure is a common precursor to worsening of this microvascular disease (ADA, 2007a). It is prudent to avoid activities that cause systolic blood pressure to rise to 180 to 200 mmHg (e.g., Valsalva maneuver, high-intensity aerobic or strength exercises), as systemic pressure increases could potentially exacerbate the progression of this disease. Persons with progressive nephropathy or end-stage renal disease may benefit from lower-intensity physical activities. Most clients with nephropathy should be referred to a clinical setting where their fragile metabolic condition may be carefully monitored. In many cases, clients with this disease participate in physical-activity sessions while undergoing renal dialysis.

Neuropathy

Neuropathy is a nerve disorder. The two main nerve diseases related to diabetes are autonomic neuropathy (AN), and peripheral neuropathy (PN). When this disease affects the autonomic nerves to the heart, it is called cardiac autonomic neuropathy (CAN). The heart rate is altered. The maximal heart rate is blunted, while resting heart rate (HRrest) increases (e.g., HRrest > 100 bpm). CAN causes hypertension and hypotension and increases the risk for exercise-induced hypotension after strenuous activity (Vinik & Erbas, 2002). Persons with AN have impaired sweating and thermoregulatory abilities and impaired hypoglycemia awareness. Persons with CAN exhibit a lower fitness level and fatigue at relatively low workloads due to the disruption in nerve innervation to the heart (Vinik & Erbas, 2002). Consequently, physical activity for these persons should focus on low-level daily activities, where mild changes in heart rate and blood pressure can be accommodated. Before beginning any exercise program for persons with AN or CAN, the ACE-AHFS should gain physician approval and proceed cautiously.

Peripheral nerve disease affects the extremities, especially the lower legs and feet. Repeated weightbearing activities on insensitive feet can lead to chronic irritation, open sores, and musculoskeletal injuries, especially fractures. Persons with PN are susceptible to overstretching due to loss of sensation, as well as infection, particularly when daily hygiene is lacking. Proper footwear for any weightbearing activity is important to prevent undetectable sores, which may turn into infections. However, people with PN should also participate in non-weightbearing activities (Vinik & Erbas, 2002). Such interventions may include aquatic exercise, recumbent cycling, chair exercises, and upper-extremity exercises. Additionally, activities requiring a full range of joint motion are highly effective in reducing stiffness due to muscle contractures. Some non-traditional exercises (e.g., yoga, Pilates, and tai chi) may be prudent for the client who has PN.

Case Studies

Case Study 1

Jim has T1DM. He is 35 years old and has had diabetes since the age of 13. He is 5’10” (1.8 m) and weighs 165 pounds (75 kg). Jim was highly involved in high school and college sports, but has not been regularly active for about 12 years. He currently uses an insulin pump and monitors his blood glucose once or twice each day. He visits his doctor each year and his self-reported health is good. He reports no diabetes-related complications and believes his A1C was 8.5% when it was measured about eight months ago. Jim’s goal is to begin an aerobic program so that he can run a 10K with his son, who is a teenager. He has come to an ACE-AHFS for professional assistance.

As a general rule, an ACE-AHFS must obtain more information about Jim’s health before developing an exercise program. According to established guidelines (ACSM, 2010), Jim is considered a higher-risk client. It is prudent for the ACE-AHFS to obtain physician approval before
When initiating the resistance-training program, the ACE-AHFS should begin at the lower end of the range of each FITT element. It is essential that Jim learns proper lifting techniques and breathing cues (e.g., breath on effort) before starting a resistance program. If Jim does the resistance-training program following the aerobic regimen, he should check his blood glucose after completing his aerobic session and resistance-training session. If there is a long delay (e.g., several hours) between the aerobic and resistance-training programs, then Jim should do the SBGM before and after each respective regimen.

