Lifetime Physical Fitness & Wellness
A Personalized Program

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Cardiorespiratory Endurance

“Daily physical activity is the miracle medication that people are looking for. It makes you look and feel younger, boosts energy, provides lifetime weight management, improves self-confidence and self-esteem, and enhances independent living, health, and quality of life. It further allows you to enjoy a longer life by decreasing the risk of many chronic conditions, including heart disease, high blood pressure, stroke, diabetes, some cancers, and osteoporosis.”

Objectives

▶ Define cardiorespiratory endurance and describe the benefits of cardiorespiratory endurance training in maintaining health and well-being.

▶ Define aerobic and anaerobic exercise, and give examples.

▶ Be able to assess cardiorespiratory fitness through five different test protocols: 1.5-Mile Run Test, 1.0-Mile Walk Test, Step Test, Astrand-Ryhming Test, and 12-Minute Swim Test.

▶ Be able to interpret the results of cardiorespiratory endurance assessments according to health fitness and physical fitness standards.

▶ Determine your readiness to start an exercise program.

▶ Explain the principles that govern cardiorespiratory exercise prescription: intensity, mode, duration, frequency, and rate of progression.

▶ Learn some ways to foster adherence to exercise.

Assess your cardiorespiratory endurance.
Maintain a log of all your fitness activities.
Visit www.cengagebrain.com to access course materials and companion resources for this text including quiz questions designed to check your understanding of the chapter contents. See the preface on page xv for more information.
During light-intensity and moderate-intensity exercise, people as a whole have a lower incidence of cardiovascular disease, a regular aerobic exercise program by itself does not offer an absolute guarantee against cardiovascular disease. The best way to minimize the risk for cardiovascular disease is to manage the risk factors. Many factors, including a genetic predisposition, can increase the risk. Research data, however, indicate that a regular aerobic exercise program will delay the onset of cardiovascular problems and will improve the chances of surviving a heart attack. Even moderate increases in aerobic fitness significantly lower the incidence of premature cardiovascular deaths. Data from the research study on death rates by physical fitness groups (illustrated in Figure 1.11, page 19) indicate that the decrease in cardiovascular mortality is greatest between the unfit and the moderately fit groups. A further decrease in cardiovascular mortality is observed between the moderately fit and the highly fit groups.

Is light-intensity aerobic exercise more effective in burning fat? During light-intensity and moderate-intensity exercise, a greater percentage of the energy is derived from fat. It is also true, however, that an even greater percentage of the energy comes from fat when doing absolutely nothing (resting/sleeping). And when one does nothing, as in a sedentary lifestyle, one doesn’t burn many calories.

Let’s examine this issue. During resting conditions, the human body is a very efficient “fat-burning machine.” That is, most of the energy, approximately 70 percent, is derived from fat and only 30 percent from carbohydrates. But we burn few calories at rest, about 1.5 calories per minute compared with 3 to 4 calories during light-intensity exercise, 5 to 7 calories during moderate-intensity exercise, and 8 to 10 (or more) calories per minute during vigorous-intensity exercise. As we begin to exercise and subsequently increase its intensity, we progressively rely more on carbohydrates and less on fat for energy, until we reach maximal intensity, when 100 percent of the energy is derived from carbohydrates. Even though a lower percentage of the energy is derived from fat during vigorous-intensity exercise, the total caloric expenditure is so much greater (twice as high or more) that overall the total fat burned is still higher than during moderate intensity.

A word of caution, nonetheless: Do not start vigorous-intensity exercise without several weeks of proper and gradual conditioning. Even worse is if such exercise is a weight-bearing activity. If you do such exercise from the outset, you increase the risk of injury and may have to stop exercising altogether. Also, people with an initial low level of fitness often compensate with greater caloric intake following vigorous-intensity exercise, thus defeating the added energy expenditure obtained through exercise (additional information on this subject is provided on pages 161–163).

Do energy drinks enhance performance? People associate energy with work. If an energy drink can enhance work capacity, the benefits of such drinks would surpass plain thirst-quenching drinks. Energy drinks typically contain sugar (discussed in Chapter 3), herbal extracts, large amounts of caffeine, and water-soluble vitamins. Consumers are led to believe that these ingredients increase energy metabolism, provide an energy boost, improve endurance, and aid in weight loss. These purported benefits are yet to be proven through scientific research.

The energy content of many of these drinks is around 60 grams of sugar and 240 calories in a 16-ounce drink, with little additional nutritive value. If you are going to participate in an intense and lengthy workout, the carbohydrate content can boost performance and help you get through the workout. If, however, you are concerned with weight management, 240 calories is an extraordinarily large amount of calories in a two-cup drink. Weight gain may be the end result if you drink a few of these throughout the day to give you a boost while studying or while at work. Sugar-free energy drinks, available for the weight-conscious consumer, provide little or no energy (calories), although they are packed with nervous system stimulants.

The high caffeine content can also have adverse health effects. Caffeine intake above 400 mg can precipitate cardiac arrhythmias, nervousness, irritability, and gastrointestinal discomfort. Many of the popular energy drinks (Red Bull, Sobe Adrenaline Rush, Full Throttle, Rip It Energy Fuel) contain about 80 mg of caffeine per 8-ounce cup. If you drink two 16-ounce cans, you’ll end up with upward of 300 mg of caffeine through these drinks alone. You may also have to consider additional caffeine intake from other beverages that you routinely consume during the day (coffee, tea, sodas). As with most addictive substances, invariably a sugar and caffeine rush is likely to end up in a physiological crash, requiring a subsequent larger intake to obtain a similar “physical high.”
When I first started exercising, I really dreaded doing it. I was 50 pounds overweight, and I would run out of breath just trying to walk to the end of the block. But I was determined to stop being a couch potato and get moving; so I began walking every day. I started really slow, and worked my way up. I walked just a couple blocks and back and slowly I increased it by a block each time. Eventually I was able to walk a mile a day. I was really proud of that. To other people in my class, that was nothing, but I couldn’t compare myself to other people. I just had to focus on what I was able to do and be happy that I was improving. That was a couple years ago and I am still exercising. Eventually I combined walking and jogging, until I was able to jog a full mile, and then some more. I first set my goals on a 5-K run, which I accomplished without much difficulty. Then last March my buddy and I ran a half marathon! It wasn’t easy, but we jogged the entire 13.1 miles. Although I have lost 35 pounds and I am still overweight, I know I am much healthier than I was before. I know that having good cardiorespiratory fitness puts me at less of a health risk. Also, running makes me feel really good. I have never regretted the time and effort I have put into my exercise program.

Cardiorespiratory endurance is the single most important component of health-related physical fitness. The exception occurs among older adults, for whom muscular strength is particularly important. In any case, people can get by without high levels of strength and flexibility, but we cannot do without a good cardiorespiratory (CR) system, facilitated by aerobic exercise.

Aerobic exercise is especially important in preventing cardiovascular disease. A poorly conditioned heart, which has to pump more often just to keep a person alive, is subject to more wear and tear than a well-conditioned heart. In situations that place strenuous demands on the heart, such as doing yard work, lifting heavy objects or weights, or running to catch a bus, the unconditioned heart may not be able to sustain the strain. Regular participation in CR endurance activities also helps a person achieve and maintain recommended body weight—the fourth component of health-related physical fitness.

Physical activity, unfortunately, is no longer a natural part of our existence. Technological developments have driven most people in developed countries into sedentary lifestyles. For instance, when many people go to a store only a couple of blocks away, they drive their automobiles and then spend a couple of minutes driving around the parking lot to find a spot 20 yards closer to the store’s entrance. At times, they don’t even have to

Real Life Story
Kaleo’s Experience

Personal Cardiorespiratory Fitness Profile

I. Have you ever experienced the feeling of being aerobically fit? If so, can you describe that feeling?

II. Do you understand the concept of oxygen uptake and the difference between absolute and relative oxygen uptake? What are the applications of the latter two?

III. At 70-percent training intensity, your exercise prescription requires a heart rate of 156 beats per minute. Is there a difference between jogging and doing zumba when exercising at this same heart rate? Please expound on your response.

IV. Can you identify and relate to the factors that motivated Kaleo to become aerobically fit and what helped him stay with the exercise program? What factors do you think can help you start or stay with aerobic exercise?

V. Your cardiorespiratory fitness test indicates that your VO2max is 48 mL/kg/min. If you chose to exercise at 50 percent of your VO2max (moderate intensity, as most people like to do during aerobic exercise), can you compute how many calories you burn per minute at this intensity level and the total minutes that you’d have to exercise to burn the equivalent of one pound of fat?

Key Terms

Cardiorespiratory endurance The ability of the lungs, heart, and blood vessels to deliver adequate amounts of oxygen to the cells to meet the demands of prolonged physical activity.
carry the groceries to the car, as an employee working at the store offers to do this for them.

Similarly, during a visit to a multilevel shopping mall, almost everyone chooses to take the escalator instead of the stairs (which tend to be inaccessible). Automobiles, elevators, escalators, telephones, intercoms, remote controls, electric garage door openers—all are modern-day conveniences that minimize the amount of movement and effort required of the human body.

One of the most harmful effects of modern-day technology is an increase in chronic conditions related to a lack of physical activity. These hypokinetic diseases include hypertension, heart disease, chronic low back pain, and obesity. (The term “hypo” means low or little, and “kinetic” implies motion.) Lack of adequate physical activity is a fact of modern life that most people can avoid no longer. To enjoy modern-day conveniences and still expect to live life to its fullest, however, one has to make a personalized lifetime exercise program a part of daily living.

Basic Cardiorespiratory Physiology: A Quick Survey

Before we begin to overhaul our bodies with an exercise program, we should understand the mechanisms that we propose to alter and survey the ways by which to measure how well we perform them. CR endurance is a measure of how the pulmonary (lungs), cardiovascular (heart and blood vessels), and muscular systems work together during aerobic activities. As a person breathes, part of the oxygen in the air is taken up by the alveoli in the lungs. As blood passes through the alveoli, oxygen is picked up by hemoglobin and transported in the blood to the heart. The heart then is responsible for pumping the oxygenated blood through the circulatory system to all organs and tissues of the body.

At the cellular level, oxygen is used to convert food substrates (primarily carbohydrates and fats) through aerobic metabolism into adenosine triphosphate (ATP). This compound provides the energy for physical activity, body functions, and maintenance of a constant internal equilibrium. During physical exertion, more ATP is needed to perform the activity. As a result, the lungs, heart, and blood vessels have to deliver more oxygen to the muscle cells to supply the required energy.

During prolonged exercise, an individual with a high level of CR endurance is able to deliver the required amount of oxygen to the tissues with relative ease. In contrast, the CR system of a person with a low level of endurance has to work much harder, the heart has to work at a higher rate, less oxygen is delivered to the tissues, and consequently, the individual fatigues faster. Hence, a higher capacity to deliver and utilize...
Cardiorespiratory endurance refers to the ability of the lungs, heart, and blood vessels to deliver adequate amounts of oxygen to the cells to meet the demands of prolonged physical activity.

Oxygen—called oxygen uptake, or VO₂—indicates a more efficient CR system. Measuring oxygen uptake, therefore, is an important way by which to evaluate our CR health.

Aerobic and Anaerobic Exercise

Cardiorespiratory endurance activities often are called aerobic exercises. Examples are walking, jogging, swimming, cycling, cross-country skiing, aerobics (including water aerobics), and rope skipping. By contrast, the intensity of anaerobic exercise is so high that oxygen cannot be delivered and utilized to produce energy. Because energy production is limited in the absence of oxygen, anaerobic activities can be carried out for only short periods—two to three minutes. The higher the intensity of the activity, the shorter the duration.

Good examples of anaerobic activities are the 100, 200, and 400 meters in track and field, the 100 meters in swimming, gymnastics routines, and strength training. Anaerobic activities do not contribute much to developing the CR system. Only aerobic activities will increase CR endurance. The basic guidelines for CR exercise prescription are set forth later in this chapter.

Critical Thinking

Your friend Joe is not physically active and doesn’t exercise. He manages to keep his weight down by dieting and tells you that because he feels and looks good, he doesn’t need to exercise. How do you respond to your friend?

