Cardiorespiratory Endurance

Looking Ahead

After reading this chapter, you should be able to:

- Describe how the body produces the energy it needs for exercise
- List the major effects and benefits of cardiorespiratory endurance exercise
- Explain how cardiorespiratory endurance is measured and assessed
- Describe how frequency, intensity, time (duration), and type of exercise affect the development of cardiorespiratory endurance
- Explain the best ways to prevent and treat common exercise injuries

Test Your Knowledge

1. Compared to sedentary people, those who engage in regular moderate endurance exercise are likely to
   a. have fewer colds.
   b. be less anxious and depressed.
   c. fall asleep more quickly and sleep better.
   d. be more alert and creative.

2. About how much blood does the heart pump each minute during aerobic exercise?
   a. 5 quarts
   b. 10 quarts
   c. 20 quarts

3. During an effective 30-minute cardiorespiratory endurance workout, you should lose 1–2 pounds.
   True or false?

Answers

1. ALL FOUR. Endurance exercise has many immediate benefits that affect all the dimensions of wellness and improve overall quality of life.
2. c. During exercise, cardiac output increases to 20 or more quarts per minute, compared to about 5 quarts per minute at rest.
3. FALSE. Any weight loss during an exercise session is due to fluid loss that needs to be replaced to prevent dehydration and enhance performance. It is best to drink enough during exercise to match fluid loss in sweat (usually about 6–12 ounces every 15–20 minutes of exercise); weigh yourself before and after a workout to make sure that you are drinking enough.

Fit and Well Online Learning Center

Visit the Fit and Well Online Learning Center for resources that will help you get the most out of your course!

- Study and review aids include practice quizzes, glossary flashcards, chapter summaries, learning objectives, PowerPoint presentations, Common Questions Answered, student handouts, crossword puzzles, Internet activities, and links to wellness Web sites.
- Behavior change tools include a daily fitness and nutrition journal, a behavior change workbook, sample behavior change plans, and blank behavior change logs to print and use.
- Chapter 3 resources also include three “custom chapters” that provide more in-depth information on topics of special interest—“Developing Sport and Movement Skills,” “Prevention and Care of Athletic Injuries,” and “The Environment and Exercise.”
Cardiorespiratory endurance—the ability of the body to perform prolonged, large-muscle, dynamic exercise at moderate-to-high levels of intensity—is a key health-related component of fitness. As explained in Chapter 2, a healthy cardiorespiratory system is essential to high levels of fitness and wellness.

This chapter reviews the short- and long-term effects and benefits of cardiorespiratory endurance exercise. It then describes several tests that are commonly used to assess cardiorespiratory fitness. Finally, it provides guidelines for creating your own cardiorespiratory endurance program, one that is geared to your current level of fitness and built around activities you enjoy.

**BASIC PHYSIOLOGY OF CARDIORESPIRATORY ENDURANCE EXERCISE**

A basic understanding of the body processes involved in cardiorespiratory endurance exercise can help you design a safe and effective fitness program.

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**cardiorespiratory system**  
The system that circulates blood through the body; consists of the heart, blood vessels, and respiratory system.

**pulmonary circulation**  
The part of the circulatory system that moves blood between the heart and the lungs; controlled by the right side of the heart.

**systemic circulation**  
The part of the circulatory system that moves blood between the heart and the rest of the body; controlled by the left side of the heart.

**venae cavae**  
The large veins through which blood is returned to the right atrium of the heart.

**atria**  
The two upper chambers of the heart in which blood collects before passing to the ventricles; also called auricles.

**ventricles**  
The two lower chambers of the heart from which blood flows through arteries to the lungs and other parts of the body.

**aorta**  
The large artery that receives blood from the left ventricle and distributes it to the body.

**systole**  
Contraction of the heart.

**diastole**  
Relaxation of the heart.

**blood pressure**  
The force exerted by the blood on the walls of the blood vessels; created by the pumping action of the heart.

**veins**  
Vessels that carry blood to the heart.

**arteries**  
Vessels that carry blood away from the heart.

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**FIGURE 3.1 The cardiorespiratory system.**

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**The Cardiorespiratory System**

The cardiorespiratory system consists of the heart, the blood vessels, and the respiratory system (Figure 3.1). The cardiorespiratory system transports oxygen, nutrients, and other key substances to the organs and tissues that need them; it also carries waste products to where they can be used or expelled.

**The Heart**  
The heart is a four-chambered, fist-sized muscle located just beneath the sternum (breastbone). It pumps oxygen-poor blood to the lungs and oxygenated (oxygen-rich) blood to the rest of the body. Blood
actually travels through two separate circulatory systems: The right side of the heart pumps blood to the lungs in what is called **pulmonary circulation**, and the left side pumps blood through the rest of the body in **systemic circulation**.

The following steps describe the path blood follows as it travels through the cardiorespiratory system (Figure 3.2):

1. Waste-laden, oxygen-poor blood travels through large vessels, called *venae cavae*, into the heart’s right upper chamber, or *atrium*.
2. After the right atrium fills, it contracts and pumps blood into the heart’s right lower chamber, or *ventricle*.
3. When the right ventricle is full, it contracts and pumps blood through the pulmonary artery into the lungs.
4. In the lungs, blood picks up oxygen and discards carbon dioxide.
5. The cleaned, oxygenated blood flows from the lungs through the pulmonary veins into the heart’s left atrium.
6. After the left atrium fills, it contracts and pumps blood into the left ventricle.
7. When the left ventricle is full, it pumps blood through the **aorta**—the body’s largest artery—for distribution to the rest of the body’s blood vessels.

The period of the heart’s contraction is called **systole**; the period of relaxation is called **diastole**. During systole, the atria contract first, pumping blood into the ventricles. A fraction of a second later, the ventricles contract, pumping blood to the lungs and the body. During diastole, blood flows into the heart.

**Blood pressure**, the force exerted by blood on the walls of the blood vessels, is created by the pumping action of the heart; blood pressure is greater during systole than during diastole. A person weighing 150 pounds has about 5 quarts of blood, which are circulated about once every minute.

The heartbeat—the split-second sequence of contractions of the heart’s four chambers—is controlled by nerve impulses. These signals originate in a bundle of specialized cells in the right atrium called the pacemaker or sinoatrial (SA) node. Unless it is speeded up or slowed down by the brain in response to such stimuli as danger or the tissues’ need for more oxygen, the heart produces nerve impulses at a steady rate.

**The Blood Vessels** Blood vessels are classified by size and function. **Veins** carry blood to the heart; **arteries**
carry it away from the heart. Veins have thin walls, but arteries have thick elastic walls that enable them to expand and relax with the volume of blood being pumped through them.

After leaving the heart, the aorta branches into smaller and smaller vessels. The smallest arteries branch still further into capillaries, tiny vessels only one cell thick. The capillaries deliver oxygen and nutrient-rich blood to the tissues and pass on oxygen-poor, waste-laden blood. From the capillaries, this blood empties into small veins (ve- nues) and then into larger veins that return it to the heart to repeat the cycle.

Blood pumped through the heart doesn’t reach the cells of the heart, so the organ has its own network of arteries, veins, and capillaries. Two large vessels, the right and left coronary arteries, branch off the aorta and supply the heart muscle with oxygenated blood. Blockage of a coronary artery is a leading cause of heart attacks (see Chapter 11).

The Respiratory System The respiratory system supplies oxygen to the body, carries off carbon dioxide—a waste product of body processes—and helps regulate acid produced during metabolism. Air passes in and out of the lungs as a result of pressure changes brought about by the contraction and relaxation of the diaphragm and rib muscles; the lungs expand and contract about 12–20 times per minute. As air is inhaled, it passes through the nasal passages, the throat, larynx, trachea (windpipe), and bronchi into the lungs. The lungs consist of many branching tubes that end in tiny, thin-walled air sacs called alveoli.

Carbon dioxide and oxygen are exchanged between alveoli and capillaries in the lungs. Carbon dioxide passes from blood cells into the alveoli, where it is carried up and out of the lungs (exhaled). Oxygen from inhaled air is passed from the alveoli into blood cells; these oxygen-rich blood cells then return to the heart and are pumped throughout the body. Oxygen is an important component of the body’s energy-producing system, so the cardiorespiratory system’s ability to pick up and deliver oxygen is critical for the functioning of the body.

The Cardiorespiratory System at Rest and During Exercise At rest and during light activity, the cardiorespiratory system functions at a fairly steady pace. Your heart beats at a rate of about 50–90 beats per minute, and you take about 12–20 breaths per minute. A typical resting blood pressure in a healthy adult, measured in millimeters of mercury, is 120 systolic and 80 diastolic (120/80).

During exercise, the demands on the cardiorespiratory system increase. Body cells, particularly working muscles, need to obtain more oxygen and fuel and to eliminate more waste products. To meet these demands, your body makes the following changes:

- Heart rate increases, up to 170–210 beats per minute during intense exercise.
- The heart’s stroke volume increases, meaning that the heart pumps out more blood with each beat.
- The heart pumps and circulates more blood per minute as a result of the faster heart rate and greater stroke volume. During exercise, this cardiac output increases to 20 or more quarts per minute, compared to about 5 quarts per minute at rest.
- Blood flow changes, so as much as 85–90% of the blood may be delivered to working muscles. At rest, about 15–20% of blood is distributed to the skeletal muscles.
- Systolic blood pressure increases, while diastolic blood pressure holds steady or declines slightly. A typical exercise blood pressure might be 175/65.
- To oxygenate this increased blood flow, you take deeper breaths and breathe faster, up to 40–60 breaths per minute.

All of these changes are controlled and coordinated by special centers in the brain, which use the nervous system and chemical messengers to control the process.

Energy Production

Metabolism is the sum of all the chemical processes necessary to maintain the body. Energy is required to fuel vital body functions—to build and break down tissue, contract muscles, conduct nerve impulses, regulate body temperature, and so on.

The rate at which your body uses energy—its metabolic rate—depends on your level of activity. At rest, you have a low metabolic rate; if you begin to walk, your metabolic rate increases. If you jog, your metabolic rate may increase more than 800% above its resting level. Olympic-caliber distance runners can increase their metabolic rate by 2000% or more.

Energy from Food The body converts chemical energy from food into substances that cells can use as fuel. These fuels can be used immediately or stored for later use. The body’s ability to store fuel is critical, because if all the energy from food were released immediately, much of it would be wasted.

The three classes of energy-containing nutrients in food are carbohydrates, fats, and proteins. During digestion, most carbohydrates are broken down into the simple sugar glucose. Some glucose remains circulating in the blood (“blood sugar”), where it can be used as a quick source of fuel to produce energy. Glucose may also be converted to glycogen and stored in the liver, muscles, and kidneys. If glycogen stores are full and the body’s immediate need for energy is met, the remaining glucose is converted to fat and stored in the body’s fatty tissues. Excess energy from dietary fat is also stored as body fat. Protein in the diet is used primarily to build new tissue, but it can be broken down...
BASIC PHYSIOLOGY OF CARDIORESPIRATORY ENDURANCE EXERCISE

Exercise and the Three Energy Systems

The muscles in your body use three energy systems to create ATP and fuel cellular activity. These systems use different fuels and chemical processes and perform different, specific functions during exercise (Table 3.1).

**The Immediate Energy System** The immediate (“explosive”) energy system provides energy rapidly but for only a short period of time. It is used to fuel activities that last for about 10 or fewer seconds—examples in sports include weight lifting and shot-putting; examples in daily life include rising from a chair or picking up a bag of groceries. The components of this energy system include existing cellular ATP stores and creatine phosphate (CP), a chemical that cells can use to make ATP. CP levels are depleted rapidly during exercise, so the maximum capacity of this energy system is reached within a few seconds. Cells must then switch to the other energy systems to restore levels of ATP and CP. (Without adequate ATP, muscles will stiffen and become unusable.)

**Table 3.1 Characteristics of the Body’s Energy Systems**

<table>
<thead>
<tr>
<th>Energy System*</th>
<th>Immediate</th>
<th>Nonoxidative</th>
<th>Oxidative</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration of Activity for Which System Predominates</strong></td>
<td>0–10 seconds</td>
<td>10 seconds–2 minutes</td>
<td>&gt;2 minutes</td>
</tr>
<tr>
<td><strong>Intensity of Activity for Which System Predominates</strong></td>
<td>High</td>
<td>High</td>
<td>Low to moderately high</td>
</tr>
<tr>
<td><strong>Rate of ATP Production</strong></td>
<td>Immediate, very rapid</td>
<td>Rapid</td>
<td>Slower, but prolonged</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Adenosine triphosphate (ATP), creatine phosphate (CP)</td>
<td>Muscle stores of glycogen and glucose</td>
<td>Body stores of glycogen, glucose, fat, and protein</td>
</tr>
<tr>
<td><strong>Oxygen Used?</strong></td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Sample Activities</strong></td>
<td>Weight lifting, picking up a bag of groceries</td>
<td>400-meter run, running up several flights of stairs</td>
<td>1500-meter run, 30-minute walk, standing in line for a long time</td>
</tr>
</tbody>
</table>

*For most activities, all three systems contribute to energy production; the duration and intensity of the activity determine which system predominates.