Case Study 2

Jane is 55 years old and was diagnosed with T2DM about three years ago. Jane is 5’3” (1.6 m) and weighs 180 pounds (82 kg). She is currently taking an oral medication (troglitazone) for her diabetes and antihypertensive medications for her high blood pressure (ACE inhibitor: lisinopril, 40 mg; beta blocker: atenolol, 25 mg) and does not regularly monitor her blood glucose. She reports SBGM about twice per week and her A1C is about 9.0%. Jane reports that her health is good. She does not suffer from diabetes complications, but gets easily fatigued doing housework and cleaning. Furthermore, she reports that taking a 15- to 25-minute stroll with her husband at the local mall creates discomfort in her knees and hips. She has not seen her doctor in more than a year; however, her diabetes educator has encouraged her to participate in regular physical activity. She has asked the ACE-AHFS for assistance in the development of an exercise/physical-activity program. Her goals are to improve her endurance and lose about 45 pounds (20 kg).

To develop an appropriate exercise regimen, the ACE-AHFS should conduct a fitness assessment (ACSM, 2009). Results from the submaximal YMCA bicycle protocol found Jim’s aerobic fitness to be average for his age and gender. His percent body fat as determined from skinfold assessment was 17%, while his musculoskeletal fitness was good. Results from the fitness and exercise habits assessments suggest that Jim can immediately participate in aerobic activity. His desire to participate in a 10K does not preclude alternate activities (e.g., recumbent cycle ergometer, upright cycle ergometer, stair stepping). Blood glucose readings should be recorded, and if his pre-exercise blood glucose is above 250 mg/dL, the ACE-AHFS should postpone the session until his glucose is below 250 mg/dL. If Jim’s pre-exercise blood glucose is less than 100 mg/dL, he should consume about 15 to 20 grams of carbohydrates for every 30 minutes of anticipated exercise to limit hypoglycemia onset.

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applicable method of safely and effectively losing the desired weight.

Because Jane is 55 years old and has T2DM, she should complete the PAR-Q and PARmed-X questionnaires to ensure physician approval and identify possible limits in her exercise program. Her discomfort while walking requires further evaluation. The lack of regular blood glucose monitoring must be addressed, along with her elevated A1C%. The use of the questionnaires may aid physician encouragement for more frequent glucose monitoring and A1C checkups. Also, these questionnaires improve the safety and appropriateness of an exercise program for Jane.

Once the ACE-AHFS has gotten physician approval with possible information from a stress test (if needed), and disease status and limitations are obtained, he or she can develop an exercise regimen for Jane. Of greatest importance are the client’s personal interests and goals. Because Jane has difficulty with short-term weightbearing activity, the ACE-AHFS can help her choose activities that are less wearing on her joints and identify enjoyable activities that she would more likely engage in on a regular basis. Due to her desire to lose about 45 pounds (20 kg), Jane should be encouraged to seek out weight-management professionals to advise her about that goal.

Jane should exercise wherever the social stigma of obesity and overweight issues is minimized. She must feel comfortable in her exercise surroundings. This is an important issue because the wrong exercise environment could cripple her motivation to maintain her physical-activity program.

What health-related fitness assessments can be administered? One of Jane’s blood pressure medications is a heart rate–altering medication (e.g., beta blocker) that eliminates the use of a cardiorespiratory fitness assessment using sub-maximal protocols that base aerobic capacity on heart rate measurement. A field test requiring a weightbearing exercise (e.g., 1.5 mile walk/run test or a 12-minute walk/run test) is inappropriate, given her excessive weight. Fortunately, a stress test was conducted by her physician and is an excellent starting point for program development. From the stress test, resting and maximum parameters, including heart rate, blood pressure, and RPE can be identified. Jane’s physician probably determined the upper limit of exercise intensity on the PARmed-X. Based on this information, she was not to exercise at over 70% of her maximum heart rate. From this information, an individualized FITT program can be devised for Jane that focuses on the lower end of the range for each FITT element. The program must be safe, effective, reasonable, and prudent for this type of client. The FITT should look as follows:

