8

Cardiorespiratory Endurance

In This Chapter

Student Web Resources

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Lesson 8.1

Cardiorespiratory Endurance Facts

Lesson Objectives

After reading this lesson, you should be able to

1. describe the health and wellness benefits of cardiorespiratory endurance;
2. explain how physical activity benefits the cardiovascular, respiratory, and muscle systems;
3. describe some methods for assessing your cardiorespiratory endurance; and
4. determine how much cardiorespiratory endurance is enough.

Lesson Vocabulary

aerobic capacity, artery, cardiorespiratory endurance, cardiovascular system, cholesterol, fibrin, graded exercise test, high-density lipoprotein (HDL), lipoprotein, low-density lipoprotein (LDL), maximal oxygen uptake, respiratory system, vein

Do you have good cardiorespiratory endurance? Do you do enough regular vigorous physical activity to build good cardiorespiratory endurance? Of the 11 parts of fitness, cardiorespiratory endurance is the most important because it gives you many health and wellness benefits, including a chance for a longer life. In addition, the activity that you do to improve your cardiorespiratory endurance helps you look your best. As shown in figure 8.1, cardiorespiratory endurance requires fitness of your heart, lungs, blood, blood vessels, and muscles. In this lesson, you'll learn how proper physical activity improves your cardiorespiratory endurance. You'll also learn how to assess your cardiorespiratory endurance.

Cardiorespiratory endurance is the ability to exercise your entire body for a long time without stopping. It requires a strong heart, healthy lungs, and clear blood vessels to supply your large muscles with oxygen. Examples of activities that require good cardiorespiratory endurance are distance running, swimming, and cross-country skiing. Cardiorespiratory endurance is sometimes referred to by other names, including cardiovascular fitness, cardiovascular endurance, and cardiorespiratory fitness. The term *aerobic capacity* is also used to describe good cardiorespiratory function, but it is not exactly the same as cardiorespiratory endurance (see this chapter's Science in Action feature).

This book uses the term *cardiorespiratory endurance*. The first word in the term is *cardiorespiratory* because two vital systems are involved. Your

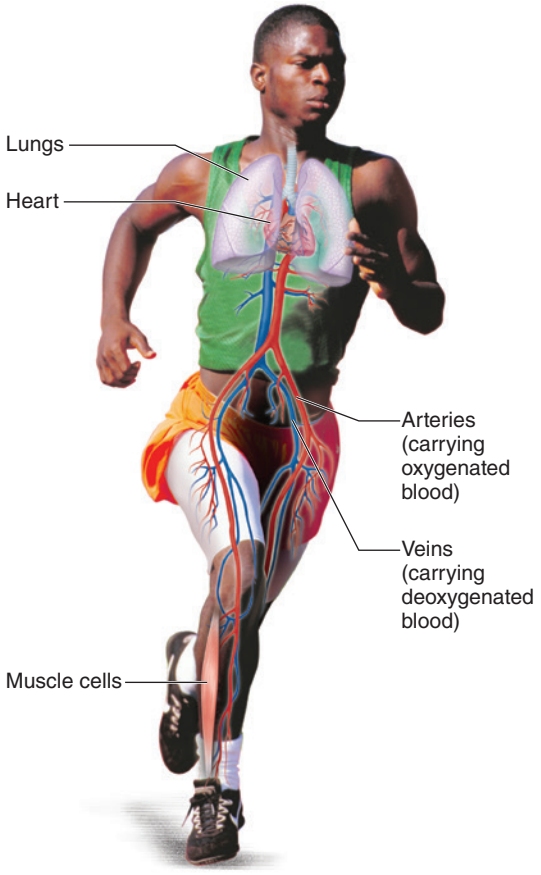

FIGURE 8.1 Cardiorespiratory endurance requires fitness of many parts of the body, including heart, lungs, muscles, and blood vessels.

cardiovascular system is made up of your heart, blood vessels, and blood. Your **respiratory system** is made up of your lungs and the air passages that

bring air, including oxygen, to your lungs from outside of your body. In your lungs, oxygen enters your blood, and carbon dioxide is eliminated. Your cardiovascular and respiratory systems work together to bring your muscle cells and other body cells the materials they need and to rid the cells of waste. Together, the two systems help you function both effectively (with the most benefits possible) and efficiently (with the least effort).

The second word in the term *cardiorespiratory endurance* refers to the ability to sustain effort. Together, then, these two words—*cardiorespiratory* and *endurance*—refer to the ability to sustain effort, which hinges on fitness of the cardiovascular (cardio) and respiratory systems.