**ATP: The Energy “Currency” of Cells** The basic form of energy used by cells is **adenosine triphosphate (ATP)**. When a cell needs energy, it breaks down ATP, a process that releases energy in the only form the cell can use directly. Cells store a small amount of ATP; when they need more, they create it through chemical reactions that utilize the body’s stored fuels—glucose, glycogen, and fat. When you exercise, your cells need to produce more energy. Consequently, your body mobilizes its stores of fuel to increase ATP production.

**Exercise and the Three Energy Systems**

The muscles in your body use three energy systems to create ATP and fuel cellular activity. These systems use different fuels and chemical processes and perform different, specific functions during exercise (Table 3.1).

**The Immediate Energy System** The immediate (“explosive”) energy system provides energy rapidly but for only a short period of time. It is used to fuel activities that last for about 10 or fewer seconds—examples in sports include weight lifting and shot-putting; examples in daily life include rising from a chair or picking up a bag of groceries. The components of this energy system include existing cellular ATP stores and creatine phosphate (CP), a chemical that cells can use to make ATP. CP levels are depleted rapidly during exercise, so the maximum capacity of this energy system is reached within a few seconds. Cells must then switch to the other energy systems to restore levels of ATP and CP. (Without adequate ATP, muscles will stiffen and become unusable.)
The Nonoxidative Energy System  The nonoxidative (anaerobic) energy system is used at the start of an exercise session and for high-intensity activities lasting for about 10 seconds to 2 minutes, such as the 400-meter run. During daily activities, this system may be called on to help you run to catch a bus or dash up several flights of stairs. The nonoxidative energy system creates ATP by breaking down glucose and glycogen. This system doesn’t require oxygen, which is why it is sometimes referred to as the anaerobic system. The capacity of this system to produce energy is limited, but it can generate a great deal of ATP in a short period of time. For this reason, it is the most important energy system for very intense exercise.

There are two key limiting factors for the nonoxidative energy system. First, the body’s supply of glucose and glycogen is limited. If these are depleted, a person may experience fatigue and dizziness, and judgment may be impaired. (The brain and nervous system rely on carbohydrates as fuel.) Second, the nonoxidative system releases substances called hydrogen ions that are thought to interfere with metabolism and muscle contraction, thereby causing fatigue. During heavy exercise, such as sprinting, the body produces large amounts of hydrogen ions and muscles fatigue rapidly. The anaerobic energy system also creates metabolic acids. Fortunately, exercise training increases the body’s ability to cope with metabolic acid. One of these acids, called lactic acid, is often linked to fatigue during intense exercise. However, it is an important fuel at rest and during exercise and may actually prevent fatigue.

The Oxidative Energy System  The oxidative (aerobic) energy system is used during any physical activity that lasts longer than about 2 minutes, such as distance running, swimming, hiking, or even standing in line. The oxidative system requires oxygen to generate ATP, which is why it is considered an aerobic system. The oxidative system cannot produce energy as quickly as the other two systems, but it can supply energy for much longer periods of time. It provides energy during most daily activities.

In the oxidative energy system, ATP production takes place in cellular structures called mitochondria. Because mitochondria can use carbohydrates (glucose and glycogen) or fats to produce ATP, the body’s stores of fuel for this system are much greater than those for the other two energy systems. The actual fuel used depends on the intensity and duration of exercise and on the fitness status of the individual. Carbohydrates are favored during more intense exercise (over 65% of maximum capacity); fats are used for mild, low-intensity activities. During a prolonged exercise session, carbohydrates are the predominant fuel at the start of the workout, but fat utilization increases over time. Fit individuals use a greater proportion of fat as fuel because increased fitness allows people to do activities at lower intensities. This is an important adaptation because glycogen depletion is one of the limiting factors for the oxidative energy system. Thus, by being able to use more fat as fuel, a fit individual can exercise for a longer time before glycogen is depleted and muscles become fatigued.

Oxygen is another limiting factor. The oxygen requirement of this energy system is proportional to the intensity of exercise—as intensity increases, so does oxygen consumption. There is a limit to the body’s ability to increase the transport and use of oxygen; this limit is referred to as maximal oxygen consumption, or \( \text{VO}_2\max \). \( \text{VO}_2\max \) is influenced by genetics, fitness status (power-generating capacity and fatigue resistance), gender, and age. It depends on many factors, including the capacity of blood to carry oxygen, the rate at which oxygen is transported to the tissues, and the amount of oxygen that cells extract from the blood. \( \text{VO}_2\max \) determines how intensely a person can perform endurance exercise and for how long, and it is considered the best overall measure of the capacity of the cardiorespiratory system. (The assessment tests described later in the chapter are designed to help you predict your \( \text{VO}_2\max \).)

The Energy Systems in Combination  Your body typically uses all three energy systems when you exercise. The intensity and duration of the activity determine which system predominates. For example, when you play tennis, you use the immediate energy system when hitting the ball, but you replenish cellular energy stores using the nonoxidative and oxidative systems. When cycling, the oxidative system predominates. However, if you must suddenly exercise intensely—ride up a steep hill, for
example—the other systems become important because the oxidative system is unable to supply ATP fast enough to sustain high-intensity effort.

**Physical Fitness and Energy Production**  
Physically fit people can increase their metabolic rate substantially, generating the energy needed for powerful or sustained exercise. People who are not fit cannot respond to exercise in the same way. Their bodies are less capable of delivering oxygen and fuel to exercising muscles; they can't burn as many calories during or after exercise; and they are less able to cope with lactic acid and other substances produced during intense physical activity that contribute to fatigue. Because of this, they become fatigued more rapidly—their legs hurt and they breathe heavily walking up a flight of stairs, for example. Regular physical training can substantially improve the body's ability to produce energy and meet the challenges of increased physical activity.

In designing an exercise program, focus on the energy system most important to your goals. Because improving the functioning of the cardiorespiratory system is critical to overall wellness, endurance exercise that utilizes the oxidative energy system—activities performed at moderate-to-high intensities for a prolonged duration—is a key component of any health-related fitness program.

**QUESTIONS FOR CRITICAL THINKING AND REFLECTION**

When you think about the types of physical activity you engage in during your typical day or week, which ones use the immediate energy system? The nonoxidative energy system? The oxidative energy system? How can you increase activities that use the oxidative energy system?

**BENEFITS OF CARDIORESPIRATORY ENDURANCE EXERCISE**

Cardiorespiratory endurance exercise helps the body become more efficient and better able to cope with physical challenges. It also lowers risk for many chronic diseases.

**Improved Cardiorespiratory Functioning**

Earlier in this chapter, we described some of the major changes that occur in the cardiorespiratory system when you exercise, such as increases in cardiac output and blood pressure, breathing rate, blood flow to the skeletal muscles, and sweating. In the short term, all these changes help the body respond to the challenge of exercise. When performed regularly, endurance exercise also leads to permanent adaptations in the cardiorespiratory system (Figure 3.3, p. 64). These improvements reduce the effort required to do everyday tasks and make the body better able to respond to physical challenges. This, in a nutshell, is what it means to be physically fit.

Endurance exercise enhances the heart's health by:

- Maintaining or increasing the heart's own blood and oxygen supply.
- Increasing the heart muscle's function, so it pumps more blood per beat. This improved function keeps the heart rate lower both at rest and during exercise. The resting heart rate of a fit person is often 10–20 beats per minute lower than that of an unfit person. This translates into as many as 10 million fewer beats in the course of a year.
- Strengthening the heart's contractions.
- Increasing the heart's cavity size (in young adults).
- Increasing blood volume so the heart pushes more blood into the circulatory system during each contraction.
- Reducing blood pressure.
**Immediate effects**

- Increased levels of neurotransmitters, constant or slightly increased blood flow to the brain.
- Increased heart rate and stroke volume (amount of blood pumped per beat).
- Increased pulmonary ventilation (amount of air breathed into the body per minute). More air is taken into the lungs with each breath and breathing rate increases.
- Reduced blood flow to the stomach, intestines, liver, and kidneys, resulting in less activity in the digestive tract and less urine output.
- Increased energy (ATP) production.
- Increased blood flow to the skin and increased sweating to help maintain a safe body temperature.
- Increased systolic blood pressure; increased blood flow and oxygen transport to working skeletal muscles and the heart; increased oxygen consumption. As exercise intensity increases, blood levels of lactic acid increase.

**Long-term effects**

- Improved self-image, cognitive functioning, and ability to manage stress; enhanced learning, memory, energy level, and sleep; decreased depression, anxiety, and risk for stroke.
- Increased heart size and resting stroke volume; lower resting heart rate. Risk of heart disease and heart attack significantly reduced.
- Improved ability to extract oxygen from air during exercise. Reduced risk of colds and upper respiratory tract infections.
- Increased sweat rate and earlier onset of sweating, helping to cool the body.
- Decreased body fat.
- Reduced risk of colon cancer and certain other forms of cancer.
- Increased number and size of mitochondria in muscle cells; increased amount of stored glycogen; increased myoglobin content; improved ability to use lactic acid and fats as fuel. All of these changes allow for greater energy production and power output. Insulin sensitivity remains constant or improves, helping to prevent type 2 diabetes. Fat-free mass may also increase somewhat.
- Increased density and breaking strength of bones, ligaments, and tendons; reduced risk for low-back pain, injuries, and osteoporosis.
- Increased blood volume and capillary density; higher levels of high-density lipoproteins (HDL) and lower levels of triglycerides; lower resting blood pressure; increased ability of blood vessels to secrete nitric oxide; and reduced platelet stickiness (a factor in coronary artery disease).

**FIGURE 3.3 Immediate and long-term effects of regular cardiorespiratory endurance exercise.** When endurance exercise is performed regularly, short-term changes in the body develop into more permanent adaptations; these include improved ability to exercise, reduced risk of many chronic diseases, and improved psychological and emotional well-being.

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**Improved Cellular Metabolism**

Regular endurance exercise improves the body’s metabolism, down to the cellular level, enhancing your ability to produce and use energy efficiently. Cardiorespiratory training improves metabolism by doing the following:

- Increasing the number of capillaries in the muscles. Additional capillaries supply the muscles with more fuel and oxygen and more quickly eliminate waste products. Greater capillary density also helps heal injuries and reduce muscle aches.
- Training muscles to make the most of oxygen and fuel so they work more efficiently.
- Increasing the size of and number of mitochondria in muscle cells, increasing cells’ energy capacity.
- Preventing glycogen depletion and increasing the muscles’ ability to use lactic acid and fat as fuels.

Regular exercise may also help protect cells from chemical damage caused by agents called free radicals. (See Chapter 8 for details on free radicals and special enzymes the body uses to fight them.)

Fitness programs that best develop metabolic efficiency include both long-duration, moderately intense endurance exercise and brief periods of more intense effort. For example, climbing a small hill while jogging or cycling introduces the kind of intense exercise that leads to more efficient use of lactic acid and fats.
Benefits of Exercise for Older Adults

Research has shown that most aspects of physiological functioning peak when people are about 30 years old and then decline at a rate of about 0.5–1.0% per year. This decline in physical capacity is characterized by a decrease in maximal oxygen consumption, cardiac output, muscular strength, fat-free mass, joint mobility, and other factors. However, regular exercise can substantially alter the rate of decline in functional status, and it is associated with both longevity and improved quality of life.

Regular endurance exercise can improve maximal oxygen consumption in older people by up to 15–30%—the same degree of improvement seen in younger people. In fact, studies have shown that Masters athletes in their 70s have $VO_{2\max}$ values equivalent to those of sedentary 20-year-olds: At any age, endurance training can improve cardiorespiratory functioning, cellular metabolism, body composition, and psychological and emotional well-being. Older people who exercise regularly have better balance and greater bone density and are less likely than their sedentary peers to suffer injuries as a result of falls. Regular endurance training also substantially reduces the risk of many chronic and disabling diseases including heart disease, cancer, diabetes, osteoporosis, and dementia.

Other forms of exercise training are also beneficial for older adults. Resistance training is a safe and effective way to build strength and fat-free mass and can help people remain independent as they age. Lifting weights has also been shown to boost spirits in older people, perhaps because improvements in strength appear quickly and are easily applied to everyday tasks such as climbing stairs and carrying groceries. Flexibility exercises can improve the range of motion in joints and also help people maintain functional independence as they age.

It’s never too late to start exercising. Even in people over 80, beginning an exercise program can improve physical functioning and quality of life. Most older adults are able to participate in moderate walking and strengthening and stretching exercises, and modified programs can be created for people with chronic conditions and other special health concerns (see Chapter 7). The wellness benefits of exercise are available to people of all ages and levels of ability.

Reduced Risk of Chronic Disease

Regular endurance exercise lowers your risk of many chronic, disabling diseases. It can also help people with those diseases improve their health (see the box “Benefits of Exercise for Older Adults”). The most significant health benefits occur when someone who is sedentary becomes moderately active.

Cardiovascular Diseases  Sedentary living is a key contributor to cardiovascular disease (CVD). CVD is a general category that encompasses several diseases of the heart and blood vessels, including coronary heart disease (which can cause heart attacks), stroke, and high blood pressure. Sedentary people are significantly more likely to die of CVD than are fit individuals.