Benefits of Aerobic Training

Everyone who participates in a CR or aerobic exercise program can expect a number of beneficial physiological adaptations from training (Figure 6.1). Among them are the following:

1. A higher maximal oxygen uptake (VO₂max). The amount of oxygen that the body is able to use during exercise increases significantly. This allows the individual to exercise longer and more intensely before becoming fatigued. Depending on the initial fitness level, the increases in VO₂max average 15 to 20 percent, although increases greater than 50 percent have been reported in people who have very low initial levels of fitness or who were significantly overweight prior to starting the aerobic exercise program.

2. An increase in the oxygen-carrying capacity of the blood. As a result of training, the red blood cell count goes up. Red blood cells contain hemoglobin, which transports oxygen in the blood.

3. A decrease in resting heart rate (RHR) and an increase in cardiac muscle strength. During resting conditions, the heart ejects between 5 and 6 liters of blood per minute (a liter is slightly larger than a quart). This amount of blood, also referred to as cardiac output, meets the body’s energy demands in the resting state. Like any other muscle, the heart responds to training by increasing in

Key Terms

- **Hypokinetic diseases** “Hypo” denotes “lack of”; therefore, chronic ailments that result from a lack of physical activity.
- **Alveoli** Air sacs in the lungs where oxygen is taken up and carbon dioxide (produced by the body) is released from the blood.
- **Hemoglobin** Iron-containing compound, found in red blood cells, that transports oxygen.
- **Adenosine triphosphate (ATP)** A high-energy chemical compound that the body uses for immediate energy.
- **Oxygen uptake (VO₂)** The amount of oxygen the human body uses.
- **Aerobic** Describes exercise that requires oxygen to produce the necessary energy (ATP) to carry out the activity.
- **Anaerobic** Describes exercise that does not require oxygen to produce the necessary energy (ATP) to carry out the activity.
- **Maximal oxygen uptake (VO₂max)** Maximum amount of oxygen the body is able to utilize per minute of physical activity, commonly expressed in milliliters per kilogram per minute (mL/Kg/min); the best indicator of cardiorespiratory or aerobic fitness.
- **Resting heart rate (RHR)** Heart rate after a person has been sitting quietly for 15 to 20 minutes.
- **Cardiac output** Amount of blood pumped by the heart in one minute.
strength and size. As the heart gets stronger, the muscle can produce a more forceful contraction, which helps the heart to eject more blood with each beat. This stroke volume yields a lower heart rate. The lower heart rate also allows the heart to rest longer between beats. Average resting and maximal cardiac outputs, stroke volumes, and heart rates for sedentary, trained, and highly trained (elite) males are shown in Table 6.1. Resting heart rates frequently decrease by 10 to 20 beats per minute (bpm) after only 6 to 8 weeks of training. A reduction of 20 bpm saves the heart about 10,483,200 beats per year. The average heart beats between 70 and 80 bpm. As seen in Table 6.1, RHRs in highly trained athletes are often around 45 bpm.

4. A lower heart rate at given workloads. When compared with untrained individuals, a trained person has a lower heart rate response to a given task because of greater efficiency of the CR system. Individuals are surprised to find that following several weeks of training, a given workload (let’s say a 10-minute mile) elicits a much lower heart rate response than their response when they first started training.

5. An increase in the number, size, and capacity of the mitochondria. All energy necessary for cell function is produced in the mitochondria. As their size and

| Table 6.1 Average Resting and Maximal Cardiac Output, Stroke Volume, and Heart Rate for Sedentary, Trained, and Highly Trained Young Males |
|---------------------------------|----------------|----------|----------------|----------------|----------|
| Resting | Cardiac Output (L/min) | Stroke Volume (mL) | Heart Rate (bpm) | Maximal |
| Sedentary | 5–6 | 68 | 74 | Heart Rate (bpm) |
| Trained | 5–6 | 90 | 56 |
| Highly Trained | 5–6 | 110 | 45 |

Cardiac Output (L/min) | Stroke Volume (mL) | Heart Rate (bpm) |
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NOTE: Cardiac output and stroke volume in women are about 25 percent lower than in men.

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numbers increase, so does their potential to produce energy for muscular work.

6. An increase in the number of functional capillaries. Capillaries allow for the exchange of oxygen and carbon dioxide between the blood and the cells. As more vessels open up, more gas exchange can take place, delaying the onset of fatigue during prolonged exercise. This increase in capillaries also speeds the rate at which waste products of cell metabolism can be removed. This increased capillarization also occurs in the heart, which enhances the oxygen delivery capacity to the heart muscle itself.

7. Ability to recover rapidly. Trained individuals have a faster recovery time after exercising. A fit system is able to more quickly restore any internal equilibrium disrupted during exercise.

8. Lower blood pressure and blood lipids. A regular aerobic exercise program leads to lower blood pressure (thereby reducing a major risk factor for stroke) and lower levels of fats (such as cholesterol and triglycerides), which have been linked to the formation of atherosclerotic plaque, which obstructs the arteries. This decreases the risk for coronary heart disease (see Chapter 10).

9. An increase in fat-burning enzymes. These enzymes are significant because fat is lost primarily by burning it in muscle. As the concentration of the enzymes increases (along with the number and size of the mitochondria), so does the ability to burn fat (triglycerides) as opposed to carbohydrates (glucose/glycogen) during submaximal workloads (below 85 percent of VO$_{2\text{max}}$).

**Physical Fitness Assessment**

The assessment of physical fitness serves several purposes:

- To educate participants regarding their present fitness levels and compare them with health fitness and physical fitness standards
- To motivate individuals to participate in exercise programs
- To provide a starting point for an individualized exercise prescription and to establish realistic goals
- To evaluate improvements in fitness achieved through exercise programs and adjust exercise prescription and fitness goals accordingly
- To monitor changes in fitness throughout the years

**Key Terms**

- **Stroke volume** Amount of blood pumped by the heart in one beat.
- **Workload** Load (or intensity) placed on the body during physical activity.
- **Mitochondria** Structures within the cells where energy transformations take place.
- **Capillaries** Smallest blood vessels carrying oxygenated blood to the tissues in the body.
- **Recovery time** Amount of time that the body takes to return to resting levels after exercise.
Tips to Increase Daily Physical Activity

Adults need recess, too! There are 1,440 minutes in every day. Schedule a minimum of 30 of these minutes for physical activity. With a little creativity and planning, even the person with the busiest schedule can make room for physical activity. For many folks, before or after work or meals is often an available time to cycle, walk, or play. Think about your weekly or daily schedule and look for or make opportunities to be more active. Every little bit helps. Consider the following suggestions:

- Play with children, grandchildren, or pets. Everybody wins. If you find it too difficult to be active after work, try it before work.
- Do household tasks.
- Work in the yard or garden.
- Avoid labor-saving devices. Turn off the self-propelled option on your lawnmower or vacuum cleaner.
- Use leg power. Take small trips on foot to get your body moving.
- Exercise while watching TV (for example, use hand weights, stationary bicycle/treadmill/stairclimber, or stretch).
- Spend more time playing sports than sitting in front of the TV or the computer.
- Dance to music.
- Keep a pair of comfortable walking or running shoes in your car and office. You’ll be ready for activity wherever you go!
- Make a Saturday morning walk a group habit.
- Learn a new sport or join a sports team.
- Avoid carts when golfing.
- When out of town, stay in hotels with fitness centers.

**Try It** Keep a three-day log of all your activities. List the activities performed, time of day, and how long you were engaged in these activities. You may be surprised by your findings.

SOURCE: Adapted from Centers for Disease Control and Prevention, Atlanta, 2005.

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**Responders versus Nonresponders**

Individuals who follow similar training programs show a wide variation in physiological responses. Heredity plays a crucial role in how each person responds to and improves after beginning an exercise program. Several studies have documented that following exercise training, most individuals, called responders, readily show improvements, but a few nonresponders exhibit small or no improvements at all. This concept is referred to as the principle of individuality.

After several months of aerobic training, increases in $\text{VO}_{2\text{max}}$ are between 15 and 20 percent on the average, although individual responses can range from 0 percent (in a few selected cases) to more than 50 percent improvement, even when all participants follow exactly the same training program. Nonfitness and low-fitness participants, however, should not label themselves as nonresponders based on the previous discussion. Nonresponders constitute less than 5 percent of exercise participants. Although additional research is necessary, lack of improvement in CR endurance among nonresponders might be related to low levels of leg strength. A lower-body strength-training program has been shown to help these individuals improve $\text{VO}_{2\text{max}}$ through aerobic exercise.1

Following your self-assessment of CR fitness, if your fitness level is less than adequate, do not let that discourage you, but do set a priority to be physically active every day. In addition to regular exercise, lifestyle behaviors—walking, taking stairs, cycling to work, parking farther from the office, doing household tasks, gardening, and doing yard work, for example—provide substantial benefits. In this regard, daily physical activity and exercise
Cardiorespiratory endurance, CR fitness, or aerobic capacity is determined by the maximal amount of oxygen the human body is able to utilize (the oxygen uptake) per minute of physical activity (VO$_{2\text{max}}$). This value can be expressed in liters per minute (L/min) or milliliters per kilogram per minute (mL/kg/min). The relative value in mL/kg/min is used most often because it considers total body mass (weight) in kilograms. When comparing two individuals with the same absolute value, the one with the lesser body mass will have a higher relative value, indicating that more oxygen is available to each kilogram (2.2 pounds) of body weight. Because all tissues and organs of the body need oxygen to function, higher oxygen consumption indicates a more efficient CR system.

Oxygen uptake expressed in L/min is valuable in determining the caloric expenditure of physical activity. The human body burns about five calories for each liter of oxygen consumed. During aerobic exercise the average person trains between 50 and 85 percent of maximal oxygen uptake. A person with a maximal oxygen uptake of 3.5 L/min who trains at 60 percent of maximum uses 2.1 (3.5 x .60) liters of oxygen per minute of physical activity. This indicates that 10.5 calories are burned during each minute of exercise (2.1 x 5). If the activity is carried out for 30 minutes, 315 calories (10.5 x 30) have been burned. Because a pound of body fat represents about 3,500 calories, the previous example indicates that this individual would have to exercise for a total of 333 minutes (3,500 ÷ 10.5) to burn the equivalent of a pound of body fat. At 30 minutes per exercise session, approximately 11 sessions would be required to expend the 3,500 calories.

**Components of Oxygen Uptake (VO$_2$)**

The amount of oxygen the body actually uses at rest or during submaximal (VO$_2$) or maximal (VO$_{2\text{max}}$) exercise is determined by the heart rate, the stroke volume, and the amount of oxygen removed from the vascular system (for use by all organs and tissues of the body, including the muscular system).

**Heart Rate**

Normal heart rate ranges from about 40 bpm during resting conditions in trained athletes to 200 bpm or higher during maximal exercise. The maximal heart rate (MHR) that a person can achieve starts to drop by about one beat per year beginning at about 12 years of age. Maximal heart rate in trained endurance athletes is sometimes slightly lower than in untrained individuals. This adaptation to training is thought to allow the heart more time to effectively fill with blood so as to produce a greater stroke volume.

**Stroke Volume**

Stroke volume ranges from 50 mL per beat (stroke) during resting conditions in untrained individuals to 200 mL at maximum in endurance-trained athletes (see Table 6.1). Following endurance training, stroke volume increases significantly. Some of the increase is the result of a stronger heart muscle, but it also is related to an increase in total blood volume and a greater filling capacity of the heart muscle.

**Key Terms**

**Responders** Individuals who exhibit improvements in fitness as a result of exercise training.

**Nonresponders** Individuals who exhibit small or no improvements in fitness as compared to others who undergo the same training program.

**Principle of individuality** Training concept holding that genetics plays a major role in individual responses to exercise training and these differences must be considered when designing exercise programs for different people.

**Physical activity** Bodily movement produced by skeletal muscles; requires expenditure of energy and produces progressive health benefits. Examples include walking, taking the stairs, dancing, gardening, yard work, house cleaning, snow shoveling, washing the car, and all forms of structured exercise.

**Exercise** A type of physical activity that requires planned, structured, and repetitive bodily movement with the intent of improving or maintaining one or more components of physical fitness.

**Maximal heart rate (MHR)** Highest heart rate for a person, related primarily to age.
ventricles during the resting phase (diastole) of the cardiac cycle. As more blood enters the heart, more blood can be ejected with each heartbeat (systole). The increase in stroke volume is primarily responsible for the increase in VO$_{2\text{max}}$ with endurance training.