Benefits of Physical Activity and Cardiorespiratory Endurance

Doing regular physical activity can help you look better by controlling your weight, building your muscles, and helping you develop good posture. Regular physical activity also produces changes in your body's organs, such as making your heart muscle stronger and your blood vessels healthier. These changes improve your cardiorespiratory endurance and wellness and reduce your risk of hypokinetic diseases, especially heart disease and diabetes.

Physical activity provides benefits for both your cardiovascular and respiratory systems. In this lesson, you'll learn how each part of these systems benefits and how all the parts work together to promote optimal functioning and good health.

FIT FACT

In the early 1900s, medical doctors referred to an enlarged heart as the "athlete's heart" because athletes' hearts tend to be large, and enlarged hearts were associated with disease. By midcentury, research showed that the large heart muscle of a trained athlete was a sign of health, not disease.

Heart

Because your heart is a muscle, it benefits from exercise and activities, such as jogging, swimming, and long-distance hiking. Your heart acts as a pump to deliver blood to cells throughout your body. When you do vigorous physical activity, your muscle cells need more oxygen and produce more waste products. Therefore, your heart must pump more blood to supply the additional oxygen and remove the additional waste. If your heart is unable to pump enough blood, your muscles will be less able to contract and will fatigue more quickly.

Your heart's capacity to pump blood is crucial when you're doing physical activity, especially for an extended length of time. Your heart has two ways to get more blood to your muscles—by beating faster and by sending more blood with each beat (this is called stroke volume).

Your resting heart rate is determined by counting the number of heartbeats per minute when you're relatively inactive. A person who does regular physical activity might have a resting heart rate of 55 to 60 beats per minute, whereas a person who does not exercise regularly might have a resting heart rate of 70 or more beats per minute. As a result, a very fit person's heart beats approximately 9.5 million fewer times each year than that of the average person. As you can see in figure 8.2, a fit person's heart works more efficiently by pumping more blood with fewer beats.

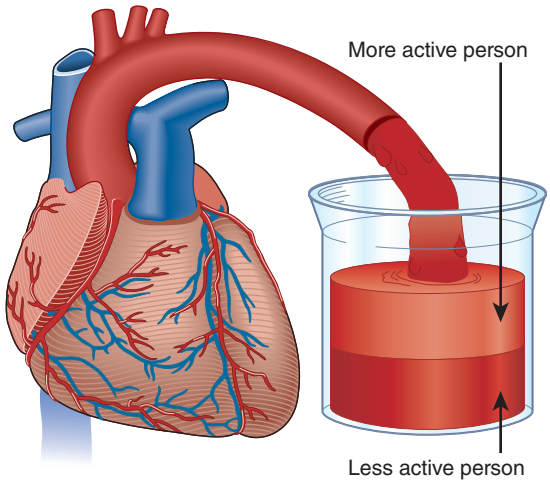

FIGURE 8.2 The heart muscle of a fit, active person pumps more blood per heartbeat than that of a less active person.

Lungs

When you inhale, air enters the lungs, causing them to expand. In the lungs, oxygen is transferred from the air to the blood for transport to the tissues of the body. When you exhale, air leaves the lungs. The diaphragm (a band of muscular tissue located at the base of your lungs) and abdominal muscles (which help move the diaphragm) work to allow you to breathe in and out (figure 8.3*a*). Fit people can take in more air with each breath than unfit people because they have more efficient respiratory muscles. As shown in figure 8.3*b*, a fit person gets more air in the lungs with each breath and therefore can transport the same amount of air to the lungs in fewer breaths. Healthy lungs also have the capacity to easily transfer oxygen to the blood. Together healthy lungs and fit respiratory muscles contribute to good cardiorespiratory endurance.

Blood

Although your body needs a certain amount of fat, excessive amounts trigger formation of fatty deposits along your artery walls. **Cholesterol**—a waxy, fat-like substance found in meat, dairy products, and egg yolk—can be dangerous because high levels can build up in your body without your noticing it.

Cholesterol is carried through your bloodstream by particles called **lipoproteins**. One kind, **low-density lipoprotein (LDL)**, is often referred to as "bad cholesterol" because it carries cholesterol that is more likely to stay in your body and contribute to atherosclerosis. An LDL count below 100 is considered optimal for good health. Another kind, **high-density lipoprotein (HDL)**, is often referred to as "good cholesterol" because it carries excess cholesterol out of your bloodstream and into your liver for elimination from your body. Therefore, HDLs appear to help prevent atherosclerosis. An HDL count above 60 is considered optimal for good health.

In addition to being free of fatty deposits, healthy arteries are free from inflammation, which contributes to arterial clogging. Blood tests can pick up markers of inflammation.