Cardiorespiratory endurance exercise lowers your risk of CVD by doing the following:

- Promoting a healthy balance of fats in the blood. High concentrations of blood fats such as cholesterol and triglycerides are linked to CVD. Exercise raises levels of “good cholesterol” (high-density lipoproteins, or HDL) and may lower levels of “bad cholesterol” (low-density lipoproteins, or LDL).
  - Reducing high blood pressure, which is a contributing factor to several kinds of CVD.
  - Enhancing the function of the cells that line the arteries (endothelial cells).
  - Reducing inflammation.
  - Preventing obesity and type 2 diabetes, both of which contribute to CVD.

Details on various types of CVD, their associated risk factors, and lifestyle factors that can reduce your risk for developing CVD are discussed in Chapter 11.

Cancer  Although the findings are not conclusive, some studies have shown a relationship between increased physical activity and a reduction in a person’s risk of cancer. Exercise reduces the risk of colon cancer in women, and it may reduce the risk of cancers of the breast and reproductive organs. Physical activity during the high school and college years may be particularly important.

QUESTION FOR CRITICAL THINKING AND REFLECTION

If you already follow an exercise program, how could you modify it to help improve your cellular metabolism? What specific activities (or changes to existing ones) could you incorporate into your program for this purpose?
for preventing breast cancer later in life. Exercise may also reduce the risk of pancreatic cancer and prostate cancer. See Chapter 12 for more information on various types of cancer.

**Type 2 Diabetes** Regular exercise helps prevent the development of type 2 diabetes, the most common form of diabetes. Exercise metabolizes (burns) excess sugar and makes cells more sensitive to the hormone insulin, which is involved in the regulation of blood sugar levels. Obesity is a key risk factor for diabetes, and exercise helps keep body fat at healthy levels. But even without fat loss, exercise improves control of blood sugar levels in many people with diabetes, and physical activity is an important part of treatment. (See Chapter 6 for more on diabetes and insulin resistance.)

**Osteoporosis** A special benefit of exercise, especially for women, is protection against osteoporosis, a disease that results in loss of bone density and poor bone strength. Weight-bearing exercise—particularly weight training—helps build bone during the teens and twenties. People with denser bones can better endure the bone loss that occurs with aging. With stronger bones and muscles and better balance, fit people are less likely to experience debilitating falls and bone fractures. (See Chapter 8 for more on osteoporosis.)

**Deaths from All Causes** Physically fit people have a reduced risk of dying prematurely from all causes, with the greatest benefits found for people with the highest levels of fitness (see Figure 3.4 for the results of one study). Poor fitness is a good predictor of premature death and is as important a risk factor as smoking, high blood pressure, obesity, and diabetes.

**Better Control of Body Fat**

Too much body fat is linked to a variety of health problems, including CVD, cancer, and type 2 diabetes. Healthy body composition can be difficult to achieve and maintain because a diet that contains all essential nutrients can be relatively high in calories, especially for someone who is sedentary. Excess calories are stored in the body as fat. Regular exercise increases daily calorie expenditure so that a healthy diet is less likely to lead to weight gain. Endurance exercise burns calories directly and, if intense enough, continues to do so by raising resting metabolic rate for several hours following an exercise session. A higher metabolic rate means that it is easier for a person to maintain a healthy weight or to lose weight. Exercise alone cannot ensure a healthy body composition, however; as described in Chapters 6 and 9, you will lose more weight more rapidly and keep it off longer if you decrease your calorie intake and boost your calorie expenditure through exercise.

**Improved Immune Function**

Exercise can have either positive or negative effects on the immune system, the physiological processes that protect us from disease. Moderate endurance exercise boosts immune function, whereas overtraining (excessive training) depresses it. Physically fit people get fewer colds and upper respiratory tract infections than people who are not fit. Exercise affects immune function by influencing levels of specialized cells and chemicals involved in the immune response. In addition to regular moderate exercise, the immune system can be strengthened by eating a well-balanced diet, managing stress, and getting 7–8 hours of sleep every night.

**MOTIVATION BOOSTER**

**Focus on benefits.** Make a list of five benefits of endurance exercise that are particularly meaningful to you—reducing your risk of diabetes, for example, or being able to hike with friends. Put the list in a prominent location—on your mirror or refrigerator, for example—and use it as a motivational tool for beginning and maintaining your fitness program.

**Improved Psychological and Emotional Well-Being**

Most people who participate in regular endurance exercise experience social, psychological, and emotional
Exercise, Mood, and the Mind

Although much of the discussion of the benefits of exercise focuses on improvements to physical wellness, many people discover that the best reason to become and stay active is the boost that regular exercise provides to the nonphysical dimensions of wellness. The following are just some of the effects of regular physical activity.

- **Reduced anxiety.** Exercise reduces symptoms of anxiety such as worry and self-doubt both in people who are anxious most of the time (trait anxiety) and in people who become anxious in response to a particular experience (state anxiety). Exercise is associated with a lower risk for panic attacks, generalized anxiety disorder, and social anxiety disorder.

- **Reduced depression and improved mood.** Exercise relieves feelings of sadness and hopelessness and can be as effective as psychotherapy in treating mild-to-moderate cases of depression. Exercise improves mood and increases feelings of well-being in both depressed and nondepressed people.

- **Improved sleep.** Regular physical activity helps people fall asleep more easily; it also improves the quality of sleep, making it more restful.

- **Reduced stress.** Exercise reduces the body’s overall response to all forms of stressors and helps people deal more effectively with the stress they do experience.

- **Enhanced self-esteem, self-confidence, and self-efficacy.** Exercise can boost self-esteem and self-confidence by providing opportunities for people to succeed and excel; it also improves body image (see Chapters 6 and 9). Sticking with an exercise program increases people’s belief in their ability to be active, thereby boosting self-efficacy.

- **Enhanced creativity and intellectual functioning.** In studies of college students, physically active students score higher on tests of creativity than sedentary students. Exercise improves alertness and memory in the short term, and over time, exercise helps maintain reaction time, short-term memory, and nonverbal reasoning skills.

- **Improved work productivity.** Workers’ quality of work, time-management abilities, and mental and interpersonal performance have been found to be better on days they exercise.

- **Increased opportunities for social interaction.** Exercise provides many opportunities for positive interaction with others.

How does exercise cause all these positive changes? A variety of mechanisms has been proposed. Physical activity stimulates the thought and emotion centers of the brain, producing improvements in mood and cognitive functioning. It increases alpha brain-wave activity, which is associated with a highly relaxed state. Exercise stimulates the release of chemicals such as endorphins, which may suppress fatigue, decrease pain, and produce euphoria, and phenylethylamine, which may boost energy, mood, and attention. Exercise decreases the secretion of hormones triggered by emotional stress and alters the levels of many other neurotransmitters, including serotonin, a brain chemical linked to mood.

Exercise also provides a distraction from stressful stimuli and an emotional outlet for feelings of stress, hostility, and aggression. Finally, exercise is a fun way to spend time!

**ASSESSING CARDIORESPIRATORY FITNESS**

The body’s ability to maintain a level of exertion (exercise) for an extended time is a direct reflection of cardiorespiratory fitness. It is determined by the body’s ability to take up, distribute, and use oxygen during physical activity. As explained earlier, the best quantitative measure of cardiorespiratory endurance is maximal oxygen consumption, expressed as VO2max, the amount of oxygen the body uses when a person reaches maximum ability to supply oxygen during exercise (measured in milliliters of oxygen used per minute for each kilogram of body weight). Maximal oxygen consumption can be measured precisely in an exercise physiology laboratory through analysis of the air a person inhales and exhales while exercising to a level of exhaustion (maximum intensity). This procedure can be expensive and time-consuming, making it impractical for the average person.

**Choosing an Assessment Test**

Fortunately, several simple assessment tests provide reasonably good estimates of maximal oxygen consumption (within ±10–15% of the results of a laboratory test). Three commonly used assessments are the following:

- **The 1-mile walk test.** This estimates your level of cardiorespiratory fitness (maximal oxygen consumption) based on the amount of time it takes you to complete...
1 mile of brisk walking and your heart rate at the end of your walk. A fast time and a low heart rate indicate a high level of cardiorespiratory endurance.

- **The 3-minute step test.** The rate at which the pulse returns to normal after exercise is also a good measure of cardiorespiratory capacity; heart rate remains lower and recovers faster in people who are more physically fit. For the step test, you step continually at a steady rate and then monitor your heart rate during recovery.

- **The 1.5-mile run-walk test.** Oxygen consumption increases with speed in distance running, so a fast time on this test indicates high maximal oxygen consumption.

Lab 3.1 provides detailed instructions for each of these tests. To assess yourself, choose one of these methods based on your access to equipment, your current physical condition, and your own preference. Don’t take any of these tests without checking with your physician if you are ill or have any of the risk factors for exercise discussed in Chapter 2 and Lab 2.1. Table 3.2 lists the fitness prerequisites and cautions recommended for each test.

### Monitoring Your Heart Rate

Each time your heart beats, it pumps blood into your arteries; this surge of blood causes a pulse that you can feel by holding your fingers against an artery. Counting your pulse to determine your exercise heart rate is a key part of most assessment tests for maximal oxygen consumption. Heart rate can also be used to monitor exercise intensity during a workout. (Intensity is described in more detail in the next section.)

The two most common sites for monitoring heart rate are the carotid artery in the neck and the radial artery in the wrist (Figure 3.5). To take your pulse, press your index and middle fingers gently on the correct site. You may have to shift position several times to find the best place to feel your pulse. Don’t use your thumb to check your pulse; it has a pulse of its own that can confuse your count. Be careful not to push too hard, particularly when taking your pulse in the carotid artery (strong

### Table 3.2 Fitness Prerequisites and Cautions for the Cardiorespiratory Endurance Assessment Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Fitness Prerequisites/Cautions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-mile walk test</td>
<td>Recommended for anyone who meets the criteria for safe exercise. This test can be used by individuals who cannot perform other tests because of low fitness level or injury.</td>
</tr>
<tr>
<td>3-minute step test</td>
<td>If you suffer from joint problems in your ankles, knees, or hips or are significantly overweight, check with your physician before taking this test. People with balance problems or for whom a fall would be particularly dangerous, including older adults and pregnant women, should use special caution or avoid this test.</td>
</tr>
<tr>
<td>1.5-mile run-walk test</td>
<td>Recommended for people who are healthy and at least moderately active. If you have been sedentary, you should participate in a 4- to 8-week walk-run program before taking the test. Don’t take this test in extremely hot or cold weather if you aren’t used to exercising under those conditions.</td>
</tr>
</tbody>
</table>
Heart Rate Monitors

A heart rate monitor is an electronic device that checks the user’s pulse, either continuously or on demand. These devices make it easy to monitor your heart rate before, during, and after exercise.

**Wearable Monitors**

Most consumer-grade monitors have two pieces—a strap that wraps around the user’s chest and a wrist strap. The chest strap contains one or more small electrodes, which detect changes in the heart’s electrical voltage. A transmitter in the chest strap sends this data to a receiver in the wrist strap. A small computer in the wrist strap calculates the wearer’s heart rate and displays it on a small screen.

In a few low-cost monitors, the chest and wrist straps are connected together by a wire, but the most popular monitors use wireless technology to transmit data between the straps. In advanced wireless monitors, data is encoded so it cannot be read by any other monitors that may be nearby, as is often the case in a crowded gym. A one-piece (or “strapless”) heart rate monitor does not include a chest strap; the wrist-worn device contains sensors that detect a pulse in the wearer’s hand.

**Monitors in Gym Equipment**

Many pieces of workout equipment—including newer-model treadmills, stationary bikes, and elliptical trainers—feature built-in heart rate monitors. The monitor is usually mounted into the device’s handles. To check your heart rate at any time while working out, simply grip the handles in the appropriate place; within a few seconds, your current heart rate will appear on the device’s console.

**Other Features**

Heart rate monitors can do more than just check your pulse. For example, most monitors can tell you the following kinds of information:

- Highest and lowest heart rate during a session
- Average heart rate
- Target heart range, based on your age, weight, and other factors
- Time spent within the target range
- Number of calories burned during a session

Some monitors can upload their data to a computer, so information can be stored and analyzed. The analytical software can help you track your progress over a period of time or a number of workouts.

**Advantages**

Heart rate monitors are useful if very close tracking of heart rate is important in your program. They offer several advantages:

- They are accurate, and they reduce the risk of mistakes when checking your own pulse. (Note, however, that chest-strap monitors are considered more accurate than strapless models. If you use a monitor built into gym equipment, its accuracy will depend on how well the device is maintained.)
- They are easy to use, although a sophisticated, multifunction monitor may take some time to master.
- They do the monitoring for you, so you don’t have to worry about checking your own pulse.

When shopping for a heart rate monitor, do your homework. Quality, reliability, and warranties vary. Ask personal trainers in your area for their recommendations, and look for product reviews in consumer magazines or online.

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### Interpreting Your Score

Once you’ve completed one or more of the assessment tests, use the table under “Rating Your Cardiovascular Fitness” at the end of Lab 3.1 to determine your current level of cardiorespiratory fitness. As you interpret your score, remember that field tests of cardiorespiratory fitness are not precise scientific measurements and have up to a 10–15% margin of error.