Amount of Oxygen Removed from Blood
The amount of oxygen removed from the vascular system is known as the arterial-venous oxygen difference (a-VO$_{2\text{diff}}$). The oxygen content in the arteries at sea level is typically 20 mL of oxygen per 100 cubic centimeters (cc) of blood. (This value decreases at higher altitudes because of the drop in barometric pressure, which affects the amount of oxygen picked up by hemoglobin.) The oxygen content in the veins during a resting state is about 15 mL per 100 cc. Thus, the a-VO$_{2\text{diff}}$—the amount of oxygen in the arteries minus the amount in the veins—at rest is 5 mL per 100 cc. The arterial value remains constant during both resting and exercise conditions. Because of the additional oxygen removed during maximal exercise, the venous oxygen content drops to about 5 mL per 100 cc, yielding an a-VO$_{2\text{diff}}$ of 15 mL per 100 cc. The latter value may be slightly higher in endurance athletes.

These three factors are used to compute VO$_2$ using the following equation:

$$\text{VO}_2 \text{ in } \text{L/min} = (\text{HR} \times \text{SV} \times \text{a-VO}_{2\text{diff}}) \div 100,000$$

where

- HR = heart rate
- SV = stroke volume

For example, the resting VO$_2$ (also known as the resting metabolic rate) of an individual with a RHR of 76 bpm and a stroke volume of 79 mL would be

$$\text{VO}_2 \text{ in } \text{L/min} = (76 \times 79 \times 5) \div 100,000 = 0.3 \text{ L/min}$$

Likewise, the VO$_{2\text{max}}$ of a person exercising maximally who achieves a heart rate of 190 bpm and a maximal stroke volume of 120 mL would be

$$\text{VO}_{2\text{max}} \text{ in } \text{L/min} = (190 \times 120 \times 15) \div 100,000 = 3.42 \text{ L/min}$$

To convert L/min to mL/kg/min, multiply the L/min value by 1,000 and divide by body weight in kilograms. In the above example, if the person weighs 70 kilograms, the VO$_{2\text{max}}$ in mL/kg/min would be 48.9 (3.42 $\times$ 1,000 $\div$ 70).

### Critical Thinking

You can improve your relative VO$_{2\text{max}}$ without engaging in an aerobic exercise program. How do you accomplish this? Would you benefit from doing so?

Because the actual measurement of the stroke volume and the a-VO$_{2\text{diff}}$ is impractical in the fitness setting, VO$_2$ also is determined through gas (air) analysis. The person being tested breathes into a metabolic cart that measures the difference in oxygen content between the person’s exhaled air and the atmosphere. The air we breathe contains 21 percent oxygen; thus, VO$_2$ can be assessed by establishing the difference between 21 percent and the percent of oxygen left in the air the person exhales, according to the total volume of air taken into the lungs. This type of equipment, however, is expensive. Consequently, several alternative methods of estimating VO$_{2\text{max}}$ using limited equipment have been developed. These methods are discussed next.

VO$_{2\text{max}}$ is affected by genetics, training, gender, age, and body composition. Although aerobic training can help people attain good or excellent CR fitness, only those with a strong genetic component are able to reach an “elite” level of aerobic capacity (60 to 80 mL/kg/min). Further, VO$_{2\text{max}}$ is 15 to 30 percent higher in men. This is related to a greater hemoglobin content, lower body fat (see “Essential and Storage Fat” in Chapter 4, page 122), and larger heart size in men (a larger heart pumps more blood, and thus produces a greater stroke volume). VO$_{2\text{max}}$ also decreases by about 1 percent per year starting at age 25. This decrease, however, is only 0.5 percent per year in physically active individuals.

### Tests to Estimate VO$_{2\text{max}}$

Even though most CR endurance tests probably are safe to administer to apparently healthy individuals (those with no major coronary risk factors or symptoms), a health history questionnaire (including the PAR-Q), such as found in Activity 1.3 in Chapter 1, should be used as a minimum screening tool prior to exercise testing or participation. The American College of Sports Medicine (ACSM) also recommends that a physician be present for all maximal exercise tests on apparently healthy men 45 or older and women 55 or older. A maximal test is any test that requires the participant’s all-out or nearly all-out effort. For submaximal exercise tests, a physician should be present when testing higher-risk/symptomatic individuals or diseased people, regardless of the participants’ current age.

Five exercise tests used to assess CR fitness are introduced in this chapter: the 1.5-Mile Run Test, the 1.0-Mile Walk Test, the Step Test, the Astrand-Ryhming Test, and the 12-Minute Swim Test. The procedures for each test are explained in detail in Figures 6.2, 6.3, 6.4, 6.5, and 6.6, respectively.

Several tests are provided in this chapter, so you may choose one depending on time, equipment, and individual physical limitations. For example, people who can’t jog or walk can take the Astrand-Ryhming (bicycle) or swim test. You may perform more than one test, but because they are different and they estimate VO$_{2\text{max}}$ they will not necessarily yield the same results. Therefore, to make valid comparisons, you should take the same test when doing pre- and post-assessments. You may record the results of your test(s) in Activity 6.1.
Cardiorespiratory Endurance

The amount of oxygen removed from the blood as determined by the difference in oxygen content between arterial and venous blood.

Key Terms

Arterial-venous oxygen difference (a-VO2diff) The amount of oxygen removed from the blood as determined by the difference in oxygen content between arterial and venous blood.

1. Make sure you qualify for this test. This test is contraindicated for unconditioned beginners, individuals with symptoms of heart disease, and those with known heart disease or risk factors.
2. Select the testing site. Find a school track (each lap is one-fourth of a mile) or a premeasured 1.5-mile course.
3. Have a stopwatch available to determine your time.
4. Conduct a few warm-up exercises prior to the test. Do some stretching exercises, some walking, and slow jogging.
5. Initiate the test and try to cover the distance in the fastest time possible (walking or jogging). Time yourself during the run to see how fast you have covered the distance. If any unusual symptoms arise during the test, do not continue. Stop immediately and retake the test after another 6 weeks of aerobic training.
6. At the end of the test, cool down by walking or jogging slowly for another 3 to 5 minutes. Do not sit or lie down after the test.
7. According to your performance time, look up your estimated maximal oxygen uptake (VO2max) in Table 6.2.

Example: A 20-year-old male runs the 1.5-mile course in 10 minutes and 20 seconds. Table 6.2 shows a VO2max of 49.5 mL/kg/min for a time of 10:20. According to Table 6.8, this VO2max would place him in the “good” cardiorespiratory fitness category.

1.5-Mile Run Test

The 1.5-Mile Run Test is used most frequently to predict VO2max according to the time the person takes to run or walk a 1.5-mile course (see Figure 6.2). VO2max is estimated based on the time the person takes to cover the distance (see Table 6.2).

The only equipment necessary to conduct this test is a stopwatch and a track or premeasured 1.5-mile course. This perhaps is the easiest test to administer, but a note of caution is in order when conducting the test: Given that the objective is to cover the distance in the shortest time, it is considered a maximal exercise test. The 1.5-Mile Run Test should be limited to conditioned individuals who have been cleared for exercise. The test is not recommended for unconditioned beginners, men over age 45 and women over age 55 without proper medical clearance, symptomatic individuals, and those with known disease or risk factors for coronary heart disease. A program of at least 6 weeks of aerobic training is recommended before unconditioned individuals take this test.

1.0-Mile Walk Test

The 1.0-Mile Walk Test can be used by individuals who are unable to run because of low fitness levels or injuries. All that is required is a brisk 1.0-mile walk that will elicit an exercise heart rate of at least 120 bpm at the end of the test.

You will need to know how to take your heart rate by counting your pulse. You can do this by gently placing the middle and index fingers over the radial artery on the inside of the wrist on the side of the thumb or over the carotid artery in the neck just below the jaw line.

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body weight in pounds. The procedure for this test and the equation are given in Figure 6.3.

**Step Test**

The Step Test requires little time and equipment and can be administered to almost anyone, because a submaximal workload is used to estimate VO\(_{2\text{max}}\). Symptomatic and diseased individuals should not take this test. Significantly overweight individuals and those with joint problems in the lower extremities may have difficulty performing the test.

The actual test takes only three minutes. A 15-second recovery heart rate is taken between 5 and 20 seconds following the test (see Figure 6.4 and Table 6.3). The required equipment consists of a bench or gymnasium bleacher 16¼ inches high, a stopwatch, and a metronome.

Once people learn to take their own heart rate, a large group of people can be tested at once, using gymnasium bleachers for the steps.

**Astrand-Ryhming Test**

Because of its simplicity and practicality, the Astrand-Ryhming Test is one of the most popular tests used to estimate VO\(_{2\text{max}}\) in the laboratory setting. The test is conducted on a bicycle ergometer and, similar to the Step Test, requires only submaximal workloads and little time to administer.

The cautions given for the Step Test also apply to the Astrand-Ryhming Test.

---

**Figure 6.3** Procedure for the 1.0-Mile Walk Test.

1. Select the testing site. Use a 440-yard track (4 laps to a mile) or a premeasured 1.0-mile course.
2. Determine your body weight in pounds prior to the test.
3. Have a stopwatch available to determine total walking time and exercise heart rate.
4. Walk the 1.0-mile course at a brisk pace (the exercise heart rate at the end of the test should be above 120 beats per minute).
5. At the end of the 1.0-mile walk, check your walking time and immediately count your pulse for 10 seconds. Multiply the 10-second pulse count by 6 to obtain the exercise heart rate in beats per minute.
6. Convert the walking time from minutes and seconds to minute units. Because each minute has 60 seconds, divide the seconds by 60 to obtain the fraction of a minute. For instance, a walking time of 12 minutes and 15 seconds would equal 12 + \(15 \div 60\), or 12.25 minutes.
7. To obtain the estimated maximal oxygen uptake (VO\(_{2\text{max}}\)) in mL/kg/min, plug your values in the following equation:

\[
\text{VO}_{2\text{max}} = 88.768 - (0.0957 \times W) + (8.892 \times G) - (1.4537 \times T) - (0.1194 \times \text{HR})
\]

Where:

\[
\begin{align*}
W & = \text{Weight in pounds} \\
G & = \text{Gender (use 0 for women and 1 for men)} \\
T & = \text{Total time for the one-mile walk in minutes} \\
\text{HR} & = \text{Exercise heart rate in beats per minute at the end of the 1.0-mile walk}
\end{align*}
\]

**Example:** A 19-year-old female who weighs 140 pounds completed the 1.0-mile walk in 14 minutes 39 seconds with an exercise heart rate of 148 beats per minute. Her estimated VO\(_{2\text{max}}\) would be:

\[
\begin{align*}
W &= 140 \text{ lbs} \\
G &= 0 \text{ (female gender = 0)} \\
T &= 14:39 = 14 + (39 \div 60) = 14.65 \text{ min} \\
\text{HR} &= 148 \text{ bpm} \\
\text{VO}_{2\text{max}} &= 88.768 - (0.0957 \times 140) + (8.892 \times 0) - (1.4537 \times 14.65) - (0.1194 \times 148) \\
&= 36.4 \text{ mL/kg/min}
\end{align*}
\]

Cardiorespiratory Endurance

1. Conduct the test with a bench or gymnasium bleacher 16 ³/₄ inches high.
2. Perform the stepping cycle to a four-step cadence (up-up-down-down). Men should perform 24 complete step-ups per minute, regulated with a metronome set at 96 beats per minute. Women perform 22 step-ups per minute, or 88 beats per minute on the metronome.
3. Allow a brief practice period of 5 to 10 seconds to familiarize yourself with the stepping cadence.
4. Begin the test and perform the step-ups for exactly 3 minutes.
5. Upon completing the 3 minutes, remain standing and take your heart rate for a 15-second interval from 5 to 20 seconds into recovery. Convert recovery heart rate to beats per minute (multiply 15-second heart rate by 4).
6. Maximal oxygen uptake (VO₂max) in mL/kg/min is estimated according to the following equations:
   - Men:
     \[ \text{VO}_2\text{max} = 111.33 - (0.42 \times \text{recovery heart rate in bpm}) \]
   - Women:
     \[ \text{VO}_2\text{max} = 65.81 - (0.1847 \times \text{recovery heart rate in bpm}) \]

**Example:** The recovery 15-second heart rate for a male following the 3-minute step test is found to be 39 beats. His VO₂max is estimated as follows:
- 15-second heart rate = 39 beats
- Minute heart rate = 39 \times 4 = 156 bpm
- VO₂max = 111.33 - (0.42 \times 156) = 45.81 mL/kg/min
- VO₂max also can be obtained according to recovery heart rates in Table 6.3.