Regular physical activity helps you improve your health and resist disease by reducing your LDL (bad cholesterol) and increasing your HDL (good cholesterol). It also helps reduce inflammation in your arteries and can help prevent the formation of blood clots by reducing the amount of **fibrin** in your blood. Fibrin is a substance involved in making your blood clot, and high amounts of fibrin can contribute to the development of atherosclerosis.

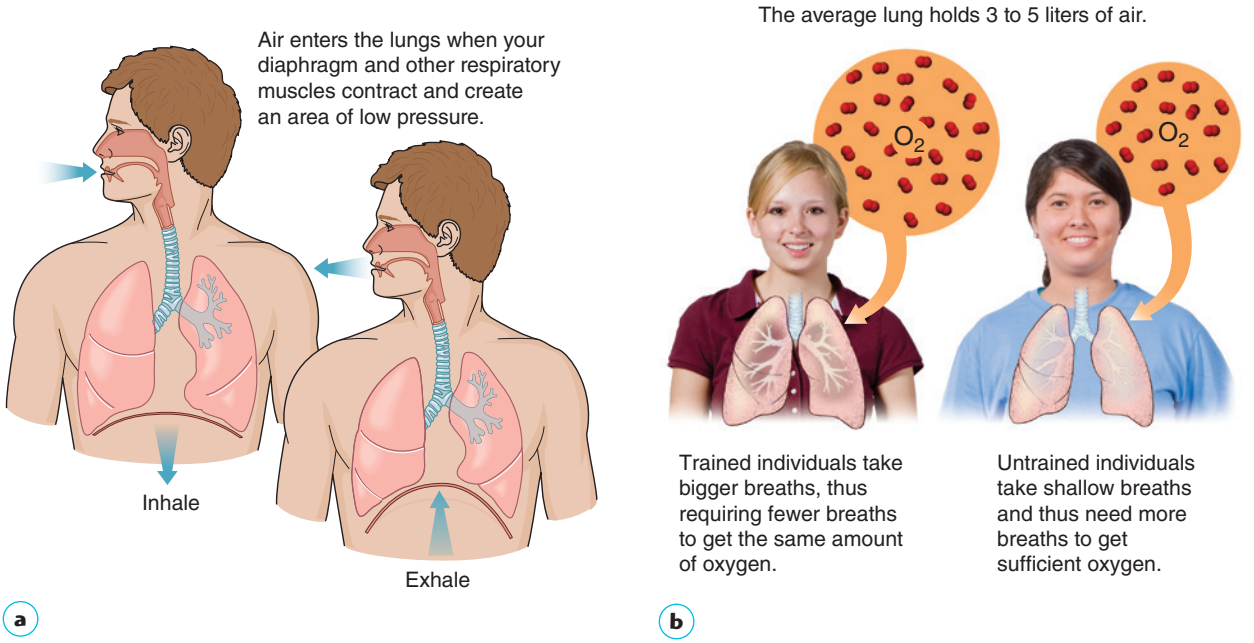

FIGURE 8.3 *(a)* The lungs and diaphragm during inhalation and exhalation; *(b)* fit people can breathe more efficiently than unfit people.

Arteries

Each **artery** carries blood from your heart to another part of your body. The beating of your heart forces blood through your arteries. Therefore, a strong heart and healthy lungs are not very helpful if your arteries are not clear and open. As you now know, fatty deposits on the inner walls of an artery lead to atherosclerosis. An extreme case of atherosclerosis can totally block the blood flow in an artery. The hardened deposits can also allow the formation of blood clots, severely blocking your blood flow. In either case, your heart muscle does not get enough oxygen, and a heart attack occurs.

Regular physical activity also provides other cardiovascular benefits. Scientists have found that people who exercise regularly develop more branching of the arteries in the heart. Figure 8.4 shows that the heart muscle has its own arteries (coronary arteries), which supply it with blood and oxygen. People who exercise regularly develop extra coronary arteries. The importance of this richer network of blood vessels can be shown in two examples.

- After astronaut Ed White died in a fire while training for a mission, an autopsy was performed. Doctors found that one of the major arteries in his heart was completely blocked due to atherosclerosis. However, because of all the physical training that astronauts perform, scientists think White's body had developed an extra branching of arteries in his heart muscle. Therefore, he didn't die of a heart attack when a main artery was blocked. Instead, he had been able to continue a high level of physical fitness training without signs of heart trouble.
- Like White, professional hockey player Richard Zednik had very good cardiorespiratory endurance. This fact became crucial to his survival during a hockey game when his carotid artery was cut by an opponent's skate. For most people, this would be a deadly injury. However, the doctor who performed the rescue surgery reported that because of Zednik's fitness level, he had very healthy and elastic arteries that were large and easy to repair. Zednik made a full recovery.