You can use the assessment tests to monitor the progress of your fitness program by retesting yourself from time to time. Always compare scores for the same test: Your scores on different tests may vary considerably because of differences in skill and motivation and weaknesses in the tests themselves.

### Questions for Critical Thinking and Reflection

Why do you think a relatively slow resting pulse rate is a sign of good cardiorespiratory fitness? What physical conditions or attributes are reflected in your pulse rate?
DEVELOPING A CARDIORESPIRATORY ENDURANCE PROGRAM

Cardiorespiratory endurance exercises are best for developing the type of fitness associated with good health, so they should serve as the focus of your exercise program. To create a successful endurance exercise program, follow these guidelines:

- Set realistic goals.
- Set your starting frequency, intensity, and duration of exercise at appropriate levels.
- Choose suitable activities.
- Warm up and cool down.
- Adjust your program as your fitness improves.

Setting Goals

You can use the results of cardiorespiratory fitness assessment tests to set a specific oxygen consumption goal for your cardiorespiratory endurance program. Your goal should be high enough to ensure a healthy cardiorespiratory system, but not so high that it will be impossible to achieve. Scores in the fair and good ranges for maximal oxygen consumption suggest good fitness; scores in the excellent and superior ranges indicate a high standard of physical performance.

Through endurance training, an individual may be able to improve maximal oxygen consumption (VO$_2$max) by about 10–30%. The amount of improvement possible depends on genetics, age, health status, and initial fitness level: people who start at a very low fitness level can improve by a greater percentage than elite athletes because the latter are already at a much higher fitness level, one that may approach their genetic physical limits. If you are tracking VO$_2$max using the field tests described in this chapter, you may be able to increase your score by more than 30% due to improvements in other physical factors, such as muscle power, which can affect your performance on the tests.

Another physical factor you can track to monitor progress is resting heart rate—your heart rate at complete rest, measured in the morning before you get out of bed and move around. Resting heart rate may decrease by as much as 10–15 beats per minute in response to endurance training. Changes in resting heart rate may be noticeable after only about 4–6 weeks of training.

You may want to set other types of goals for your fitness program. For example, if you walk, jog, or cycle as part of your fitness program, you may want to set a time or distance goal—working up to walking 5 miles in one session, completing a 4-mile run in 28 minutes, or cycling a total of 35 miles per week. A more modest goal might be to achieve the Surgeon General’s minimum activity level of doing at least 30 minutes of moderate activity on most days. Although it’s best to base your program on “SMART” goals, you may also want to set more qualitative goals, such as becoming more energetic, sleeping better, and improving the fit of your clothes.

MOTIVATION BOOSTER

Improve your self-talk. If you are having trouble starting a fitness program, try listening to your self-talk about exercise. Do you rationalize, make excuses, procrastinate, or avoid responsibility for your habits? This may be the case if you find yourself thinking things such as “My schedule won’t allow me to exercise” or “I’ll start when the weather improves.” Look for ways to counter such thinking and change your habits. For example, try thinking “Lots of busy people work out, so I can find time, too,” or “I can use the gym until the weather gets better.” Remember: When you make excuses, the only one who loses is you.

Applying the FITT Equation

As described in Chapter 2, you can use the acronym FITT to remember key parameters of your fitness program: Frequency, Intensity, Time (duration), and Type of activity.

Frequency of Training  To build cardiorespiratory endurance, you should exercise 3–5 days per week. Beginners should start with 3 and work up to 5 days per week. Training more than 5 days per week can lead to injury and isn’t necessary for the typical person on an exercise program designed to promote wellness. (It is safe to do moderate-intensity activity such as walking and gardening every day.) Training fewer than 3 days per week makes it difficult to improve your fitness (unless exercise intensity is very high) or to use exercise to lose weight. In addition, you risk injury because your body never gets a chance to fully adapt to regular exercise training.

Intensity of Training  Intensity is the most important factor in achieving training effects. You must exercise intensely enough to stress your body so that fitness improves. Four methods of monitoring exercise intensity are described below; choose the method that works best for you. Be sure to make adjustments in your intensity levels for environmental or individual factors. For example, on a hot and humid day or on your first day back to your program after an illness, you should decrease your intensity level.

TARGET HEART RATE ZONE  One of the best ways to monitor the intensity of cardiorespiratory endurance exercise is to measure your heart rate. It isn’t necessary to exercise at your maximum heart rate to improve maximal oxygen
consumption. Fitness adaptations occur at lower heart rates with a much lower risk of injury.

According to the American College of Sports Medicine, your target heart rate zone—rates at which you should exercise to experience cardiorespiratory benefits—is between 65% and 90% of your maximum heart rate. To calculate your target heart rate zone, follow these steps:

1. Estimate your maximum heart rate (MHR) by subtracting your age from 220, or have it measured precisely by undergoing an exercise stress test in a doctor’s office, hospital, or sports medicine lab. (Note: The formula to estimate maximum heart rate carries an error of about ±10–15 beats per minute and can be very inaccurate for some people, particularly older adults and young children. If your exercise heart rate seems inaccurate—that is, exercise within your target zone seems either too easy or too difficult—then use the perceived exertion method described in the next section or have your maximum heart rate measured precisely.)

2. Multiply your MHR by 65% and 90% to calculate your target heart rate zone. (Note: Very unfit people should use 55% of MHR for their training threshold.)

For example, a 19-year-old would calculate her target heart rate zone as follows:

MHR = 220 – 19 = 201

65% training intensity = 0.65 × 201 = 131 bpm

90% training intensity = 0.90 × 201 = 181 bpm

To gain fitness benefits, the young woman in our example would have to exercise at an intensity that raises her heart rate to between 131 and 181 bpm.

An alternative method for calculating target heart rate range uses heart rate reserve, the difference between maximum heart rate and resting heart rate. Using this method, target heart rate is equal to resting heart rate plus between 50% (40% for very unfit people) and 85% of heart rate reserve. Although some people (particularly those with very low levels of fitness) will obtain more accurate results using this more complex method, both methods provide reasonable estimates of an appropriate target heart rate zone. Formulas for both methods of calculating target heart rate are given in Lab 3.2.

If you have been sedentary, start by exercising at the lower end of your target heart rate range (65% of maximum heart rate or 50% of heart rate reserve) for at least 4–6 weeks. Fast and significant gains in maximal oxygen consumption can be made by exercising closer to the top of the range, but you may increase your risk of injury and overtraining. You can achieve significant health benefits by exercising at the bottom of your target range, so don’t feel pressured into exercising at an unnecessarily intense level. If you exercise at a lower intensity, you can increase the duration or frequency of training to obtain as much benefit to your health, as long as you are above the 65% training threshold. (For people with a very low initial level of fitness, a lower training intensity, 55–64% of maximum heart rate or 40–49% of heart rate reserve, may be sufficient to achieve improvements in maximal oxygen consumption, especially at the start of an exercise program. Intensities of 70–85% of maximum heart rate are appropriate for average individuals.)

By monitoring your heart rate, you will always know if you are working hard enough to improve, not hard enough, or too hard. As your program progresses and your fitness improves, you will need to jog, cycle, or walk faster in order to reach your target heart rate zone.

To monitor your heart rate during exercise, count your pulse while you’re still moving or immediately after you stop exercising. Count beats for 10 seconds, and then multiply that number by 6 to see if your heart rate is in the range of 65–90% of maximum heart rate.

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Target Heart Rate Range (bpm)*</th>
<th>10-Second Count (beats)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>20–24</td>
<td>127–180</td>
<td>21–30</td>
</tr>
<tr>
<td>25–29</td>
<td>124–176</td>
<td>20–29</td>
</tr>
<tr>
<td>30–34</td>
<td>121–171</td>
<td>20–28</td>
</tr>
<tr>
<td>35–39</td>
<td>118–167</td>
<td>19–27</td>
</tr>
<tr>
<td>40–44</td>
<td>114–162</td>
<td>19–27</td>
</tr>
<tr>
<td>45–49</td>
<td>111–158</td>
<td>18–26</td>
</tr>
<tr>
<td>50–54</td>
<td>108–153</td>
<td>18–25</td>
</tr>
<tr>
<td>55–59</td>
<td>105–149</td>
<td>17–24</td>
</tr>
<tr>
<td>60–64</td>
<td>101–144</td>
<td>16–24</td>
</tr>
<tr>
<td>65+</td>
<td>97–140</td>
<td>16–23</td>
</tr>
</tbody>
</table>

*Target heart rates lower than those shown here are appropriate for individuals with a very low initial level of fitness. Ranges are based on the following formula: Target heart rate = 0.65 to 0.90 of maximum heart rate, assuming maximum heart rate = 220 – age. The heart rate range values shown here correspond to ratings of perceived exertion (RPE) values of about 12–18.
METs One way scientists describe fitness is in terms of the capacity to increase metabolism (energy usage level) above rest. Scientists use METs to measure the metabolic cost of an exercise. One MET represents the body’s resting metabolic rate—that is, the energy requirement of the body at rest. Exercise intensity is expressed in multiples of resting metabolic rate. For example, an exercise intensity of 2 METs is 2 times the resting metabolic rate.

METs are used to describe exercise intensities for occupational activities and exercise programs. Exercise intensities of less than 3–4 METs are considered low. Household chores and most industrial jobs fall into this category. Exercise at these intensities does not improve fitness for most people, but it will improve fitness for people with low physical capacities. Activities that increase metabolism by 6–8 METs are classified as moderate-intensity exercises and are suitable for most people beginning an exercise program. Vigorous exercise increases metabolic rate by more than 10 METs. Fast running or cycling, as well as intense play in sports like racquetball, can place people in this category. Table 3.4 lists the MET ratings for various activities.

METs are intended to be only an approximation of exercise intensity. Skill, body weight, body fat, and environment affect the accuracy of METs. As a practical matter, however, these limitations can be disregarded. METs are a good way to express exercise intensity because this system is easy for people to remember and apply.

**RATINGS OF PERCEIVED EXERTION** Another way to monitor intensity is to monitor your perceived level of exertion. Repeated pulse counting during exercise can become a nuisance if it interferes with the activity. As your exercise program progresses, you will probably become familiar with the amount of exertion required to raise your heart rate to target levels. In other words, you will know how you feel when you have exercised intensely enough. If this is the case, you can use the scale of ratings of perceived exertion (RPE) shown in Figure 3.6 to monitor the intensity of your exercise session without checking your pulse.

To use the RPE scale, select a rating that corresponds to your subjective perception of how hard you are exercising when you are training in your target heart rate zone. If your target zone is about 135–155 bpm, exercise intensely enough to raise your heart rate to that level, and then associate a rating—for example, “somewhat hard” or “hard” (14 or 15)—with how hard you feel you are working. To reach and maintain a similar intensity in future workouts,
exercise hard enough to reach what you feel is the same level of exertion. You should periodically check your RPE against your target heart rate zone to make sure it’s correct. RPE is an accurate means of monitoring exercise intensity, and you may find it easier and more convenient than pulse counting.

**TALK TEST** Another easy method of monitoring exercise exertion—in particular, to prevent overly intense exercise—is the talk test. Although your breathing rate will increase during cardiorespiratory endurance exercise, you should not work out so intensely that you cannot speak comfortably. The talk test is an effective gauge of intensity for many types of activities.

**Time (Duration) of Training** A total duration of 20–60 minutes is recommended; exercise can take place in a single session or in multiple sessions lasting 10 or more minutes. The total duration of exercise depends on its intensity. To improve cardiorespiratory endurance during a low- to moderate-intensity activity such as walking or slow swimming, you should exercise for 45–60 minutes. For high-intensity exercise performed at the top of your target heart rate zone, a duration of 20 minutes is sufficient. Some studies have shown that 5–10 minutes of extremely intense exercise (greater than 90% of maximal oxygen consumption) improves cardiorespiratory endurance. However, training at high intensity, particularly during high-impact activities, increases the risk of injury. Also, because of the discomfort of high-intensity exercise, you are more likely to discontinue your exercise program. Longer-duration, low- to moderate-intensity activities generally result in more gradual gains in maximal oxygen consumption. In planning your program, start with less vigorous activities and gradually increase intensity.

**Type of Activity** Cardiorespiratory endurance exercises include activities that involve the rhythmic use of large-muscle groups for an extended period of time, such as jogging, walking, cycling, aerobic dancing and other forms of group exercise, cross-country skiing, and swimming. (For a discussion of the benefits of walking and running, see the box “Should I Walk or Run for Fitness?” on p. 74.) Start-and-stop sports, such as tennis and racquetball, also qualify, as long as you have enough skill to play continuously and intensely enough to raise your heart rate to target levels.

Having fun is a strong motivator; select a physical activity that you enjoy, and it will be easier to stay with your program. Exercising with a friend can also be helpful as a motivator. Consider whether you prefer competitive or individual sports and whether starting something new would be best. Other important considerations are access to facilities, expense, equipment, and the time required to achieve an adequate skill level and workout.

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**Warming Up and Cooling Down**

It’s important to warm up before every session of cardiorespiratory endurance exercise and to cool down afterward. Because the body’s muscles work better when their temperature is slightly above resting level, warming up enhances performance and decreases the chance of injury. It gives the body time to redirect blood to active muscles and the heart time to adapt to increased demands. Warming up also helps spread synovial fluid throughout the joints, which helps protect their surfaces from injury.