- \( F = 4\text{–}6 \text{ days per week} \)
- \( I = 50\text{–}60\% \text{ of maximal heart rate, or RPE approximately } 2\text{–}3 \text{ (on the 0\text{–}10 scale)} \)
- \( T = 15\text{–}30 \text{ minutes} \)
- \( T = \text{alternate between weightbearing (e.g., walking) and non-weightbearing (e.g., aquatic exercise; recumbent ergometer; chair exercises) activities} \)

Body composition assessment is not necessary when someone is already known to be obese, but a morphological assessment can be easily administered. Initial measures should include body weight, selected skinfold site thicknesses, as well as abdominal, hip, and waist circumferences. These measurements provide a good baseline for serial assessments. Jane’s measurements were as follows:

- Body weight: 180 lb (82 kg)
- Abdominal skinfold: 36 mm
- Iliac skinfold: 32 mm
- Thigh skinfold: 40 mm
- Triceps skinfold: 34 mm
- Chest skinfold: 28 mm
- Waist circumference: 42 in (107 cm)
- Hip circumference: 48 in (123 cm)
- Upper-arm circumference: 18 in (46 cm)
- Thigh circumference: 22 in (56 cm)

From these measurements, it is obvious that weight loss will have a favorable impact on Jane’s anthropometric measurements. The measurements can also be motivating for Jane as she strives to improve her fitness and lose weight.

Musculoskeletal fitness should not be assessed in the initial phase of the program. Jane has enough to do at this point. Incorporating an additional routine into Jane’s activity regimen is not appropriate at the outset. As previously indicated, the ACE-AHFS should start with an aerobic
program to engage Jane in an exercise routine before initiating the resistance-training program. The ACE-AHFS must require SBGM before and after each exercise session as a prerequisite to safe exercise programming. Jane may be able to engage in low-intensity exercise (e.g., 40% HRmax) if her pre-exercise blood glucose is above 250 mg/dL. If Jane’s pre-exercise blood glucose is below 100 mg/dL, then she should consume about 15 to 20 grams of carbohydrates for every 30 minutes of anticipated exercise. Jane’s beta blocker for hypertension can mask hyperglycemia, so the ACE-AHFS should periodically check her blood pressure, especially at the start of a program. Jane is willing to come to a fitness facility two days each week. For Jane to succeed in her exercise program, she should exercise on two additional days. She should be instructed on the correct use of RPE to ensure a safe and effective exercise environment when she is not supervised.

The ACE-AHFS should always encourage clients to drink adequate amounts of water, especially clients prone to dehydration. The ACE-AHFS should also discourage clients from exercising when the temperature is above 80° F (27° C).

During the first activity session, Jane should be closely supervised and should be comfortable when exercising. The intensity level should be appropriate. She should expend energy. Also, she must accurately monitor her blood glucose. For Jane to exercise for the recommended 30- to 60-minute exercise period, she may need to alternate between a circuit of five-minute aerobic activities with 10-minute rest intervals or initiate a low-intensity aerobic interval program of similar work and rest intervals. Keep in mind that a client with T2DM must be closely monitored and given prompt feedback about accomplishments and progress. Also, the ACE-AHFS must ensure that blood glucose levels are normal when the client leaves the facility to minimize the risk of low glucose or hypoglycemia problems.

Summary

The ACE-AHFS must realize that physical activity and/or exercise is an essential part of the therapeutic regimen in diabetes management and care. Diabetes presents challenges for exercise that requires the ACE-AHFS to perform careful assessment of client status, determine client ability, and individualize the exercise program to meet the needs and goals of those with either T1DM or T2DM. Careful attention to the client and his diabetes-related comorbidities is a must for safe and effective exercise-training administration. The ACE-AHFS should also maintain close communication with each client’s physician to update progress or address any issues/concerns of the exercise program and/or responses that may need attention.
References


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Suggested Reading


American Diabetes Association (2007). Clinical practice recommendations. Diabetes Care, 30 (Suppl. 1), S1–S103.