**Table 6.3** Predicted Maximal Oxygen Uptake for the Step Test

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Critical Thinking

Should fitness testing be a part of a fitness program? • Why or why not? • Does preparticipation fitness testing have benefits, or should fitness testing be done at a later date?

Heart rate monitors increase the accuracy of heart rate assessment.

Interpreting the Results of Your Maximal Oxygen Uptake

After obtaining your VO$_{2\text{max}}$, you can determine your current level of CR fitness by consulting Table 6.8. Locate the VO$_{2\text{max}}$ in your age category, and on the top row you will find your present level of CR fitness. For example, a 19-year-old male with a VO$_{2\text{max}}$ of 35 mL/kg/min would be classified in the “average” CR fitness category. After you initiate your personal CR exercise program (see Activity 6.4), you may wish to retest yourself periodically to evaluate your progress.

Principles of CR

Exercise Prescription

Before proceeding with the principles of exercise prescription, you should ask yourself if you are willing to give exercise a try. A low percentage of the U.S. population is truly committed to exercise. The first six weeks of the program are most critical. Adherence to exercise is greatly enhanced if you are able to make it through four to six weeks of training. Keep in mind, that all of the benefits of exercise cannot help unless you commit and participate in a lifetime program of physical activity.

Readiness for Exercise

The first step is to ask yourself: Am I ready to start an exercise program? The information provided in Activity 6.2 can help you answer this question. You are evaluated...
### Table 6.4
Conversion of the Time for 30 Pulse Beats to Pulse Rate per Minute.

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### Table 6.5
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Table 6.6  Age-Based Correction Factors for Maximal Oxygen Uptake

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<td>.846</td>
<td>56</td>
<td>.704</td>
</tr>
<tr>
<td>21</td>
<td>1.04</td>
<td>39</td>
<td>.838</td>
<td>57</td>
<td>.698</td>
</tr>
<tr>
<td>22</td>
<td>1.03</td>
<td>40</td>
<td>.830</td>
<td>58</td>
<td>.692</td>
</tr>
<tr>
<td>23</td>
<td>1.02</td>
<td>41</td>
<td>.820</td>
<td>59</td>
<td>.686</td>
</tr>
<tr>
<td>24</td>
<td>1.01</td>
<td>42</td>
<td>.810</td>
<td>60</td>
<td>.680</td>
</tr>
<tr>
<td>25</td>
<td>1.00</td>
<td>43</td>
<td>.800</td>
<td>61</td>
<td>.674</td>
</tr>
<tr>
<td>26</td>
<td>.987</td>
<td>44</td>
<td>.790</td>
<td>62</td>
<td>.668</td>
</tr>
<tr>
<td>27</td>
<td>.974</td>
<td>45</td>
<td>.780</td>
<td>63</td>
<td>.662</td>
</tr>
<tr>
<td>28</td>
<td>.961</td>
<td>46</td>
<td>.774</td>
<td>64</td>
<td>.656</td>
</tr>
<tr>
<td>29</td>
<td>.948</td>
<td>47</td>
<td>.768</td>
<td>65</td>
<td>.650</td>
</tr>
<tr>
<td>30</td>
<td>.935</td>
<td>48</td>
<td>.762</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>.922</td>
<td>49</td>
<td>.756</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


Table 6.7  12-Minute Swim Test Fitness Categories

<table>
<thead>
<tr>
<th>Distance (yards)</th>
<th>Fitness Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥700</td>
<td>Excellent</td>
</tr>
<tr>
<td>500–700</td>
<td>Good</td>
</tr>
<tr>
<td>400–500</td>
<td>Average</td>
</tr>
<tr>
<td>200–400</td>
<td>Fair</td>
</tr>
<tr>
<td>≤200</td>
<td>Poor</td>
</tr>
</tbody>
</table>


Figure 6.6  Procedure for the 12-Minute Swim Test.

1. Enlist a friend to time the test. The only other requisites are a stopwatch and a swimming pool. Do not attempt to do this test in an unsupervised pool.
2. Warm up by swimming slowly and doing a few stretching exercises before taking the test.
3. Start the test and swim as many laps as possible in 12 minutes. Pace yourself throughout the test and do not swim to the point of complete exhaustion.
4. After completing the test, cool down by swimming another 2 or 3 minutes at a slower pace.
5. Determine the total distance you swam during the test and look up your fitness category in Table 6.7.

Monitoring heart rate on the carotid artery during the Astrand-Rhyming Test.

Table 6.8  Cardiorespiratory Fitness Classification According to Maximal Oxygen Uptake (VO\textsubscript{2max})

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Poor</th>
<th>Fair</th>
<th>Average</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>&lt;29</td>
<td>&lt;24.9</td>
<td>25–33.9</td>
<td>34–43.9</td>
<td>44–52.9</td>
<td>≥53</td>
</tr>
<tr>
<td></td>
<td>30–39</td>
<td>&lt;22.9</td>
<td>23–30.9</td>
<td>31–41.9</td>
<td>42–49.9</td>
<td>≥50</td>
</tr>
<tr>
<td></td>
<td>40–49</td>
<td>&lt;19.9</td>
<td>20–26.9</td>
<td>27–38.9</td>
<td>39–44.9</td>
<td>≥45</td>
</tr>
<tr>
<td></td>
<td>50–59</td>
<td>&lt;17.9</td>
<td>18–24.9</td>
<td>25–37.9</td>
<td>38–42.9</td>
<td>≥43</td>
</tr>
<tr>
<td></td>
<td>60–69</td>
<td>&lt;15.9</td>
<td>16–22.9</td>
<td>23–35.9</td>
<td>36–40.9</td>
<td>≥41</td>
</tr>
<tr>
<td></td>
<td>≥70</td>
<td>≥12.9</td>
<td>13–20.9</td>
<td>21–32.9</td>
<td>33–37.9</td>
<td>≥38</td>
</tr>
<tr>
<td>Women</td>
<td>&lt;29</td>
<td>&lt;23.9</td>
<td>24–30.9</td>
<td>31–38.9</td>
<td>39–48.9</td>
<td>≥49</td>
</tr>
<tr>
<td></td>
<td>30–39</td>
<td>&lt;19.9</td>
<td>20–27.9</td>
<td>28–36.9</td>
<td>37–44.9</td>
<td>≥45</td>
</tr>
<tr>
<td></td>
<td>40–49</td>
<td>&lt;16.9</td>
<td>17–24.9</td>
<td>25–34.9</td>
<td>35–41.9</td>
<td>≥42</td>
</tr>
<tr>
<td></td>
<td>50–59</td>
<td>&lt;14.9</td>
<td>15–21.9</td>
<td>22–33.9</td>
<td>34–39.9</td>
<td>≥40</td>
</tr>
<tr>
<td></td>
<td>60–69</td>
<td>&lt;12.9</td>
<td>13–20.9</td>
<td>21–32.9</td>
<td>33–36.9</td>
<td>≥37</td>
</tr>
<tr>
<td></td>
<td>≥70</td>
<td>≤11.9</td>
<td>12–19.9</td>
<td>20–30.9</td>
<td>31–34.9</td>
<td>≥35</td>
</tr>
</tbody>
</table>

■ High physical fitness standard  ■ Health fitness standard

NOTE: See the Chapter 1 discussion on health fitness versus physical fitness.

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Cardiorespiratory Endurance Test Results

Name: ________________________________ Date: ________________

Course: ___________________ Section: ________________ Gender: _______ Age: _______

**Necessary Lab Equipment**

1.5-Mile Run: School track or premeasured course and a stopwatch.

1.0-Mile Walk Test: School track or premeasured course and a stopwatch.

Step Test: A bench or gymnasium bleachers 16 1/4 inches high, a metronome, and a stopwatch.

Astrand-Rhyming Test: A bicycle ergometer that allows for regulation of workloads in kilopounds per meter (or watts) and a stopwatch.

12-Minute Swim Test: Swimming pool and a stopwatch.

**Objective**

To estimate maximal oxygen uptake (VO$_{2\text{max}}$) and cardiorespiratory endurance classification.

**Lab Preparation**

Wear appropriate exercise clothing including jogging shoes and a swimsuit if required. Be prepared to take the 1.0-Mile Walk Test, the Step Test, the Astrand-Rhyming Test, the 1.5-Mile Run Test, and/or the 12-Minute Swim Test. If more than one test will be conducted, perform them in the order just listed and allow at least 15 minutes between tests. Avoid vigorous physical activity 24 hours prior to this lab.

I. 1.5-Mile Run Test

1.5-Mile Run Time: ________ min and ________ sec  VO$_{2\text{max}}$ (see Table 6.2, page 195): ________ mL/kg/min

Cardiorespiratory Fitness Category (Table 6.8, page 200): ___________________

II. 1.0-Mile Walk Test

Weight (W) = _______ lbs   Gender (G) = _____ (female = 0, male = 1)   Time = _____ min and _____ sec

Heart Rate (HR) = ______ bpm

Time in minutes (T) = min + (sec ÷ 60) or T = _______ + (_______ ÷ 60) = ______ min

VO$_{2\text{max}}$ = 88.768 - (0.0957 × W) + (8.892 × G) - (1.4537 × T) - (0.1194 × HR)

VO$_{2\text{max}}$ = 88.768 - (0.0957 × ______) + (8.892 × ______) - (1.4537 × ______) - (0.1194 × ______)

VO$_{2\text{max}}$ = 88.768 - (_______) + (_______) - (_______) - (_______) = ______ mL/kg/min

Cardiorespiratory Fitness Category (Table 6.8, page 200): ___________________

III. Step Test

15-second recovery heart rate: _______ beats   VO$_{2\text{max}}$ (Table 6.3, page 197): ________ mL/kg/min

Cardiorespiratory Fitness Category (Table 6.8, page 200): ___________________
Cardiorespiratory Endurance Test Results (continued)

IV. Astrand-Rhyming Test

Weight (W) = _______ lbs  Weight (BW) in kilograms = (W ÷ 2.2046) = _______ kg  Workload = _______ kpm

<table>
<thead>
<tr>
<th>Exercise Heart Rates</th>
<th>Time to count 30 beats</th>
<th>Heart Rate (bpm) (from Table 6.4, page 199)</th>
<th>Time to count 30 beats</th>
<th>Heart Rate (bpm) (from Table 6.4, page 199)</th>
</tr>
</thead>
<tbody>
<tr>
<td>First minute:</td>
<td></td>
<td></td>
<td>Fourth minute:</td>
<td></td>
</tr>
<tr>
<td>Second minute:</td>
<td></td>
<td></td>
<td>Fifth minute:</td>
<td></td>
</tr>
<tr>
<td>Third minute:</td>
<td></td>
<td></td>
<td>Sixth minute:</td>
<td></td>
</tr>
</tbody>
</table>

Average heart rate for the fifth and sixth minutes = _______ bpm

VO$_{2\text{max}}$ in L/min (Table 6.5, page 199) = _______ L min  Correction factor (from Table 6.6, page 200) = _______

Corrected VO$_{2\text{max}}$ = VO$_{2\text{max}}$ in L/min × correction factor = _______ × _______ = _______ L/min

VO$_{2\text{max}}$ in mL/kg/min = corrected VO$_{2\text{max}}$ in L/min × 1000 ÷ BW in kg = ____ × 1000 ÷ ____ = ____ mL/kg/min

Cardiorespiratory Fitness Category (Table 6.8, page 200): ___________________

V. 12-Minute Swim Test

Distance swum in 12 minutes: _______ yards

Cardiorespiratory Fitness Category (Table 6.7, page 200): ___________________

VI. What I Learned and Where I Go From Here:

1. Interpret the results of your cardiorespiratory endurance test(s). Indicate the cardiorespiratory fitness classification you would like to achieve by the end of the term and explain how you are planning to achieve this goal.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

2. Briefly discuss the advantages and disadvantages of the cardiorespiratory endurance tests used in this lab.

______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________
______________________________________________________________________________

______________________________________________________________________________
Exercise Readiness Questionnaire

Carefully read each statement and circle the number that best describes your feelings in each statement. Please be completely honest with your answers.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Mildly Agree</th>
<th>Mildly Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can walk, ride a bike (or use a wheelchair), swim, or walk in a shallow pool.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2. I enjoy exercise.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>3. I believe exercise can lower the risk for disease and premature mortality.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>4. I believe exercise contributes to better health.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5. I have participated previously in an exercise program.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>6. I have experienced the feeling of being physically fit.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>7. I can envision myself exercising.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8. I am contemplating an exercise program.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>9. I am willing to stop contemplating and give exercise a try for a few weeks.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>10. I am willing to set aside time at least three times a week for exercise.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11. I can find a place to exercise (the streets, a park, a YMCA, a health club).</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>12. I can find other people who would like to exercise with me.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>13. I will exercise when I am moody, fatigued, and even when the weather is bad.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14. I am willing to spend a small amount of money for adequate exercise clothing (shoes, shorts, leotards, or swimsuit).</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>15. If I have any doubts about my present state of health, I will see a physician before beginning an exercise program.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>16. Exercise will make me feel better and improve my quality of life.</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

Scoring Your Test:

This questionnaire allows you to examine your readiness for exercise. You have been evaluated in four categories: mastery (self-control), attitude, health, and commitment. Mastery indicates that you can be in control of your exercise program. Health measures the strength of your convictions about the wellness benefits of exercise. Commitment shows dedication and resolution to carry out the exercise program. Write the number you circled after each statement in the corresponding spaces below. Add the scores on each line to get your totals. Scores can vary from 4 to 16. A score of 12 and above is a strong indicator that that factor is important to you, and 8 and below is low. If you score 12 or more points in each category, your chances of initiating and adhering to an exercise program are good. If you fail to score at least 12 points in three categories, your chances of succeeding at exercise may be slim. You need to be better informed about the benefits of exercise, and a retraining process may be required.