As mentioned in Chapter 2, a warm-up session should include low-intensity, whole-body movements similar to those in the activity that will follow. Low-intensity movements might include walking slowly before beginning a brisk walk, hitting forehands and backhands before a tennis match, and running a 12-minute mile before progressing to an 8-minute one. An active warm-up of 5–10 minutes is adequate for most types of exercise. However, warm-up time will depend on your level of fitness, experience, and individual preferences.

If you like to stretch before exercising, experts recommend that you stretch after the active part of your warm-up, when your body temperature has been elevated (see Chapter 5). Studies have found that stretching prior to exercise can decrease performance, so some experts recommend that stretching be done after a workout.

Cooling down after exercise is important for returning the body to a nonexercising state. A cool-down helps maintain blood flow to the heart and brain and redirects blood from working muscles to other areas of the body; it helps prevent a large drop in blood pressure, dizziness, and other potential cardiovascular complications. A cool-down, consisting of 5–10 minutes of reduced activity, should follow every workout to allow heart rate, breathing, and circulation to return to normal. Decrease the intensity of exercise gradually during your cool-down. For example, following a running workout, begin your cool-down by jogging at half speed for 30 seconds to a minute; then do several minutes of walking, reducing your speed slowly. A good rule of thumb is to cool down at least until your heart rate

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**WEB TERMS**

- **MET** A unit of measure that represents the body’s resting metabolic rate—that is, the energy requirement of the body at rest.
- **ratings of perceived exertion (RPE)** A system of monitoring exercise intensity based on assigning a number to the subjective perception of target intensity.
- **synovial fluid** Fluid produced within many joints that provides lubrication and nutrients for the joints.
Should I Walk or Run for Fitness?

Which exercise is more beneficial for fitness—walking or running? Enthusiasts have been debating this question for years, and experts say the answer is a complicated one, at least in technical terms. Each has its advantages and drawbacks, but both walking and running can be excellent forms of exercise.

Common Benefits

Walking and running (or jogging) both allow you to burn calories and build cardiorespiratory fitness. They are both affordable, since all you need is a good pair of shoes. They are also highly accessible for most people because you can run or walk just about anywhere, as long as you choose a route that is safe.

Big Differences

As forms of exercise, the main difference between walking and running is the way they allow your body to burn calories. All things being equal, running burns more calories than walking—that is, until you factor in the duration of your exercise.

For example, if you run a mile, your body will primarily burn carbohydrates for energy because you are exercising at a relatively high intensity for a relatively short amount of time. If you walk a mile, however, your body will metabolize more fat because you are exercising for a longer amount of time. Because of walking’s potential as a fat-burning exercise, some experts say that it is more effective to walk briskly for 45 minutes than to run for 20 minutes. However, running increases post-exercise metabolism more than walking, which contributes to the energy cost of exercise.

In terms of cardiorespiratory fitness, evidence varies, but experts say that brisk walking (up to a speed of about 5 mph) produces the same or better fitness benefits compared to running. Your results will depend on factors such as your age and weight, the pace at which you move, and the distance or amount of time you run or walk.

Building Cardiorespiratory Fitness

Building fitness is as much an art as a science. Your rate of progress will depend on your age, health status, genetics, initial level of fitness, and motivation. Your fitness improves when you overload your body. However, you must increase the intensity, frequency, and duration of exercise carefully to avoid injury and overtraining.

For the initial stage of your program, which may last anywhere from 3 to 6 weeks, exercise at the low end of your target heart rate zone. Begin with a frequency of 3–4 days per week, and choose a duration appropriate for your fitness level: 12–15 minutes if you are very unfit, 20 minutes if you are sedentary but otherwise healthy, and 30–40 minutes if you are an experienced exerciser. Use this stage of your program to allow both your body and your schedule to adjust to your new exercise routine. Once you can exercise at the upper

drops below 100 beats per minute. Doing stretching exercises at the end of a workout is an excellent strategy: Your muscles are warm, allowing you to stretch farther with less risk of injury; in addition, there is no danger of decreased performance.

The general pattern of a safe and successful workout for cardiorespiratory fitness is illustrated in Figure 3.7.
levels of frequency (4–5 days per week) and duration (30–40 minutes) without excessive fatigue or muscle soreness, you are ready to progress.

The next phase of your program is the improvement stage, lasting from 4 to 6 months. During this phase, slowly and gradually increase the amount of overload until you reach your target level of fitness (see the sample training progression in Table 3.5). Take care not to increase overload too quickly. It is usually best to avoid increasing intensity and duration during the same session or all three training variables in 1 week. Increasing duration in increments of 5–10 minutes every 2–3 weeks is usually appropriate. Signs that you are increasing overload too quickly include muscle aches and pains, lack of usual interest in exercise, extreme fatigue, and inability to complete a workout. Keep an exercise log or training diary to help you monitor your workouts and progress.

Maintaining Cardiorespiratory Fitness

You will not improve your fitness indefinitely. The more fit you become, the harder you have to work to improve. There are limits to the level of fitness you can achieve, and if you increase intensity and duration indefinitely, you are likely to become injured or overtrained. After an improvement stage of 4–6 months, you may reach your goal of an acceptable level of fitness. You can then maintain fitness by continuing to exercise at the same intensity at least 3 nonconsecutive days every week. If you stop exercising, you lose your gains in fitness fairly rapidly. If you take time off for any reason, start your program again at a lower level and rebuild your fitness in a slow and systematic way.

When you reach the maintenance stage, you may want to set new goals for your program and make some adjustments to maintain your motivation. Adding variety to your program can be a helpful strategy. Engaging in multiple types of endurance activities, an approach known as cross-training, can help boost enjoyment and prevent some types of injuries. For example, someone who has been jogging 5 days a week may change her program so that she jogs 3 days a week, plays tennis 1 day a week, and goes for a bike ride 1 day a week.

Table 3.5  Sample Progression for an Endurance Program

| Stage/Week | Frequency (days/week) | Intensity* (beats/minute) | Time (duration in minutes) |
|------------|-----------------------|--------------------------|__________________________|
| Initial stage | 1                      | 3                        | 120–130                  | 15–20                    |
|             | 2                      | 3                        | 120–130                  | 20–25                    |
|             | 3                      | 4                        | 130–145                  | 20–25                    |
|             | 4                      | 4                        | 130–145                  | 25–30                    |
| Improvement stage | 5–7                  | 3–4                      | 145–160                  | 25–30                    |
|             | 8–10                   | 3–4                      | 145–160                  | 30–35                    |
|             | 11–13                  | 3–4                      | 150–165                  | 30–35                    |
|             | 14–16                  | 4–5                      | 150–165                  | 30–35                    |
|             | 17–20                  | 4–5                      | 160–180                  | 35–40                    |
|             | 21–24                  | 4–5                      | 160–180                  | 35–40                    |
| Maintenance stage | 25+                  | 3–5                      | 160–180                  | 20–60                    |

*The target heart rates shown here are based on calculations for a healthy 20-year-old with a resting heart rate of 60 beats per minute; the program progresses from an initial target heart rate of 50% to a maintenance range of 70–85% of heart rate reserve.


FIGURE 3.7 The FITT principle for a cardiorespiratory endurance workout. Longer-duration exercise at lower intensities can often be as beneficial for promoting health as shorter-duration, high-intensity exercise.
Exercise in Hot Weather

Following a few simple principles can minimize the problems associated with exercising in the heat. To help alert people about weather conditions that could increase the risk of heat illness, the U.S. Weather Service developed the heat index—a measure that incorporates both temperature and relative humidity. For example, a temperature of 95 degrees combined with a relative humidity of 50% has a heat index of 107.

Prolonged exposure or physical activity when the heat index is 80–90 can cause fatigue; at a heat index of 90 or above, heat cramps, heat exhaustion, and heatstroke become more likely. Reduce and avoid exercise when the heat index is 90 or above.

A complete chart of heat index values can be found on the Fit and Well Online Learning Center. Local heat index information is available from the National Weather Service (http://www.weather.gov).

To avoid the risk of heat illness, follow these guidelines:

- **Be in good physical condition.** Exercise training can help the body adapt to heat by increasing the sweat rate.
- **Use caution when exercising in extreme heat or humidity** (over 80°F and/or 60% humidity).
- **Slow exercise or add rest breaks** to maintain your prescribed target heart rate; as you become acclimatized, you can gradually increase intensity and duration.
- **Exercise in the early morning or evening** when temperatures are lowest.

- **Drink 2 cups of fluids 2 hours before you begin exercising,** and drink 4–8 ounces of fluid every 10–15 minutes during exercise (more frequently during high-intensity activities). Plan for regular water breaks. For an exercise session lasting longer than 60–90 minutes, choose a sports beverage that is cold (8–13°C; 46–55°F), low in sugar (less than 8 grams per 100 milliliters), and contains a small amount of electrolytes.
- **During a period of hot weather, weigh yourself every day before exercising.** If your weight has decreased by 3% or more from the previous day, don’t exercise without first rehydrating.
- **Avoid supplements and beverages containing stimulants** like ephedra and caffeine when exercising in the heat; they can promote heat-induced illness. Do not use salt pills.
- **Wear clothing that breathes,** allowing air to circulate and cool the body. Wearing white or light colors will help by reflecting, rather than absorbing, heat. A hat can help keep direct sun off your face. Do not wear rubber, plastic, or other nonporous clothing. “Sauna suits” cause loss of body water, not fat, and don’t improve body composition.
- **Rest frequently in the shade.**
- **Slow down or stop if you begin to feel uncomfortable.** Watch for the signs of heat disorders; if they occur, act appropriately.

QUESTIONS FOR CRITICAL THINKING AND REFLECTION

Suppose you want to start a new cardiorespiratory exercise program. How do your age, health status, and current level of fitness affect the kind of program you design for yourself? For the first few weeks, how often would you exercise, at what intensity (heart rate), and for how long?

EXERCISE SAFETY AND INJURY PREVENTION

Exercising safely and preventing injuries are two important challenges for people who engage in cardiorespiratory endurance exercise. This section provides basic safety guidelines that can be applied to a variety of fitness activities; visit the Fit and Well Online Learning Center for more detailed information about the prevention and care of exercise injuries and safe exercise in challenging environmental conditions. Chapters 4 and 5 include additional advice specific to strength training and flexibility training.

Hot Weather and Heat Stress

Human beings require a relatively constant body temperature to survive. A change of just a few degrees in body temperature can quickly lead to distress and even death. If you lose too much water or if your body temperature gets too high, you may suffer from heat stress. Problems associated with heat stress include dehydration, heat cramps, heat exhaustion, and heatstroke.

In a high-temperature environment, exercise safety depends on the body’s ability to dissipate heat and maintain blood flow to active muscles. The body releases heat from exercise through the evaporation of sweat. This process cools the skin and the blood circulating near the body’s surface. Sweating is an efficient process as long as the air is relatively dry. As humidity increases, however, the sweating mechanism becomes less efficient because extra moisture in the air inhibits the evaporation of sweat from the skin. This is why it takes longer to cool down in humid weather than in dry weather.

You can avoid significant heat stress by staying fit, avoiding overly intense or prolonged exercise for which you are not prepared, drinking adequate fluids before and during exercise, and wearing clothes that allow heat to dissipate. For additional tips, see the box “Exercise in Hot Weather.”
Dehydration  Your body needs water to carry out many chemical reactions and to regulate body temperature. Sweating during exercise depletes your body’s water supply and can lead to dehydration if fluids aren’t replaced. Although dehydration is most common in hot weather, it can occur in even comfortable temperatures if fluid intake is insufficient.

Dehydration increases body temperature and decreases sweat rate, plasma volume, cardiac output, maximal oxygen consumption, exercise capacity, muscular strength, and stores of liver glycogen. You may begin to feel thirsty when you have a fluid deficit of about 1% of total body weight.

Drinking fluids before and during exercise is important to prevent dehydration and enhance performance. Thirst receptors in the brain make you want to drink fluids, but during heavy or prolonged exercise or exercise in hot weather, thirst alone isn’t a good indication of how much you need to drink. As a rule of thumb, drink at least 2 cups (16 ounces) of fluid 2 hours before exercise, and then drink enough during exercise to match fluid loss in sweat. Drink at least 1 cup of fluid for every 20–30 minutes of exercise, more in hot weather or if you sweat heavily. To determine if you’re drinking enough fluid, weigh yourself before and after an exercise session—any weight loss is due to fluid loss that needs to be replaced.

Very rarely, athletes consume too much water and develop hyponatremia, a condition characterized by lung congestion, muscle weakness, and nervous system problems. Following the guidelines presented here can help prevent this condition.

Bring a water bottle when you exercise so you can replace your fluids when they’re being depleted. For exercise sessions lasting less than 60–90 minutes, cool water is an excellent fluid replacement. For longer workouts, choose a sports drink that contains water and small amounts of electrolytes (sodium, potassium, and magnesium) and simple carbohydrates (“sugar,” usually in the form of sucrose, glucose, lactate, or glucose polymers). Electrolytes, which are lost from the body in sweat, are important because they help regulate the balance of fluids in body cells and the bloodstream. The carbohydrates in typical sports drinks are rapidly digestible and can thus help maintain blood glucose levels. Choose a beverage with no more than 8 grams of simple carbohydrate per 100 milliliters. See Chapter 8 for more on diet and fluid recommendations for active people.

Heat Cramps  Involuntary cramping and spasms in the muscle groups used during exercise are sometimes called heat cramps. While depletion of sodium and potassium from the muscles is involved with the problem, the primary cause of cramps is muscle fatigue. Children are particularly susceptible to heat cramps, but the condition can also occur in adults, even those who are fit. The best treatment for heat cramps is a combination of gentle stretching, replacement of fluid and electrolytes, and rest.

Heat Exhaustion  Symptoms of heat exhaustion include the following:

- A rapid, weak pulse
- Low blood pressure
- Headache
- Faintness, weakness, dizziness
- Profuse sweating
- Pale face
- Psychological disorientation (in some cases)
- Normal or slightly elevated core body temperature

Heat exhaustion occurs when an insufficient amount of blood returns to the heart because so much of the body’s blood volume is being directed to working muscles (for exercise) and to the skin (for cooling). Treatment for heat exhaustion includes resting in a cool area, removing excess clothing, applying cool or damp towels to the body, and drinking fluids. An affected individual should rest for the remainder of the day and drink plenty of fluids for the next 24 hours.

Heatstroke  Heatstroke is a major medical emergency involving the failure of the brain’s temperature regulatory center. The body does not sweat enough, and body temperature rises dramatically to extremely dangerous levels. In addition to high body temperature, symptoms can include the following:

- Hot, flushed skin (dry or sweaty), red face
- Chills, shivering
- Very high or very low blood pressure
- Confusion, erratic behavior
- Convulsions, loss of consciousness

A heatstroke victim should be cooled as rapidly as possible and immediately transported to a hospital. To lower body temperature, get out of the heat, remove excess clothing, apply cool or damp towels to the body, and drinking fluids. An affected individual should rest for the remainder of the day and drink plenty of fluids for the next 24 hours.

Heat index  A measure of how hot it feels; the temperature that would have the same heating effect on a person as a given combination of temperature and relative humidity.

Dehydration  Excessive loss of body fluid.

Heat cramps  Sudden development of muscle spasms and pain associated with intense exercise in hot weather.

Heat exhaustion  Heat illness related to dehydration resulting from exertion in hot weather.

Heatstroke  A severe and often fatal heat illness produced by exposure to very high temperatures, especially when combined with intense exercise; characterized by significantly elevated core body temperature.

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Clothing, drink cold fluids, and apply cool or damp towels to the body or immerse the body in cold water.

**Cold Weather**

In extremely cold conditions, problems can occur if a person’s body temperature drops or if particular parts of the body are exposed. If the body’s ability to warm itself through shivering or exercise can’t keep pace with heat loss, the core body temperature begins to drop. This condition, known as hypothermia, depresses the central nervous system, resulting in sleepiness and a lower metabolic rate. As metabolic rate drops, body temperature declines even further, and coma and death can result.

**Frostbite**—the freezing of body tissues—is another potential danger of exercise in extremely cold conditions. Frostbite most commonly occurs in exposed body parts like earlobes, fingers, and toes, and it can cause permanent circulatory damage. Hypothermia and frostbite both require immediate medical treatment.

What can you do to exercise safely in cold conditions? First of all, don’t stay out in very cold temperatures for too long. Take both the temperature and the wind into account when planning your exercise session. Frostbite within 30 minutes is possible in calm conditions when the temperature is colder than −5°F or in windy conditions (30 mph) if the temperature is below 10°F. Wind chill values that reflect both the temperature and the wind speed are available as part of a local weather forecast and from the National Weather Service (http://www.weather.gov); a complete wind chill chart is available on the Fit and Well Online Learning Center.

Appropriate clothing provides insulation and helps trap warm air next to the skin. Dress in layers so you can remove them as you warm up and can put them back on if you get cold. A substantial amount of heat loss comes from the head and neck, so keep these areas covered. In subfreezing temperatures, protect the areas of your body most susceptible to frostbite—fingers, toes, ears, nose, and cheeks—with warm socks, mittens or gloves, and a cap, hood, or ski mask. Wear clothing that breathes and will wick moisture away from your skin to avoid being cooled or overheated by trapped perspiration. Many types of comfortable, lightweight clothing that provide good insulation are available. It’s also important to warm up thoroughly and to drink plenty of fluids.

**Poor Air Quality**

Air pollution can decrease exercise performance and negatively affect health, particularly if you have respiratory problems such as asthma, bronchitis, or emphysema, or if you smoke. The effects of smog are worse during exercise than at rest because air enters the lungs faster. Polluted air may also contain carbon monoxide, which displaces oxygen in the blood and reduces the amount of oxygen available to working muscles. In a 2007 study, the ACSM found that exercise in polluted air could decrease lung function to the same extent as heavy smoking. Symptoms of poor air quality include eye and throat irritations, difficulty breathing, and possibly headache and malaise.

Do not exercise outdoors during a smog alert or if air quality is very poor. If you have any type of cardiorespiratory difficulty, you should also avoid exertion outdoors when air quality is poor. You can avoid some smog and air pollution by exercising in indoor facilities, in parks, near water (riverbanks, lakeshores, and ocean beaches), or in residential areas with less traffic (areas with stop-and-go traffic will have lower air quality than areas where traffic moves quickly). Air quality is also usually better in the early morning and late evening, before and after the commute hours.

**Exercise Injuries**

Most injuries are annoying rather than serious or permanent. However, an injury that isn’t cared for properly can escalate into a chronic problem, sometimes serious enough to permanently curtail the activity. It’s important to learn how to deal with injuries so they don’t derail your fitness program. Strategies for the care of common exercise injuries and discomforts appear in Table 3.6; some general guidelines are given below.

**When to Call a Physician** Some injuries require medical attention. Consult a physician for the following:

- Head and eye injuries
- Possible ligament injuries
- Broken bones
- Internal disorders: chest pain, fainting, elevated body temperature, intolerance to hot weather

Also seek medical attention for ostensibly minor injuries that do not get better within a reasonable amount of time. You may need to modify your exercise program for a few weeks to allow an injury to heal.

**Managing Minor Exercise Injuries** For minor cuts and scrapes, stop the bleeding and clean the wound. Treat
Injuries to soft tissue (muscles and joints) with the R-I-C-E principle: Rest, Ice, Compression, and Elevation.

- **Rest**: Stop using the injured area as soon as you experience pain. Avoid any activity that causes pain.
- **Ice**: Apply ice to the injured area to reduce swelling and alleviate pain. Apply ice immediately for 10–20 minutes, and repeat every few hours until the swelling disappears. Let the injured part return to normal temperature between icings, and do not apply ice to one area for more than 20 minutes. An easy method for applying ice is to freeze water in a paper cup, peel some of the paper away, and rub the exposed ice on the injured area. If the injured area is large, you can surround it with several bags of crushed ice or ice cubes, or bags of frozen vegetables. Place a thin towel between the bag and your skin. If you use a cold gel pack, limit application time to 10 minutes. Apply ice regularly for 36–48 hours or until the swelling is gone; it may be necessary to apply ice for a week or more if swelling persists.
- **Compression**: Wrap the injured area firmly with an elastic or compression bandage between icings. If the area starts throbbing or begins to change color, the bandage may be wrapped too tightly. Do not sleep with the wrap on.

  - **Elevation**: Raise the injured area above heart level to decrease the blood supply and reduce swelling. Use pillows, books, or a low chair or stool to raise the injured area.

The day after the injury, some experts recommend also taking an over-the-counter medication such as aspirin, ibuprofen, or naproxen to decrease inflammation. To rehabilitate your body, follow the steps listed in the box “Rehabilitation Following a Minor Athletic Injury” on p. 80.

**Preventing Injuries**  The best method for dealing with exercise injuries is to prevent them. If you choose activities for your program carefully and follow the training guidelines described here and in Chapter 2, you should be able to avoid most types of injuries. Important guidelines for preventing athletic injuries include the following:

- Train regularly and stay in condition.
- Gradually increase the intensity, duration, or frequency of your workouts.
- Avoid or minimize high-impact activities; alternate them with low-impact activities.
- Get proper rest between exercise sessions.
- Drink plenty of fluids.
- Warm up thoroughly before you exercise and cool down afterward.

<table>
<thead>
<tr>
<th>Table 3.6</th>
<th>Care of Common Exercise Injuries and Discomforts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injury</td>
<td>Symptoms</td>
</tr>
<tr>
<td>Blister</td>
<td>Accumulation of fluid in one spot under the skin</td>
</tr>
<tr>
<td>Bruise (contusion)</td>
<td>Pain, swelling, and discoloration</td>
</tr>
<tr>
<td>Fracture and/or dislocation</td>
<td>Pain, swelling, tenderness, loss of function, and deformity</td>
</tr>
<tr>
<td>Joint sprain</td>
<td>Pain, tenderness, swelling, discoloration, and loss of function</td>
</tr>
<tr>
<td>Muscle cramp</td>
<td>Painful, spasmodic muscle contractions</td>
</tr>
<tr>
<td>Muscle soreness or stiffness</td>
<td>Pain and tenderness in the affected muscle</td>
</tr>
<tr>
<td>Muscle strain</td>
<td>Pain, tenderness, swelling, and loss of strength in the affected muscle</td>
</tr>
<tr>
<td>Plantar fasciitis</td>
<td>Pain and tenderness in the connective tissue on the bottom of your feet</td>
</tr>
<tr>
<td>Shin splint</td>
<td>Pain and tenderness on the front of the lower leg, sometimes also pain in the calf muscle</td>
</tr>
<tr>
<td>Side stitch</td>
<td>Pain on the side of the abdomen</td>
</tr>
<tr>
<td>Tendinitis</td>
<td>Pain, swelling, and tenderness of the affected area</td>
</tr>
</tbody>
</table>
Rehabilitation Following a Minor Athletic Injury

- Reduce the initial inflammation using the R-I-C-E principle (see text).
- After 36–48 hours, apply heat if the swelling has completely disappeared. Immerse the affected area in warm water or apply warm compresses, a hot water bottle, or a heating pad. As soon as it’s comfortable, begin moving the affected joints slowly. If you feel pain, or if the injured area begins to swell again, reduce the amount of movement. Continue stretching and moving the affected area until you have regained normal range of motion.

- Gradually begin exercising the injured area to build strength and endurance. Depending on the type of injury, weight training, walking, and resistance training with a partner can all be effective.
- Gradually reintroduce the stress of an activity until you can return to full intensity. Don’t progress too rapidly or you’ll reinjure yourself. Before returning to full exercise participation, you should have a full range of motion in your joints, normal strength and balance among your muscles, normal coordinated patterns of movement (with no injury compensation movements, such as limping), and little or no pain.

- Achieve and maintain a good level of flexibility.
- Use proper body mechanics when lifting objects or executing sports skills.
- Don’t exercise when you are ill or overtrained.
- Use proper equipment, particularly shoes, and choose an appropriate exercise surface. If you exercise on a grass field, soft track, or wooden floor, you are less likely to be injured than on concrete or a hard track. (For information on athletic shoes, see the box “Choosing Exercise Footwear.”)
- Don’t return to your normal exercise program until any athletic injuries have healed. Restart your program at a lower intensity and gradually increase the amount of overload.

TIPS FOR TODAY AND THE FUTURE

Regular, moderate exercise, even in short bouts spread through the day, can build and maintain cardiorespiratory fitness.

RIGHT NOW YOU CAN
- Assess your cardiorespiratory fitness by using one of the methods discussed in this chapter and in Lab 3.1.
- Do a short bout of endurance exercise: 10–15 minutes of walking, jogging, cycling, or another endurance activity.
- If you have physical activity planned for later in the day, drink some fluids now to make sure you are fully hydrated for your workout.
- Consider the exercise equipment, including shoes, you currently have on hand. If you need new equipment, start gathering the information you’ll need to get the best equipment you can afford.
- Contact someone you know who engages in regular endurance exercise. Ask what strategies she or he uses to find time for exercise and to stay motivated.

IN THE FUTURE YOU CAN
- Graduate to a different, more challenging fitness assessment as your cardiorespiratory fitness improves.
- Incorporate different types of exercises into your cardiorespiratory endurance training to keep yourself challenged and motivated.

QUESTIONS FOR CRITICAL THINKING AND REFLECTION

Have you ever suffered an injury while exercising? If so, how did you treat the injury? Compare your treatment with the guidelines given in this chapter. Did you do the right things? What can you do to avoid such injuries in the future?

SUMMARY

- The cardiorespiratory system consists of the heart, blood vessels, and respiratory system; it picks up and transports oxygen, nutrients, and waste products.
- The body takes chemical energy from food and uses it to produce ATP and fuel cellular activities. ATP is stored in the body’s cells as the basic form of energy.
- During exercise, the body supplies ATP and fuels cellular activities by combining three energy systems: immediate, for short periods of activity; nonoxidative (anaerobic), for intense activity, and oxidative (aerobic), for prolonged activity. Which energy system predominates depends on the duration and intensity of the activity.
- Cardiorespiratory endurance exercise improves cardiorespiratory functioning and cellular metabolism; it reduces the risk of chronic diseases such as heart disease, cancer, type 2 diabetes, obesity, and osteoporosis; and it improves immune function and psychological and emotional well-being.
- Cardiorespiratory fitness is measured by determining how well the cardiorespiratory system transports and uses oxygen.