Mastery: 1. + 5. + 6. + 9. =
Attitude: 2. + 7. + 8. + 13. =
Health: 3. + 4. + 15. + 16. =

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Behavior Modification Plan for Cardiorespiratory Endurance

Name: ___________________________ Date: ______________

Course: ________________ Section: ______________ Gender: _______ Age: _______

I. Advantages and disadvantages of starting an exercise program

Advantages:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Disadvantages:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

II. Stage of change for cardiorespiratory exercise

Use Figure 2.5 (page 61) and Table 2.3 (page 60) to identify your current stage of change in regard to participation in a cardiorespiratory endurance exercise program:

________________________________________________________________________

III. Processes and techniques for change

Identify the processes of change (Table 2.1, page 54) that may help you implement a cardiorespiratory endurance exercise program and list a minimum of three techniques (Table 2.2, page 60) that you will use with each process of change.

Advantages:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Disadvantages:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________
in four categories: mastery (self-control), attitude, health, and commitment. The higher you score in any category—mastery, for example—the more important that reason is for you to exercise.

Scores can vary from 4 to 16. A score of 12 or above is a strong indicator that the factor is important to you, whereas 8 or below is low. If you score 12 or more points in each category, your chances of initiating and sticking to an exercise program are good. If you do not score at least 12 points in each of any three categories, your chances of succeeding at exercise may be slim. You need to be better informed about the benefits of exercise, and a retraining process might be helpful to change core values regarding exercise. More tips on how you can become committed to exercise are provided in “Getting Started and Adhering to a Lifetime Exercise Program” (page 216).

Next you will have to decide positively that you will try. Using Activity 6.3, you can list the advantages and disadvantages of incorporating exercise into your lifestyle. Your list might include advantages such as:

- It will make me feel better.
- I will lose weight.
- I will have more energy.
- It will lower my risk for chronic diseases.

Your list of disadvantages might include the following:

- I don’t want to take the time.
- I’m too out of shape.
- There’s no good place to exercise.
- I don’t have the willpower to do it.

When your reasons for exercising outweigh your reasons for not exercising, you will find it easier to try. In Activity 6.3 you will also determine your stage of change for aerobic exercise. Using the information learned in Chapter 2, you can outline specific processes and techniques for change (also see the example in Chapter 9, pages 323–324).

### Guidelines for CR Exercise Prescription

In spite of the release of the U.S. Surgeon General’s statement on physical activity and health in 1996 indicating that regular moderate physical activity provides substantial health benefits, and the overwhelming evidence validating the benefits of exercise on health and longevity, only about 19 percent of adults in the United States meet minimum recommendations of the ACSM for the improvement and maintenance of CR fitness.

Most people are not familiar with the basic principles of CR exercise prescription. Thus, although they exercise regularly, they do not reap significant improvements in CR endurance.

To develop the CR system, the heart muscle has to be overloaded like any other muscle in the human body. Just as the biceps muscle in the upper arm is developed through strength-training exercises, the heart muscle has to be exercised to increase in size, strength, and efficiency. To better understand how the CR system can be developed, you have to be familiar with the four variables that govern exercise prescription: intensity, mode, duration, and frequency.

The acronym FITT is sometimes used to describe these variables: frequency, intensity, time (mode), and time (quantity and duration). Exercise progression rate is also an important component of the exercise prescription.

First, however, you should be aware that the ACSM recommends that apparently healthy men over age 45 and women over age 55 with one or more risk factor for cardiovascular disease (family history, cigarette smoker, sedentary lifestyle, obesity, high blood pressure, high LDL cholesterol, low HDL cholesterol [see Chapter 10], or prediabetes) get a medical exam and diagnostic graded exercise stress test prior to vigorous exercise.

The ACSM has defined vigorous exercise as an exercise intensity above 60 percent of maximal capacity. For individuals initiating an exercise program, this intensity is the equivalent of exercise that “substantially increases heart rate and breathing.” Symptomatic individuals, or those with known cardiac, pulmonary, or metabolic disease should undergo a medical examination and the exercise test prior to moderate exercise (one that “noticeably increases heart rate and breathing”).

### Intensity of Exercise

When trying to develop the CR system, many people ignore intensity of exercise. For muscles to develop, they have to be overloaded to a given point. The training stimulus to develop the biceps muscle, for example, can be accomplished with arm curl exercises with increasing weights. Likewise, the CR system is stimulated by making the heart pump faster for a specified period.

Health and CR fitness benefits result when the person is working between 30 and 85 percent of heart rate reserve (HRR) combined with an appropriate duration and frequency of training (see how to calculate intensity, on the next page). Health benefits are achieved when

<table>
<thead>
<tr>
<th>Key Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FITT</strong></td>
</tr>
<tr>
<td><strong>Vigorous exercise</strong></td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
</tr>
<tr>
<td><strong>Heart rate reserve (HRR)</strong></td>
</tr>
</tbody>
</table>
training at a lower exercise intensity, that is, between 30 and 60 percent of the person’s HRR. Even greater health and cardioprotective benefits, and higher and faster improvements in CR fitness ($V_{O2max}$), however, are achieved primarily through vigorous-intensity programs (at an intensity above 60 percent).8

Most people who initiate exercise programs have a difficult time adhering to vigorous-intensity exercise. Thus, unconditioned individuals (those in the “poor” CR fitness category) and older adults should start at a 30 to 40 percent training intensity (TI). For persons in “fair” fitness, training is recommended between 40 and 50 percent TI. For those in the “average” category, a 50 to 60 percent TI is recommended. Active and fit people in the “good” category should exercise between 60 and 70 percent TI, while active persons in the “excellent” fitness category can exercise at the higher TIs between 70 and 85 percent.

Following four to eight weeks of progressive training (depending on your starting TI) at light to moderate (30 to 60 percent) intensities, exercise can be performed between 60 and 85 percent TI. Increases in $V_{O2max}$ are accelerated when the heart is working closer to 85 percent of HRR. Exercise training above 85 percent is recommended only for healthy, performance-oriented individuals and competitive athletes. For most people, training above 85 percent is discouraged to avoid potential cardiovascular problems associated with very-hard-intensity exercise. As intensity increases, exercise adherence decreases and the risk of orthopedic injuries increases.

Intensity of exercise can be calculated easily, and training can be monitored by checking your pulse. To determine the intensity of exercise or cardiorespiratory training zone according to heart rate reserve, follow these steps (also refer to Activity 6.4):

1. Estimate your maximal heart rate (MHR) according to the following formula:
   \[ MHR = 207 - (.7 \times age) \]

2. Check your resting heart rate (RHR) for a full minute in the evening, after you have been sitting quietly for about 30 minutes reading or watching a relaxing TV show. As explained on pages 195–196, you can check your pulse on the wrist by placing two or three fingers over the radial artery or in the neck, using the carotid artery.

3. Determine the heart rate reserve (HRR) by subtracting the resting heart rate from the maximal heart rate:
   \[ HRR = MHR - RHR \]

4. Calculate the TIs at 30, 40, 50, 60, 70, and 85 percent. Multiply the heart rate reserve by the respective .30, .40, .50, .60, and .85, and then add the resting heart rate to all four of these figures (e.g., 60% TI = HRR $\times .60 + \text{RHR}$).

**Example.** The 30, 40, 50, 60, 70, and 85 percent TIs for a 20-year-old with a resting heart rate of 68 bpm would be as follows:

- MHR: 207 – (.7 × 20) = 193 bpm
- RHR: = 68 bpm
- HRR: 193 – 68 = 125 beats
- 30% TI = (125 × .30) + 68 = 106 bpm
- 40% TI = (125 × .40) + 68 = 118 bpm
- 50% TI = (125 × .50) + 68 = 131 bpm
- 60% TI = (125 × .60) + 68 = 143 bpm
- 70% TI = (125 × .70) + 68 = 155 bpm
- 85% TI = (125 × .85) + 68 = 174 bpm

Light-intensity CR training zone: 106 to 118 bpm
Moderate-intensity CR training zone: 118 to 143 bpm
Vigorous-intensity CR training zone: 143 to 174 bpm

Once you reach the vigorous-intensity CR training zone, continue to exercise between the 60 and 85 TIs to further improve or maintain your CR fitness (see Figure 6.7).

Following a few weeks of training, you may have a considerably lower resting heart rate (10 to 20 beats fewer in 8 to 12 weeks). Therefore, you should recompute your target zone periodically. You can compute your own CR training zone using Activity 6.4. Once you have reached an ideal level of CR endurance, frequent training in the 60 to 85 percent range will allow you to maintain your fitness level.

Moderate- versus Vigorous-Intensity Exercise
As fitness programs became popular in the 1970s, vigorous-intensity exercise (about 70 percent TI) was routinely prescribed for all fitness participants. Follow-
Cardiorespiratory Endurance

In extensive research in the late 1980s and 1990s, we learned that moderate-intensity physical activity (about 50 percent TI) provided many health benefits, including decreased risk for cardiovascular mortality; a statement endorsed by the U.S. Surgeon General in 1996. Thus, the emphasis switched from vigorous- to moderate-intensity training in the late 1990s. In the 1996 report, the surgeon general also stated that vigorous-intensity exercise would provide even greater benefits. Limited attention, however, was paid to this recommendation.

Vigorous-intensity programs yield higher improvements in VO$_{2\text{max}}$ than do moderate-intensity programs, especially in people with higher fitness levels. Furthermore, a comprehensive review of research articles looking at the protective benefits of physical fitness versus weekly amount of physical activity found that higher levels of aerobic fitness are associated with a lower incidence of cardiovascular disease (see Figure 6.8), even when the duration of moderate-intensity activity is prolonged to match the energy expenditure performed during a shorter vigorous-intensity effort. The results showed that persons who accumulate the greatest amount of weekly physical activity (100th percentile rank in Figure 6.8), have a 28 percent reduction in the

**Key Terms**

Cardiorespiratory training zone  Recommended training intensity range, in terms of exercise heart rate, to obtain adequate cardiorespiratory endurance development.

---

**Figure 6.7** Recommended cardiorespiratory or aerobic training pattern.

**Figure 6.8** Relative risk of cardiovascular disease (CVD) based on weekly volume of physical activity and aerobic fitness.
Personalized Cardiorespiratory Exercise Prescription

Name: ___________________________ Date: _____________

Course: ___________________ Section: _____________ Gender: _________ Age: _________

I. Intensity of Exercise
1. Estimate your own maximal heart rate (MHR)

\[
MHR = 207 - (0.70 \times \text{age})
\]

MHR = 207 - (0.70 \times \underline{_______}) = \underline{_______} bpm

2. Resting Heart Rate (RHR). Determine your RHR by counting your pulse for a full minute in the evening after you have been sitting quietly, reading, or watching a relaxing TV show.