(continued on p. 83)
Choosing Exercise Footwear

Footwear is perhaps the most important item of equipment for almost any activity. Shoes protect and support your feet and improve your traction. When you jump or run, you place as much as six times more force on your feet than when you stand still. Shoes can help cushion against the stress that this additional force places on your lower legs, thereby preventing injuries. Some athletic shoes are also designed to help prevent ankle rollover, another common source of injury.

General Guidelines

When choosing athletic shoes, first consider the activity you’ve chosen for your exercise program. Shoes appropriate for different activities have very different characteristics. For example, running shoes typically have highly cushioned midsoles, rubber outsoles with elevated heels, and a great deal of flexibility in the forefoot. The heels of walking shoes tend to be lower, less padded, and more beveled than those designed for running. For aerobic dance, shoes must be flexible in the forefoot and have straight, nonflared heels to allow for safe and easy lateral movements. Court shoes also provide substantial support for lateral movements; they typically have outsoles made from white rubber that will not damage court surfaces.

Also consider the location and intensity of your workouts. If you plan to walk or run on trails, you should choose shoes with water-resistant, highly durable uppers and more outsole traction. If you work out intensely or have a relatively high body weight, you’ll need thick, firm midsoles to avoid bottoming-out the cushioning system of your shoes.

Foot type is another important consideration. If your feet tend to roll inward excessively, you may need highly flexible and cushioned shoes that promote foot motion. For aerobic dancers whose feet tend to roll inward or outward, mid- or high-cut shoes may be more appropriate than low-cut aerobic shoes or cross-trainers (shoes designed to be worn for several different activities). Compared to men, women have narrower feet overall and narrower heels relative to the forefoot. Most women will get a better fit if they choose shoes that are specifically designed for women’s feet rather than shoes that are downsized versions of men’s shoes.

Successful Shopping

For successful shoe shopping, keep the following strategies in mind:

- Shop at an athletic shoe or specialty store that has personnel trained to fit athletic shoes and a large selection of styles and sizes.
- Shop late in the day or, ideally, following a workout. Your foot size increases over the course of the day and after exercise.
- Check the fit and style carefully:

  - Wear socks like those you plan to wear during exercise. If you have an old pair of athletic shoes, bring them with you. The wear pattern on your old shoes can help you select a pair with extra support or cushioning in the places you need it the most.
  - Ask for help. Trained salespeople know which shoes are designed for your foot type and your level of activity. They can also help fit your shoes properly.
  - Don’t insist on buying shoes in what you consider to be your typical shoe size. Sizes vary from shoe to shoe. In addition, foot sizes change over time, and many people have one foot that is larger or wider than the other. Try several sizes in several widths, if necessary. Don’t buy shoes that are too small.
  - Try on both shoes and wear them around for 10 or more minutes. Try walking on a noncarpeted surface. Approximate the movements of your activity: walk, jog, run, jump, and so on.

- Do you feel any pressure points?
- Do the shoes feel stable when you twist and turn on one foot?
- Do the arches of your feet fit on top of the shoe’s arch supports?
- Are the balls of your feet flat on the shoes’ soles?
- Do your heels fit snugly into the shoe? Do they stop when you walk, or do they rise up?
- Are the shoes comfortable in the store, don’t buy them. Don’t expect athletic shoes to stretch over time in order to fit your feet properly.
- If you exercise at dawn or dusk, choose shoes with reflective sections for added visibility and safety.
- Replace athletic shoes about every 3 months or 300–500 miles of jogging or walking.
What kind of clothing should I wear during exercise?

Exercise clothing should be comfortable, let you move freely, and allow your body to cool itself. Avoid clothing that constricts normal blood flow or is made from nylon or rubberized fabrics that prevent evaporation of perspiration. Cotton is an excellent material for facilitating the evaporation of sweat. If you sweat heavily when you exercise and find that too much moisture accumulates in cotton clothing, try fabrics containing synthetic materials such as polypropylene that wick moisture away from the skin. Socks made with moisture-wicking compounds may be particularly helpful for people whose feet sweat heavily.

A sports bra is a key piece of clothing for women. A good sports bra should be made of a breathable fabric to allow for evaporation of sweat; it should fit well and have comfortable seams and closures. Try on several styles and sizes to see what fits best, and try the jump test to make sure the bra will provide enough support for your activities. Find a bra that emphasizes function over fashion.

Do I need a special diet for my endurance exercise program?

No. For most people, a nutritionally balanced diet contains all the energy and nutrients needed to sustain an exercise program. Don’t waste your money on unnecessary supplements. (Chapter 8 has information about putting together a healthy diet.)

How can I measure how far I walk or run?

The simplest and cheapest way to measure distance is with a pedometer, which counts your steps. A pedometer’s accuracy depends on how precisely you measure your stride length; follow the instructions that come with your pedometer to set this measure. Although stride length varies among individuals, 2000 steps typically equals about 1 mile, and 10,000 steps equals about 5 miles. To track your distance and your progress using a pedometer, follow the guidelines in Lab 2.3. For advice on purchasing a pedometer that meets your needs, check consumer and fitness magazines and Web sites. More tips on using pedometers are provided on the Online Learning Center.

How can I safely increase exercise intensity to build fitness?

For both athletes and nonathletes, it is extremely important to increase intensity very gradually and to rest between exercise sessions. If you train too hard and/or don’t rest enough, you are more likely to be injured—and be discouraged from continuing with your fitness program. For endurance training, overload techniques such as interval training and wind sprints can help you build fitness quickly but also pose a greater risk of injury or overtraining. Start off with a few high-intensity bouts of exercise and build up gradually. Don’t practice interval training or wind sprints more than 2–3 days per week unless you have a high fitness level.

Increase intensity or duration by about 1–2% in a single workout; rest the following day and then do your typical workout. Repeat the more difficult workout after another day of rest. Adjust your progress according to how you feel. You can’t increase fitness in a few days. Be patient—with gradual increases in intensity and plenty of rest between workouts, you will be able to move to a higher level of fitness without injury.

If I plan to include both cardiorespiratory endurance training and strength training in a single workout, which should I do first?

It depends on your goals. If your primary goal is cardiorespiratory conditioning, then do your endurance workout first. If your fitness program is focused on large gains in strength and you plan to lift relatively heavy weights, then do your strength training workout first. You are likely to make the most rapid gains in fitness in whichever activity you engage in first, when you are fresh.

Is it all right to participate in cardiorespiratory endurance exercise while menstruating?

Yes. There is no evidence that exercise during menstruation is unhealthy or that it has negative effects on performance. If you have headaches, backaches, and abdominal pain during menstruation, you may not feel like exercising; for some women, exercise helps relieve these symptoms. Listen to your body, and exercise at whatever intensity is comfortable for you.

Will high altitude affect my ability to exercise?

At high altitudes (above 1500 meters or about 4900 feet), there is less oxygen available in the air than at lower altitudes. High altitude doesn’t affect anaerobic exercise, such as stretching and weight lifting, but it does affect aerobic activities—that is, any type of cardiovascular endurance exercise—because the heart and lungs have to work harder, even when the body is at rest, to deliver enough oxygen to body cells. The increased cardiovascular strain of exercise reduces endurance. To play it safe when at high altitudes, avoid heavy exercise—at least for the first few days—and drink plenty of water. And don’t expect to reach your normal lower altitude exercise capacity.

For more Common Questions Answered about endurance training, visit the Online Learning Center.

WEB
The upper limit of this measure is called maximal oxygen consumption, or VO$_2$$_{\text{max}}$.

- VO$_2$$_{\text{max}}$ can be measured precisely in a laboratory, or it can be estimated reasonably well through less expensive assessment tests.
- To have a successful exercise program, set realistic goals; choose suitable activities; begin slowly; always warm up and cool down; and, as fitness improves, exercise more often, longer, and/or harder.
- Intensity of training can be measured through target heart rate zone, METs, ratings of perceived exertion, or the “talk test.”
- With careful attention to fluid intake, clothing, duration of exercise, and exercise intensity, endurance training can be safe in hot and cold weather conditions.
- Serious injuries require medical attention. Application of the R-I-C-E principle (rest, ice, compression, elevation) is appropriate for treating many types of muscle or joint injuries.

**FOR FURTHER EXPLORATION**

**BOOKS**


**ORGANIZATIONS AND WEB SITES**

American Academy of Orthopaedic Surgeons. Provides fact sheets on many fitness and sports topics, including how to begin a program, how to choose equipment, and how to prevent and treat many types of injuries.

http://orthoinfo.aaos.org

American Heart Association. Provides information on cardiovascular health and disease, including the role of exercise in maintaining heart health and exercise tips for people of all ages.

800-AHA-USA1 http://www.americanheart.org

Dr. Pribut’s Running Injuries Page. Provides information about running and many types of running injuries.

http://www.drpribut.com/sports/spssport.html


http://www.ftc.gov/bcp/menus/consumer/health.shtm

The Human Heart. An online museum exhibit with information on the structure and function of the heart, blood vessels, and respiratory system.

http://www.fi.edu/learn/heart/index.html

MedlinePlus: Exercise and Physical Fitness. Provides links to news and reliable information about fitness from government agencies and professional associations.


Physician and Sportsmedicine. Provides many articles with easy-to-understand advice about exercise injuries.

http://www.postgradmed.com/index.html

Runner’s World Online. Contains a wide variety of information about running, including tips for beginning runners, advice about training, and a shoe buyer’s guide.

http://www.runnersworld.com

University of Florida: Keeping Fit. Provides useful information about fitness in a question-and-answer format; an extensive set of links is also provided.

http://www.hhp.ufl.edu/faculty/pbird/keepingfit

Women’s Sports Foundation. Provides information and links about training and about many specific sports activities.

http://www.womenssportsfoundation.org

Yahoo/Recreation. Contains links to many sites with practical advice on many sports and activities.

http://dir.yahoo.com/recreation/sports

See also the listings in Chapters 2 and 11.

**SELECTED BIBLIOGRAPHY**


Before taking any of the cardiorespiratory endurance assessment tests, refer to the fitness prerequisites and cautions given in Table 3.2. Choose one of the following three tests presented in this lab:

- 1-mile walk test
- 3-minute step test
- 1.5-mile run-walk test

For best results, don’t exercise strenuously or consume caffeine the day of the test, and don’t smoke or eat a heavy meal within about 3 hours of the test.

The 1-Mile Walk Test

**Equipment**
1. A track or course that provides a measurement of 1 mile
2. A stopwatch, clock, or watch with a second hand
3. A weight scale

**Preparation**
Measure your body weight (in pounds) before taking the test.

Body weight: _________ lb

**Instructions**
1. Warm up before taking the test. Do some walking, easy jogging, or calisthenics and some stretching exercises.
2. Cover the 1-mile course as quickly as possible. Walk at a pace that is brisk but comfortable. You must raise your heart rate above 120 beats per minute (bpm).
3. As soon as you complete the distance, note your time and take your pulse for 10 seconds.
   - Walking time: _________ min _________ sec
   - 10-second pulse count: _________ beats
4. Cool down after the test by walking slowly for several minutes.

**Determining Maximal Oxygen Consumption**
1. Convert your 10-second pulse count into a value for exercise heart rate by multiplying it by 6.
   - Exercise heart rate: _________ × 6 = _________ bpm
2. Convert your walking time from minutes and seconds to a decimal figure. For example, a time of 14 minutes and 45 seconds would be 14 + (45/60), or 14.75 minutes.
   - Walking time: _________ min + ( _________ sec ÷ 60 sec/min) = _________ min
3. Insert values for your age, gender, weight, walking time, and exercise heart rate in the following equation, where
   - $W$ = your weight (in pounds)
   - $A$ = your age (in years)
   - $G$ = your gender (male = 1; female = 0)
   - $T$ = your time to complete the 1-mile course (in minutes)
   - $H$ = your exercise heart rate (in beats per minute)
   - $\dot{V}O_2\text{max} = 132.853 - (0.0769 \times W) - (0.3877 \times A) + (6.315 \times G) - (3.2649 \times T) - (0.1565 \times H)
For example, a 20-year-old, 190-pound male with a time of 14.75 minutes and an exercise heart rate of 152 bpm would calculate maximal oxygen consumption as follows:

\[
\frac{\bar{VO}_{2\text{max}}}{\bar{V}O_{2\text{max}}} = 132.853 - (0.0769 \times 190) - (0.3877 \times 1) - (3.2649 \times 14.75) - (0.1565 \times 152) = 45 \text{ ml/kg/min}
\]

\[
\frac{\bar{VO}_{2\text{max}}}{\bar{V}O_{2\text{max}}} = 132.853 - (0.0769 \times \text{weight (lb)}) - (0.3877 \times \text{age (years)}) + (6.315 \times \text{gender})
\]

\[
- (3.2649 \times \text{walking time (min)}) - (0.1565 \times \text{exercise heart rate (bpm)}) = \text{ml/kg/min}
\]

4. Copy this value for \(\bar{V}O_{2\text{max}}\) into the appropriate place in the chart on the final page of this lab.

### The 3-Minute Step Test

#### Equipment

1. A step, bench, or bleacher step that is 16.25 inches from ground level
2. A stopwatch, clock, or watch with a second hand
3. A metronome

#### Preparation

Practice stepping up onto and down from the step before you begin the test. Each step has four beats: up-up-down-down. Males should perform the test with the metronome set for a rate of 96 beats per minute, or 24 steps per minute. Females should set the metronome at 88 beats per minute, or 22 steps per minute.

#### Instructions

1. Warm up before taking the test. Do some walking, easy jogging, and stretching exercises.
2. Set the metronome at the proper rate. Your instructor or a partner can call out starting and stopping times; otherwise, have a clock or watch within easy viewing during the test.
3. Begin the test and continue to step at the correct pace for 3 minutes.
4. Stop after 3 minutes. Remain standing and count your pulse for the 15-second period from 5 to 20 seconds into recovery.

   15-second pulse count: ________ beats

5. Cool down after the test by walking slowly for several minutes.

#### Determining Maximal Oxygen Consumption

1. Convert your 15-second pulse count to a value for recovery heart rate by multiplying by 4.

   \[
   \text{Recovery heart rate} = \frac{\text{15-sec pulse count}}{4} \text{ bpm}
   \]

2. Insert your recovery heart rate in the equation below, where

   \[
   H = \text{recovery heart rate (in beats per minute)}
   \]

   Males: \(\bar{V}O_{2\text{max}} = 111.33 - (0.42 \times H)\)

   Females: \(\bar{V}O_{2\text{max}} = 65.81 - (0.1847 \times H)\)

   For example, a man with a recovery heart rate of 162 bpm would calculate maximal oxygen consumption as follows:

   \[
   \frac{\bar{VO}_{2\text{max}}}{\bar{V}O_{2\text{max}}} = 111.33 - (0.42 \times 162) = 43 \text{ ml/kg/min}
   \]

   Males: \(\bar{V}O_{2\text{max}} = 111.33 - (0.42 \times \text{recovery heart rate (bpm)}) = \text{ml/kg/min}\)

   Females: \(\bar{V}O_{2\text{max}} = 65.81 - (0.1847 \times \text{recovery heart rate (bpm)}) = \text{ml/kg/min}\)

3. Copy this value for \(\bar{V}O_{2\text{max}}\) into the appropriate place in the chart on the final page of this lab.
The 1.5-Mile Run-Walk Test

Equipment
1. A running track or course that is flat and provides exact measurements of up to 1.5 miles
2. A stopwatch, clock, or watch with a second hand

Preparation
You may want to practice pacing yourself prior to taking the test to avoid going too fast at the start and becoming prematurely fatigued. Allow yourself a day or two to recover from your practice run before taking the test.

Instructions
1. Warm up before taking the test. Do some walking, easy jogging, and stretching exercises.
2. Try to cover the distance as fast as possible without overexerting yourself. If possible, monitor your own time, or have someone call out your time at various intervals of the test to determine whether your pace is correct.
3. Record the amount of time, in minutes and seconds, it takes you to complete the 1.5-mile distance.
   Running-walking time: ____________ min ____________ sec
4. Cool down after the test by walking or jogging slowly for about 5 minutes.

Determining Maximal Oxygen Consumption
1. Convert your running time from minutes and seconds to a decimal figure. For example, a time of 14 minutes and 25 seconds would be 14 + (25 sec ÷ 60 sec/min) = 14.4 minutes.
   Running-walking time: _________ min + ( ________ sec ÷ 60 sec/min) = _________ min
2. Insert your running time into the equation below, where
   \[ VO_2max = \left( \frac{483}{T} \right) + 3.5 \]
   For example, a person who completes 1.5 miles in 14.4 minutes would calculate maximal oxygen consumption as follows:
   \[ VO_2max = \left( \frac{483}{14.4} \right) + 3.5 = 37 \text{ ml/kg/min} \]
3. Copy this value for \( VO_2max \) into the appropriate place in the chart on the final page of this lab.

Rating Your Cardiovascular Fitness
Record your \( VO_2max \) score(s) and the corresponding fitness rating from the table below.

<table>
<thead>
<tr>
<th>Women</th>
<th></th>
<th></th>
<th></th>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>Very Poor</td>
<td>Poor</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Superior</td>
</tr>
<tr>
<td>18–29</td>
<td>Below 31.6</td>
<td>31.6–35.4</td>
<td>35.5–39.4</td>
<td>39.5–43.9</td>
<td>44.0–50.1</td>
<td>Above 50.1</td>
</tr>
<tr>
<td>30–39</td>
<td>Below 29.9</td>
<td>29.9–33.8</td>
<td>33.8–38.3</td>
<td>38.4–43.0</td>
<td>41.0–46.9</td>
<td>Above 46.8</td>
</tr>
<tr>
<td>40–49</td>
<td>Below 28.0</td>
<td>28.0–31.5</td>
<td>31.6–35.3</td>
<td>35.7–40.1</td>
<td>39.2–45.8</td>
<td>Above 45.1</td>
</tr>
<tr>
<td>50–59</td>
<td>Below 25.5</td>
<td>25.5–28.6</td>
<td>28.7–31.3</td>
<td>31.4–35.0</td>
<td>33.7–39.8</td>
<td>Above 39.8</td>
</tr>
<tr>
<td>60–69</td>
<td>Below 23.7</td>
<td>23.7–26.5</td>
<td>26.6–29.0</td>
<td>29.1–32.2</td>
<td>32.0–36.8</td>
<td>Above 36.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Men</th>
<th></th>
<th></th>
<th></th>
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<th></th>
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</thead>
<tbody>
<tr>
<td>Age</td>
<td>Very Poor</td>
<td>Poor</td>
<td>Fair</td>
<td>Good</td>
<td>Excellent</td>
<td>Superior</td>
</tr>
<tr>
<td>18–29</td>
<td>Below 38.1</td>
<td>38.1–42.1</td>
<td>42.2–45.7</td>
<td>45.7–51.0</td>
<td>51.1–56.1</td>
<td>Above 56.1</td>
</tr>
<tr>
<td>30–39</td>
<td>Below 36.7</td>
<td>36.7–40.9</td>
<td>41.0–44.3</td>
<td>44.4–48.8</td>
<td>48.9–54.2</td>
<td>Above 54.2</td>
</tr>
<tr>
<td>40–49</td>
<td>Below 34.6</td>
<td>34.6–38.3</td>
<td>38.4–42.3</td>
<td>42.4–46.7</td>
<td>46.8–52.8</td>
<td>Above 52.8</td>
</tr>
<tr>
<td>50–59</td>
<td>Below 31.1</td>
<td>31.1–35.1</td>
<td>35.2–38.2</td>
<td>38.3–43.2</td>
<td>43.3–49.6</td>
<td>Above 49.6</td>
</tr>
<tr>
<td>60–69</td>
<td>Below 27.4</td>
<td>27.4–31.3</td>
<td>31.4–34.9</td>
<td>35.0–39.4</td>
<td>39.5–46.0</td>
<td>Above 46.0</td>
</tr>
</tbody>
</table>

SOURCE: Ratings based on norms from The Cooper Institute of Aerobic Research, Dallas, Texas; from The Physical Fitness Specialist Manual, Revised 2002. Used with permission.
CHAPTER 3  CARDIORESPIRATORY ENDURANCE

LABORATORY ACTIVITIES

Using Your Results

How did you score? Are you surprised by your rating for cardiovascular fitness? Are you satisfied with your current rating?

If you’re not satisfied, set a realistic goal for improvement:

__________________________________________________________

Are you satisfied with your current level of cardiovascular fitness as evidenced in your daily life—your ability to walk, run, bicycle, climb stairs, do yard work, engage in recreational activities?

If you’re not satisfied, set some realistic goals for improvement, such as completing a 5K run or 25-mile bike ride:

What should you do next? Enter the results of this lab in the Preprogram Assessment column in Appendix D. If you’ve set goals for improvement, begin planning your cardiorespiratory endurance exercise program by completing the plan in Lab 3.2. After several weeks of your program, complete this lab again, and enter the results in the Postprogram Assessment column of Appendix D. How do the results compare? (Remember, it’s best to compare \( \dot{V}O_2_{max} \) scores for the same test.)

<table>
<thead>
<tr>
<th>( \dot{V}O_2_{max} )</th>
<th>Cardiovascular Fitness Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-mile walk test</td>
<td></td>
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<tr>
<td>3-minute step test</td>
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<tr>
<td>1.5-mile run-walk test</td>
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</tbody>
</table>

1. **Goals.** List goals for your cardiorespiratory endurance exercise program. Your goals can be specific or general, short or long term. In the first section, include specific, measurable goals that you can use to track the progress of your fitness program. These goals might be things like raising your cardiorespiratory fitness rating from fair to good or swimming laps for 30 minutes without resting. In the second section, include long-term and more qualitative goals, such as improving self-confidence and reducing your risk for chronic disease.

<table>
<thead>
<tr>
<th>Specific Goals: Current Status</th>
<th>Final Goals</th>
</tr>
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<tbody>
<tr>
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</table>

Other goals: __________________________

2. **Type of Activities.** Choose one or more endurance activities for your program. These can include any activity that uses large-muscle groups, can be maintained continuously, and is rhythmic and aerobic in nature. Examples include walking, jogging, cycling, group exercise such as aerobic dance, rowing, rope skipping, stair-climbing, cross-country skiing, swimming, skating, and endurance game activities such as soccer and tennis. Choose activities that are both convenient and enjoyable. Fill in the activity names on the program plan.

3. **Frequency.** On the program plan, fill in how often you plan to participate in each activity; the ACSM recommends participating in cardiorespiratory endurance exercise 3–5 days per week.

<table>
<thead>
<tr>
<th>Type of Activity</th>
<th>Frequency (check ✓)</th>
<th>Intensity (bpm or RPE)</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>T</td>
<td>W</td>
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</table>

4. **Intensity.** Determine your exercise intensity using one of the following methods, and enter it on the program plan. Begin your program at a lower intensity and slowly increase intensity as your fitness improves, so select a range of intensities for your program.

   a. **Target heart rate zone:** Calculate target heart rate zone in beats per minute and then calculate the corresponding 10-second exercise count by dividing the total count by 6. For example, the 10-second exercise counts corresponding to a target heart rate zone of 122–180 bpm would be 20–30 beats.

   Maximum heart rate: \(220 - \frac{age (years)}{2} = \) bpm

   **Maximum Heart Rate Method**

   - 65% training intensity = \(\frac{\text{maximum heart rate}}{60} \times 0.65 = \) bpm
   - 90% training intensity = \(\frac{\text{maximum heart rate}}{60} \times 0.90 = \) bpm
   - Target heart rate zone = \(\) to \(\) bpm

   10-second count = \(\) to \(\)
**Heart Rate Reserve Method**

- Resting heart rate: _______ bpm (taken after 10 minutes of complete rest)
- Heart rate reserve = \( \frac{\text{maximum heart rate}}{\text{resting heart rate}} \) bpm = _______ bpm
- 50% training intensity = \( \left( \frac{\text{heart rate reserve}}{\text{resting heart rate}} \times 0.50 \right) + \text{resting heart rate} \) bpm = _______ bpm
- 85% training intensity = \( \left( \frac{\text{heart rate reserve}}{\text{resting heart rate}} \times 0.85 \right) + \text{resting heart rate} \) bpm = _______ bpm
- Target heart rate zone = _______ to _______ bpm
- 10-second count = _______ to _______

b. Ratings of perceived exertion (RPE): If you prefer, determine an RPE value that corresponds to your target heart rate range (see p. 72 and Figure 3.6).

5. **Time (Duration).** A total time of 20–60 minutes is recommended; your duration of exercise will vary with intensity. For developing cardiorespiratory endurance, higher-intensity activities can be performed for a shorter duration; lower intensities require a longer duration. Enter a duration (or a range of duration) on the program plan.

6. **Monitoring Your Program.** Complete a log like the one below to monitor your program and track your progress. Note the date on top, and fill in the intensity and time (duration) for each workout. If you prefer, you can also track other variables such as distance. For example, if your cardiorespiratory endurance program includes walking and swimming, you may want to track miles walked and yards swum in addition to the duration of each exercise session. For more extensive sets of logs, refer to the Daily Fitness and Nutrition Journal that accompanies your text.

<table>
<thead>
<tr>
<th>Activity/Date</th>
<th>Intensity</th>
<th>Time</th>
<th>Distance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
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<td></td>
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<td></td>
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<tr>
<td>4</td>
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</table>

7. **Making Progress.** Follow the guidelines in the chapter and Table 3.5 to slowly increase the amount of overload in your program. Continue keeping a log, and periodically evaluate your progress.

**Progress Checkup: Week _____ of program**

<table>
<thead>
<tr>
<th>Goals: Original Status</th>
<th>Current Status</th>
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<tbody>
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</table>

List each activity in your program and describe how satisfied you are with the activity and with your overall progress. List any problems you’ve encountered or any unexpected costs or benefits of your fitness program so far.