RHR = \underline{_______} bpm

3. Heart Rate Reserve (HRR) = MHR - RHR

HRR = \underline{_______} - \underline{_______} = \underline{_______} beats

4. Training Intensities (TI) = HRR \times TI + RHR

30 percent TI = \underline{_______} \times .30 + \underline{_______} = \underline{_______} bpm

40 percent TI = \underline{_______} \times .40 + \underline{_______} = \underline{_______}

50 percent TI = \underline{_______} \times .50 + \underline{_______} = \underline{_______}

60 percent TI = \underline{_______} \times .60 + \underline{_______} = \underline{_______}

70 percent TI = \underline{_______} \times .70 + \underline{_______} = \underline{_______}

85 percent TI = \underline{_______} \times .85 + \underline{_______} = \underline{_______}

5. Current cardiorespiratory fitness category (see Activity 6.1, p. 201):

Cardiorespiratory Training Zone: unconditioned individuals, persons in the poor cardiorespiratory fitness category, and older adults starting an exercise program should use a 30 to 40 percent TI. Individuals in fair and average fitness are encouraged to exercise between 40 and 60 percent TI. Active individuals in the good or excellent categories should exercise between 60 and 85 percent TI.

Light-intensity cardiorespiratory training zone (30% to 40% TI): \underline{_______} to \underline{_______} bpm

Moderate-intensity cardiorespiratory training zone (40% to 60% TI): \underline{_______} to \underline{_______} bpm

Vigorous-intensity cardiorespiratory training zone (60% to 85% TI): \underline{_______} to \underline{_______} bpm

II. Mode of Exercise
Select any activity or combination of activities that you enjoy doing. The activity has to be continuous in nature and must get your heart rate up to the cardiorespiratory training zone and keep it there for as long as you exercise. Indicate your preferred mode(s) of exercise:

1. ___________________________ 2. ___________________________ 3. ___________________________

4. ___________________________ 5. ___________________________ 6. ___________________________
Personalized Cardiorespiratory Exercise Prescription (continued)

III. Cardiorespiratory Exercise Program

The following is your weekly program for development of cardiorespiratory endurance. If you are in the poor or fair cardiorespiratory fitness category, start with week 1. If you are in the average category, you may start at week 5. If you are already active and in the good or excellent category, you may start at week 9 (otherwise start at week 5). After completing the goal for week 12, you can maintain fitness by training between a 70 and 85 percent TI for about 20 to 30 minutes, a minimum of three times per week, on nonconsecutive days. You should also recompute your TIs periodically because you will experience a significant reduction in resting heart rate with aerobic training (approximately 10 to 20 beats in 8 to 12 weeks).

<table>
<thead>
<tr>
<th>Week</th>
<th>Duration (min)</th>
<th>Frequency</th>
<th>Training Intensity</th>
<th>Heart Rate (bpm)</th>
<th>Physical Activity Perceived Exertion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15</td>
<td>3</td>
<td>Between 30% and 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>4</td>
<td>Between 30% and 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>4</td>
<td>Between 30% and 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>5</td>
<td>Between 30% and 40%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>4</td>
<td>Between 40% and 60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>20</td>
<td>5</td>
<td>Between 40% and 60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>30</td>
<td>4</td>
<td>Between 40% and 60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>5</td>
<td>Between 40% and 60%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>30</td>
<td>4</td>
<td>Between 60% and 85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>30</td>
<td>5</td>
<td>Between 60% and 85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>30–40</td>
<td>5</td>
<td>Between 60% and 85%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>30–40</td>
<td>5</td>
<td>Between 60% and 85%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*See Figure 6.9, page 210.

Maintenance cardiorespiratory training zone (60% to 85% TI):…………………………………to…………………………………bpm

IV. Briefly state your experience and feelings regarding aerobic exercise.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

V. Monitoring Daily Activity

Average total number of daily steps (use 7-day average):…………………………………

Do you accumulate 10,000 steps on most days of the week (at least five days)? □ Yes □ No
risk of cardiovascular disease; whereas the individuals with the highest level of aerobic fitness (also see 100th percentile rank in Figure 6.8) reduce their risk by 64 percent, more than twice the level of risk reduction in the most active group.

Another review of several clinical studies substantiated that vigorous intensity, compared with moderate-intensity exercise, leads to better improvements in coronary heart disease risk factors, including aerobic endurance, blood pressure, and blood glucose control. As a result, the pendulum is again swinging toward vigorous intensity because of the added aerobic benefits, greater protection against disease, and larger energy expenditure that helps with weight management.

Monitoring Exercise Heart Rate
During the first few weeks of an exercise program, you should monitor your exercise heart rate regularly to make sure you are training in the proper zone. Wait until you are about five minutes into the aerobic phase of your exercise session before taking your first reading. When you check your heart rate, count your pulse for 10 seconds, then multiply by six to get the per minute pulse rate. The exercise heart rate will remain at the same level for about 15 seconds following aerobic exercise, then drops rapidly. Do not hesitate to stop during your exercise bout to check your pulse. If the rate is too low, increase the intensity of exercise. If the rate is too high, slow down.

When determining the TI for your own program, you need to consider your personal fitness goals and possible cardiovascular risk factors. Individuals who exercise at around the 50 percent TI still reap significant health benefits—in particular, improvements in the metabolic profile (see “Health Fitness Standards” in Chapter 1, page 21). Training at this lower percentage, however, may place you in only the “average” (moderate fitness) category (see Table 6.8). Exercising at this lower intensity will not allow you to achieve a “good” or “excellent” CR endurance fitness rating (the physical fitness standard). The latter ratings, and even greater health benefits, are obtained by exercising closer to the 85 percent threshold.

Rate of Perceived Exertion
Because many people do not check their heart rate during exercise, an alternative method of prescribing intensity of exercise has been devised using the physical activity perceived exertion (H-PAPE) scale (Figure 6.9). This new scale uses phrases based on common terminology used in physical activity and exercise prescription guidelines. Using the scale, a person subjectively rates the perceived exertion or difficulty of exercise when training at different intensity levels. The exercise heart rate then is associated with the corresponding perceived exertion phrase provided.

Figure 6.9 Physical activity perceived exertion scale.

The H-PAPE (Hoeger-Physical Activity Perceived Exertion) Scale provides a subjective rating of the perceived exertion or difficulty of physical activity and exercise when training at a given intensity level. The intensity level is associated with the corresponding perceived exertion phrase provided. These phrases are based on common terminology used in physical activity and exercise prescription guidelines.

<table>
<thead>
<tr>
<th>Perceived exertion</th>
<th>Training intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Light</td>
<td>40%</td>
</tr>
<tr>
<td>Moderate</td>
<td>50%</td>
</tr>
<tr>
<td>Somewhat hard</td>
<td>60%</td>
</tr>
<tr>
<td>Vigorous</td>
<td>70%</td>
</tr>
<tr>
<td>Hard</td>
<td>80%</td>
</tr>
<tr>
<td>Very hard</td>
<td>90%</td>
</tr>
<tr>
<td>All-out effort</td>
<td>100%</td>
</tr>
</tbody>
</table>


For example, if training between 143 (60% TI) and 155 (70% TI) bpm, the person may associate this with training between “somewhat hard” and “vigorous.” Some individuals perceive less exertion than others when training at a certain intensity level. Therefore, you have to associate your own inner perception of the task with the phrases given on the scale. You then may proceed to exercise at that rate of perceived exertion.

You must be sure to cross-check your target zone with your perceived exertion during the first weeks of your exercise program. To help you develop this association, you should regularly keep a record of your activities, using the form provided in Activity 6.5. After several weeks of training, you should be able to predict your exercise heart rate just by your own perceived exertion of the intensity of exercise.

Whether you monitor the intensity of exercise by checking your pulse or through the H-PAPE rate, you should be aware that changes in normal exercise conditions will affect the TI. For example, exercising on a hot, humid day or at high altitude increases the heart rate response to a given task, requiring adjustments in the intensity of your exercise.

Mode of Exercise
The mode, or type, of exercise that develops the CR system has to be aerobic in nature. Once you have established your CR training zone, any activity or combination of activities that will get your heart rate up to that zone and keep it there for as long as you exercise will give you adequate development. Examples of these activities are walking, jogging, elliptical activity, aerobics,
water aerobics, road cycling, spinning, stair climbing, and stationary jogging or cycling. The latter activities require little skill to perform and can be enjoyed by most adults to improve health and fitness. Other aerobic activities such as swimming, cross-country skiing, mountain cycling, rope skipping, racquetball, basketball, and soccer can also be used and are recommended for individuals who already possess the skills to perform these activities or have adequate fitness to learn the necessary skills to safely perform the activity.

Aerobic exercise has to involve the major muscle groups of the body, and it has to be rhythmic and continuous. As the amount of muscle mass involved during exercise increases, so do the demands on the CR system. The activity you choose should be based on your personal preferences, what you most enjoy doing, and your physical limitations. Low-impact activities greatly reduce the risk for injuries. Most injuries to beginners result from high-impact activities. Also, general strength conditioning (see Chapter 7) is recommended prior to initiating an aerobic exercise program for individuals who have been inactive. Strength conditioning can significantly reduce the incidence of injuries.

The amount of strength or flexibility you develop through various activities differs. In terms of CR development, though, the heart doesn’t know whether you are walking, swimming, or cycling. All the heart knows is that it has to pump at a certain rate, and as long as that rate is in the desired range, your CR fitness will improve. From a health fitness point of view, training in the lower end of the CR zone will yield substantial health benefits. The closer the heart rate is to the higher end of the CR training zone, however, the greater will be the health benefits and improvements in VO$_{2\text{max}}$ (high physical fitness).

Because of the specificity of training, to ascertain changes in fitness, it is recommended that you use the same mode of exercise for training and testing. If your primary mode of training is cycling, it is recommended that you assess VO$_{2\text{max}}$ using a bicycle test. For joggers, a field or treadmill running test is best. Swimmers should use a swim test.

**Duration of Exercise**

The general recommendation is that a person exercise between 20 and 60 minutes per session. For people who have been successful at losing a large amount of weight, however, up to 90 minutes of moderate-intensity activity daily may be required to prevent weight regain.

The duration of exercise is based on how intensely a person trains. The variables are inversely related. If the training is done at around 85 percent, a session of 20 to 30 minutes is sufficient. At about 50 percent intensity, the person should train close to 60 minutes. As mentioned under “Intensity of Exercise,” unconditioned people and older adults should train at lower percentages and, therefore, the activity should be carried out over a longer time.

Although the recommended guideline is 20 to 60 minutes of aerobic exercise per session, in the early stages of conditioning and for individuals who are pressed for time, accumulating 30 minutes or more of moderate-intensity physical activity throughout the day does provide health benefits. Three 10-minute exercise sessions per day (separated by at least 4 hours), at approximately 70 percent of maximal heart rate, have been shown to produce training benefits.$^{14}$ Although the increases in VO$_{2\text{max}}$ with the latter program were not as large (57 percent) as those found in a group performing a continuous 30-minute bout of exercise per day, the researchers concluded that the accumulation of 30 minutes of moderate-intensity physical activity, conducted for at least 10 minutes three times per day, benefits the CR system significantly. Activity bouts of less than 10 minutes in duration do not count toward the 30-minute daily guideline.

Results of this and other similar studies are meaningful because people often mention lack of time as the reason they do not take part in an exercise program. Many think they have to exercise at least 20 continuous minutes to get any benefits at all. Even though a duration of 20 to 30 minutes of continuous vigorous-intensity activity is ideal, short, intermittent physical activity bouts, of at least 10 minutes long each, are beneficial to the CR system.

The 2008 Federal Guidelines for Physical Activity measure duration of exercise in terms of the total quantity of physical activity performed on a weekly basis. Two hours and 30 minutes of moderate-intensity aerobic activity or 1 hour and 15 minutes of vigorous-intensity aerobic activity per week, or an equivalent combination of the two are recommended (30 minutes of moderate-intensity activity twice per week combined with 20 minutes of vigorous-intensity another two times per week).

Two hours and 30 minutes per week represents the accumulation of 30 minutes of moderate-intensity aerobic activity (done in bouts of at least 10 minutes each) per session/day performed five days per week, whereas 1 hour and 15 minutes is approximately 25 minutes of vigorous-intensity aerobic activity done three times per week. The federal guidelines also indicate that 5 hours of moderate-intensity activity, or 2 hours and 30 minutes of vigorous-intensity activity per week provide additional benefits. Thus, when possible, people are encouraged to go beyond the minimum recommendation.

From a weight management point of view, the recommendation to prevent weight gain is for people to accu-
mulate 60 minutes of moderate-intensity physical activity most days of the week,\(^{15}\) whereas 60 to 90 minutes of daily moderate-intensity activity is necessary to prevent weight regain.\(^{16}\) These recommendations are based on evidence that people who maintain healthy weight typically accumulate between 1 and 1½ hours of physical activity at least five times per week. The duration of exercise should be increased gradually to avoid undue fatigue and exercise-related injuries.

If lack of time is a concern, you should exercise at a vigorous intensity for about 30 minutes, which can burn as many calories as 60 minutes of moderate intensity (also see “The Role of Exercise Intensity and Duration in Weight Management,” Chapter 5, page 161), but only 19 percent of adults in the United States typically exercise at a vigorous-intensity level. Novice and overweight exercisers also need proper conditioning prior to vigorous-intensity exercise to avoid injuries or cardiovascular-related problems.

Exercise sessions always should be preceded by a 5 to 10-minute warm-up and be followed by a 10-minute cool-down period (see Figure 6.7). The purpose of the warm-up is to aid in the transition from rest to exercise. A good warm-up increases extensibility of the muscles and connective tissue, extends joint range of motion, and enhances muscular activity. A warm-up consists of general calisthenics, mild stretching exercises, and walking/jogging/cycling for a few minutes at a lower intensity than the actual target zone. The concluding phase of the warm-up is a gradual increase in exercise intensity to the lower end of the target training zone.

In the cool-down, the intensity of exercise is decreased gradually to help the body return to near resting levels, followed by stretching and relaxation activities. Stopping abruptly causes blood to pool in the exercised body parts, diminishing the return of blood to the heart. Less blood return can cause a sudden drop in blood pressure, dizziness, and faintness, or it can bring on cardiac abnormalities. The cool-down phase also helps dissipate body heat and aid in removing the lactic acid produced during high-intensity exercise.

**Frequency of Exercise**

The recommended exercise frequency for aerobic exercise is three to five days per week. When exercising at 60 to 85 percent of HRR, three 20- to 30-minute exercise sessions per week, on nonconsecutive days, are sufficient to improve (in the early stages) or maintain \(\text{VO}_{2\text{max}}\). When exercising at a moderate intensity, 30 to 60 minutes five days per week are required.

Research indicates that when vigorous training is conducted more than five days a week, further improvements in \(\text{VO}_{2\text{max}}\) are minimal. Although endurance athletes often train six or seven days per week (often twice per day), their training programs are designed to increase training mileage to endure long-distance races (6 to 100 miles) at a high percentage of \(\text{VO}_{2\text{max}}\) frequently at or above the anaerobic threshold.

Although three exercise sessions per week will maintain CR fitness, the importance of regular physical activity in preventing disease and enhancing quality of life has been pointed out clearly by the ACSM, the U.S. Centers for Disease Control and Prevention, and by the President’s Council on Physical Fitness and Sports.\(^{17}\) These organizations along with the U.S. Surgeon General advocate at least 30 minutes of moderate-intensity physical activity on most (defined as five days per week) or preferably all days of the week. This routine has been promoted as an effective way to improve health and quality of life. Further, the Surgeon General states that
no one, including older adults, is too old to enjoy the benefits of regular physical activity. Also, be aware that most of the benefits of exercise and activity diminish within two weeks of substantially decreased physical activity and the benefits are completely lost within a few months of inactivity.

**Excessive Sitting: A Deadly Proposition**

If you meet the guideline and exercise five times per week, but spend most of your day sitting, your lifestyle may be cancelling out the health benefits of the 30-minute exercise session. The human body was created for movement and physical activity. Our society, however, is primarily a sedentary society that lulls us into physical inactivity. Most Americans spend more than half their waking hours sitting: driving to and from work, working at a desk, sitting at the computer, and watching television. Research studies indicate that people who spend most of their day sitting have as much as a 50-percent greater risk of dying prematurely from all causes and an 80-percent greater risk of dying from cardiovascular disease. The data further indicate that death rates are still high for people who spend most of their day sitting, even though they meet the current minimum moderate-physical activity recommendations (30 minutes, at least five times per week). Among many other conditions, excessive sitting leads to weaker muscles, a sluggish central nervous system, increased fatigue, decreased insulin sensitivity, higher blood pressure, decreased activity of lipoprotein lipase (an enzyme that breaks down fats in the blood), and increased cholesterol, LDL cholesterol, and triglycerides. Thus, even if you are meeting the exercise guidelines of physical activity on most days of the week, you should not spend most of the remainder of your day being sedentary.

To minimize inactivity, look to enhance daily non-exercise activity thermogenesis (NEAT) or the energy expended doing daily activities not related to exercise. Examples of such activities include:

1. Stand as much as possible while working at home. Place your computer on an elevated stand or shelf and stand while doing work, writing emails, or surfing the Internet. Always stand while answering the phone. Standing triples the energy requirement of doing a similar activity sitting.
2. Use a standing or a treadmill desk. Perform much of your work standing. If at all possible, walk at a light-intensity level while working at your desk. You may find that such practice enhances concentration and work productivity.
3. Use a stability ball for a chair or even a stability ball chair at the office. Such use will enhance body stability, balance, and abdominal, low back, and leg strength.
5. Walk to coworkers’ offices to discuss matters with them instead of using the phone or email.
6. Take intermittent breaks. A 10-minute break every hour that you are at the computer to stretch, walk around, or talk to coworkers is quite beneficial.
7. Park farther away or get off the subway, train, or bus several blocks away from the office. When feasible, take the stairs instead of elevators and escalators.

**Rate of Progression**

How quickly an individual progresses through an exercise program depends on the person’s health status, exercise tolerance, and exercise program goals. Initially, only three weekly training sessions of 15 to 20 minutes are recommended to avoid musculo-skeletal injuries. You may then increase the duration by 5 to 10 minutes per week and the frequency so that by the fourth or fifth week you are exercising five times per week (see Activity 6.4). Thereafter, progressively increase frequency, duration, and intensity of exercise until you reach your fitness maintenance goal.

To sum up: Ideally, a person should engage in physical activity six or seven times per week. Based on the previous discussion, to reap both the high-fitness and health-fitness benefits of exercise, a person should do vigorous exercise three times per week for high fitness maintenance, and two to four additional times per week in moderate-intensity activities (see Figure 6.10) to maintain good health. Depending on the intensity of the activity and the health/fitness goals, all exercise sessions should last between 20 and 60 minutes. For adequate weight-management purposes, additional daily physical activity, up to 90 minutes, may be necessary. A summary of the CR exercise prescription guidelines according to the ACSM is provided in Figure 6.11.
Fitness Benefits of Aerobic Activities

The contributions of different aerobic activities to the health-related components of fitness vary. Although an accurate assessment of the contributions to each fitness component is difficult to establish, a summary of likely benefits of several activities is provided in Table 6.9. Instead of a single rating or number, ranges are given for some of the categories. The benefits derived are based on the person’s effort while participating in the activity.

The nature of the activity often dictates the potential aerobic development. For example, jogging is much more strenuous than walking. The effort during exercise also affects the amount of physiological development. For example, during a low-impact aerobics routine, accentuating all movements (instead of just going through the motions) increases training benefits by orders of magnitude.

Table 6.9 indicates a starting fitness level for each aerobic activity. Attempting to participate in vigorous-intensity activities without proper conditioning often leads to injuries, not to mention discouragement. Beginners should start with light-intensity activities that carry a minimum risk for injuries.
Chapter 6 Cardiorespiratory Endurance

In some cases, such as high-impact aerobics and rope skipping, the risk for orthopedic injuries remains high even if the participants are adequately conditioned. These activities should be supplemental only and are not recommended as the sole mode of exercise. Most exercise-related injuries occur as a result of high-impact activities, not high intensity of exercise.

Physicians who work with cardiac patients frequently use metabolic equivalents (METs) as an alternative method of prescribing exercise intensity. One MET represents the rate of energy expenditure at rest, that is, 3.5 mL/kg/min. METs are used to measure the intensity of physical activity and exercise in multiples of the resting metabolic rate. At an intensity level of 10 METs, the activity requires a 10-fold increase in the resting energy requirement (or approxi-

---

**Table 6.9** Ratings for Selected Aerobic Activities

<table>
<thead>
<tr>
<th>Activity</th>
<th>Recommended Starting Level</th>
<th>Injury Risk</th>
<th>Potential Cardiorespiratory Endurance Development</th>
<th>Lower Body Strength Development</th>
<th>Lower Body Flexibility Development</th>
<th>Weight Control</th>
<th>MET Level</th>
<th>Caloric Expenditure (cal/hour)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobics</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-Impact Aerobics</td>
<td>A</td>
<td>H</td>
<td>3–4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>6–12</td>
</tr>
<tr>
<td>Moderate-Impact Aerobics</td>
<td>I</td>
<td>M</td>
<td>2–4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>6–12</td>
</tr>
<tr>
<td>Low-Impact Aerobics</td>
<td>B</td>
<td>L</td>
<td>2–4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>5–10</td>
</tr>
<tr>
<td>Step Aerobics</td>
<td>I</td>
<td>M</td>
<td>2–4</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3–4</td>
<td>5–12</td>
</tr>
<tr>
<td>Cross-Country Skiing</td>
<td>B</td>
<td>M</td>
<td>4–5</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>4–5</td>
</tr>
<tr>
<td>Cross-Training</td>
<td>I</td>
<td>M</td>
<td>3–5</td>
<td>2–3</td>
<td>3–4</td>
<td>1–2</td>
<td>3–5</td>
<td>6–15</td>
</tr>
<tr>
<td>Cycling</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Road</td>
<td>I</td>
<td>M</td>
<td>2–5</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Stationary</td>
<td>B</td>
<td>L</td>
<td>2–4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Hiking</td>
<td>B</td>
<td>L</td>
<td>2–4</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>In-Line Skating</td>
<td>I</td>
<td>M</td>
<td>2–4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Jogging</td>
<td>I</td>
<td>M</td>
<td>3–5</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Jogging, Deep Water</td>
<td>A</td>
<td>L</td>
<td>3–5</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Racquet Sports</td>
<td>I</td>
<td>M</td>
<td>2–4</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Rope Skipping</td>
<td>I</td>
<td>H</td>
<td>3–5</td>
<td>2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3–5</td>
</tr>
<tr>
<td>Rowing</td>
<td>B</td>
<td>L</td>
<td>3–5</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>Swimming (front crawl)</td>
<td>B</td>
<td>L</td>
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1B = Beginner, I = Intermediate, A = Advanced
2L = Low, M = Moderate, H = High
31 = Low, 2 = Fair, 3 = Average, 4 = Good, 5 = Excellent
4One MET represents the rate of energy expenditure at rest (3.5 mL/kg/min). Each additional MET is a multiple of the resting value. For example, 5 METs represents an energy expenditure equivalent to five times the resting value, or about 17.5 mL/kg/min.
5Varies according to the person’s effort (intensity) during exercise.
6Varies according to body weight.

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**Key Terms**

**MET** Short for metabolic equivalent, the rate of energy expenditure at rest; 1 MET is the equivalent of a VO₂ of 3.5 mL/kg/min.
mately 35 mL/kg/min). MET levels for a given activity vary according to the effort expended. The MET range for various activities is included in Table 6.9. The harder a person exercises, the higher the MET level.

The effectiveness of various aerobic activities in weight management is charted in Table 6.9. As a general rule, the greater the muscle mass involved in exercise, the better the results. Rhythmic and continuous activities that involve large amounts of muscle mass are most effective in burning calories.

Vigorous-intensity activities increase caloric expenditure as well. Exercising longer, however, compensates for lower intensities. If carried out long enough (45 to 60 minutes five or six times per week), even walking is a good exercise mode for weight management. Additional information on a comprehensive weight management program is given in Chapter 5.

Cross-country skiing requires more oxygen and energy than most other aerobic activities.

**Getting Started and Adhering to a Lifetime Exercise Program**

Following the guidelines provided in Activity 6.4, you may proceed to initiate your own CR endurance program. If you have not been exercising regularly, you might begin by attempting to train five or six times a week for 30 minutes at a time. You might find this discouraging, however, and drop out before getting too far, because you will probably develop some muscle soreness and stiffness and possibly incur minor injuries. Muscle soreness and stiffness and the risk for injuries can be lessened or eliminated by increasing the intensity, duration, and frequency of exercise progressively, as outlined in Activity 6.4.

Once you have determined your exercise prescription, the difficult part begins: starting and sticking to a lifetime exercise program. Although you may be motivated after reading about the benefits to be gained from physical activity, lifelong dedication and perseverance are necessary to reap and maintain good fitness.

The first few weeks probably will be the most difficult for you, but where there’s a will, there’s a way. Once you begin to see positive changes, it won’t be as hard. Soon you will develop a habit of exercising that will be deeply satisfying and will bring about a sense of self-accomplishment. The suggestions provided in the accompanying Behavior Modification Planning box (see page 217) have been used successfully to help change behavior and adhere to a lifetime exercise program.

**Critical Thinking**

Mary started an exercise program last year as a means to lose weight and enhance her body image. She now runs about six miles every day, strength-trains daily, participates in step-aerobics twice per week, and plays tennis or racquetball twice a week. Evaluate her program and make suggestions for improvements.
Tips to Enhance Exercise Compliance

1. Set aside a regular time for exercise. If you don’t plan ahead, it is a lot easier to skip. On a weekly basis, using red ink, schedule your exercise time into your day planner. Next, hold your exercise hour “sacred.” Give exercise priority equal to the most important school or business activity of the day. If you are too busy, attempt to accumulate 30 to 60 minutes of daily activity by doing separate 10-minute sessions throughout the day. Try reading the mail while you walk, taking stairs instead of elevators, walking the dog, or riding the stationary bike as you watch the evening news.

2. Exercise early in the day, when you will be less tired and the chances of something interfering with your workout are minimal; thus, you will be less likely to skip your exercise session.

3. Select aerobic activities you enjoy. Exercise should be as much fun as your favorite hobby. If you pick an activity you don’t enjoy, you will be unmotivated and less likely to keep exercising. Don’t be afraid to try out a new activity, even if that means learning new skills.

4. Combine different activities. You can train by doing two or three different activities the same week. This cross-training may reduce the monotony of repeating the same activity every day. Try lifetime sports. Many endurance sports, such as racquetball, basketball, soccer, badminton, roller skating, cross-country skiing, and body surfing (paddling the board), provide a nice break from regular workouts.

5. Use the proper clothing and equipment for exercise. A poor pair of shoes, for example, can make you more prone to injury, discouraging you from the beginning.

6. Find a friend or group of friends to exercise with. Social interaction will make exercise more fulfilling. Besides, exercise is harder to skip if someone is waiting to go with you.

7. Set goals and share them with others. Quitting is tougher when someone else knows what you are trying to accomplish. When you reach a targeted goal, reward yourself with a new pair of shoes or a jogging suit.

8. Purchase a pedometer (step counter) and build up to 10,000 steps per day. These 10,000 steps may include all forms of daily physical activity combined. Pedometers motivate people toward activity because they track daily activity, provide feedback on activity level, and remind the participant to enhance daily activity.

9. Don’t become a chronic exerciser. Overexercising can lead to chronic fatigue and injuries. Exercise should be enjoyable, and in the process you should stop and smell the roses.

10. Exercise in different places and facilities. This will add variety to your workouts.

11. Exercise to music. People who listen to fast-tempo music tend to exercise more vigorously and longer. Using headphones when exercising outdoors, however, can be dangerous. Even indoors, it is preferable not to use headphones so you still can be aware of your surroundings.

12. Keep a regular record of your activities. Keeping a record allows you to monitor your progress and compare it against previous months and years (see Figure 6.11, page 214).

13. Conduct periodic assessments. Improving to a higher fitness category is often a reward in itself, and creating your own rewards is even more motivating.

14. Listen to your body. If you experience pain or unusual discomfort, stop exercising. Pain and aches are an indication of potential injury. If you do suffer an injury, don’t return to your regular workouts until you are fully recovered. You may cross-train using activities that don’t aggravate your injury (for instance, swimming instead of jogging).

15. If a health problem arises, see a physician. When in doubt, it’s better to be safe than sorry.

Try It The most difficult challenge about exercise is to keep going once you start. The above behavioral change tips will enhance your chances for exercise adherence. In your Online Journal or class notebook, describe which suggestions were most useful.
# Cardiorespiratory Exercise Record Form

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<th>Exercise HR</th>
<th>Type of Activity</th>
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<th>Time in Min.</th>
<th>H-PAPE*</th>
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*Physical activity perceived exertion.

Total Daily Steps

Physical activity perceived exertion, Total

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*Physical activity perceived exertion.
A Lifetime Commitment to Fitness

The benefits of fitness can be maintained only through a regular lifetime program. Exercise is not like putting money in the bank. It doesn’t help much to exercise four or five hours on Saturday and not do anything else the rest of the week. If anything, exercising only once a week is not safe for unconditioned adults.

The time involved in losing the benefits of exercise varies among the different components of physical fitness and also depends on the person’s condition before the interruption. In regard to CR endurance, it has been estimated that 4 weeks of aerobic training are completely reversed in two consecutive weeks of physical inactivity. But if you have been exercising regularly for months or years, two weeks of inactivity won’t hurt you as much as it will someone who has exercised only a few weeks. As a rule, after 48 to 72 hours of aerobic inactivity, the CR system starts to lose some of its capacity.

To maintain fitness, you should keep up a regular exercise program, even during vacations. If you have to interrupt your program for reasons beyond your control, you should not attempt to resume training at the same level you left off but, rather, build up gradually again.

Even the greatest athletes on earth, if they were to stop exercising, would be, after just a few years, at about the same risk for disease as someone who has never done any physical activity. Staying with a physical fitness program long enough brings about positive physiological and psychological changes. Once you are there, you will not want to have it any other way.

Physically challenged people can participate and derive health and fitness benefits through a vigorous-intensity exercise program.

Assess Your Behavior

1. Do you consciously attempt to incorporate as much physical activity as possible in your daily living (walk, take stairs, cycle, participate in sports and recreational activities)?
2. Are you accumulating at least 30 minutes of moderate-intensity physical activity over a minimum of five days per week?
3. Is aerobic exercise in the appropriate target zone a priority in your life a minimum of three times per week for at least 20 minutes per exercise session?
4. Do you own a pedometer and do you accumulate 10,000 or more steps on most days of the week?
5. Have you evaluated your aerobic fitness and do you meet at least the health fitness category?
Chapter 6  Cardiorespiratory Endurance

Assess Your Knowledge

Evaluate how well you understand the concepts presented in this chapter using the chapter-specific quizzing available in the online materials at www.cengagebrain.com.

1. CR endurance is determined by
   a. the amount of oxygen the body is able to utilize per minute of physical activity.
   b. the length of time it takes the heart rate to return to 120 bpm following the 1.5-Mile Run Test.
   c. the difference between the maximal heart rate and the resting heart rate.
   d. the product of the heart rate and blood pressure at rest versus exercise.
   e. the time it takes a person to reach a heart rate between 120 and 170 bpm during the Astrand-Ryhming test.

2. Which of the following is not a benefit of aerobic training?
   a. higher VO₂max
   b. increase in red blood cell count
   c. decrease in resting heart rate
   d. increase in heart rate at a given workload
   e. increase in functional capillaries

3. The oxygen uptake for a person with an exercise heart rate of 130, a stroke volume of 100, and an a-V̅O₂diff of 10 is
   a. 130,000 mL/kg/min.
   b. 1,300 L/min.
   c. 1.3 L/min.
   d. 130 mL/kg/min.
   e. 13 mL/kg/min.

4. The oxygen uptake, in mL/kg/min, for a person with a VO₂ of 2.0 L/min who weighs 60 kilograms is
   a. 120.
   b. 26.5.
   c. 33.3.
   d. 30.
   e. 120,000.

5. The Step Test estimates VO₂max according to
   a. how long a person is able to sustain the proper Step Test cadence.
   b. the lowest heart rate achieved during the test.
   c. the recovery heart rate following the test.
   d. the difference between the maximal heart rate achieved and the resting heart rate.
   e. the exercise heart rate and the total stepping time.

6. An “excellent” CR fitness rating, in mL/kg/min, for young male adults is about
   a. 10.
   b. 20.
   c. 30.
   d. 40.
   e. 50.

7. How many minutes would a person training at 2.0 L/min have to exercise to burn the equivalent of one pound of fat?
   a. 700
   b. 350
   c. 120
   d. 60
   e. 20

8. The vigorous-intensity CR training zone for a 22-year-old individual with a resting heart rate of 68 bpm is
   a. 120 to 148.
   b. 132 to 156.
   c. 138 to 164.
   d. 146 to 179.
   e. 154 to 188.

9. Which of the following activities does not contribute to the development of CR endurance?
   a. light-impact aerobics
   b. jogging
   c. 400-yard dash
   d. racquetball
   e. All of these activities contribute to its development.

10. The recommended duration for each cardiorespiratory training session is
    a. 10 to 20 minutes.
    b. 15 to 30 minutes.
    c. 20 to 60 minutes.
    d. 45 to 70 minutes.
    e. 60 to 120 minutes.

Correct answers can be found at the back of the book.
Chapter 6:

Notes


7. See note 2.


10. See note 3.


15. National Academy of Sciences, Institute of Medicine, *Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Protein*


20. See note 2.

Suggested Readings


Answer Key

This page contains answers for this chapter only

Chapter 6
1. a 2. d 3. c 4. c 5. c 6. e 7. b 8. d 9. c 10. c
CHAPTER 6 FOR EASY REFERENCE
Cardiorespiratory Exercise Prescription

Intensity of Exercise

1. Estimate your own maximal heart rate (MHR)
   \[ \text{MHR} = 207 - (.70 \times \text{age}) \]
   \[ \text{MHR} = 207 - \_ \times \_ = \_ \text{bpm} \]

2. Resting Heart Rate (RHR) = \_ bpm

3. Heart Rate Reserve (HRR) = MHR - RHR
   \[ \text{HRR} = \_ - \_ = \_ \text{beats} \]

4. Training Intensities (TI) = HRR \times TI + RHR
   \[ \text{30 Percent TI} = \_ \times .30 + \_ = \_ \text{bpm} \]
   \[ \text{40 Percent TI} = \_ \times .40 + \_ = \_ \text{bpm} \]
   \[ \text{60 percent TI} = \_ \times .60 + \_ = \_ \text{bpm} \]
   \[ \text{85 Percent TI} = \_ \times .85 + \_ = \_ \text{bpm} \]

5. Light-Intensity Cardiorespiratory Training Zone:
   \_ (30% TI) to \_ (40% TI)

6. Moderate-Intensity Cardiorespiratory Training Zone:
   \_ (40% TI) to \_ (85% TI)

7. Vigorous-Intensity Cardiorespiratory Training Zone:
   \_ (60% TI) to \_ (85% TI)
Cardiorespiratory Exercise Guidelines

Mode: Moderate- or vigorous-intensity aerobic activity (examples: walking, jogging, stair climbing, elliptical activity, aerobics, water aerobics, cycling, stair climbing, swimming, cross-country skiing, racquetball, basketball, and soccer)

Intensity: 30% to 85% of heart rate reserve (the training intensity is based on age, health status, initial fitness level, exercise tolerance, and exercise program goals)

Duration: Be active 20 to 90 minutes. At least 20 minutes of continuous vigorous-intensity or 30 minutes of moderate-intensity aerobic activity (the latter may be accumulated in segments of at least 10 minutes in duration each over the course of the day)

Frequency: 3 to 5 days per week for vigorous-intensity aerobic activity to accumulate at least 75 minutes per week, or 5 days per week of moderate-intensity aerobic activity for a minimum total of 150 minutes weekly

Rate of progression:

- Start with three training sessions per week of 15 to 20 minutes
- Increase the duration by 5 to 10 minutes per week and the frequency so that by the fourth or fifth week you are exercising five times per week
- Progressively increase frequency, duration, and intensity of exercise until you reach your fitness goal prior to exercise maintenance