Veins

Each **vein** carries blood filled with waste products from the muscle cells and other body tissues back to the heart. One-way valves in your veins keep the blood from flowing backward. Your muscles squeeze the veins to pump the blood back to your heart. Regular exercise helps your muscles squeeze your veins efficiently. Lack of physical activity can cause the valves, especially those in your legs, to stop working efficiently, thereby reducing circulation in your legs.

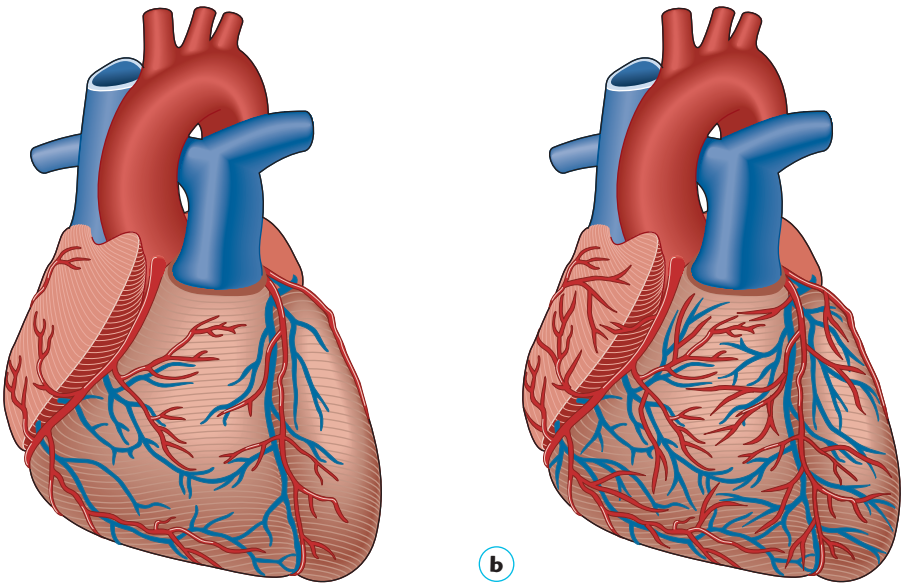

FIGURE 8.4 Blood vessels on the heart: *(a)* the heart of a typical person; *(b)* the heart of a person who exercises regularly.

> If you don't do what's best for your body, you're the one who comes up on the short end.
>
> —Julius Erving (Doctor J), Hall of Fame basketball player

Nerves of Your Heart

Your heart muscle is not like your arm and leg muscles. When your arm and leg muscles contract, nerves in them are responding to a message sent by the conscious part of your brain. In contrast, your heart is not controlled voluntarily; it beats regularly without your consciously telling it to do so. Instead, your heart rate is controlled by a part of it called a pacemaker, which sends out an electrical current telling it to beat regularly. People who do regular vigorous aerobic exercise often develop a slower heart rate because the heart pumps more blood with each beat—meaning it has greater stroke volume—and therefore can beat less often. Thus, if you exercise properly, your heart works more efficiently because each heartbeat supplies more blood and oxygen to your body than if you did not exercise. You can also function more effectively during an emergency or during vigorous physical activity.

Muscle Cells

In order to do physical activity for a long time without getting tired, your muscle cells must also function efficiently and effectively. Regular physical activity helps your cells be effective in their use of oxygen and in getting rid of waste materials. Physical activity also helps your muscle cells use blood sugar, with the aid of the hormone called insulin, to produce energy. This function is important for good health.

FITNESS TECHNOLOGY: Heart Rate Monitors

One way to count your heart rate is to use your wrist or neck pulse. But it's difficult to do so while you're exercising, so pulse is typically counted after exercise.

To count your pulse during activity, you can use a high-tech device called a heart rate monitor. One type requires you to wear a band around your chest. The band contains sensors that detect electrical stimulation from your heart's nervous system (similar to how an electrocardiogram works). A transmitter in the chest band sends a signal to a receiver located in a special watch worn on your wrist. The receiver picks up the signal and displays your heart rate on the watch. Another type of monitor counts your pulse and displays your heart rate on a watch located on your arm. It does not require the band around your chest.

You can set a heart rate watch to tell you whether you're exercising in your heart rate target zone. You can also set it to keep track of how many minutes you stay in your target zone. Heart rate monitors vary in cost, and some are better than others, so consult with your teacher or another reliable source before buying one. If your school has heart rate watches, you might want to use one to monitor your heart rate during vigorous activity.

A heart rate watch is helpful for counting your pulse during activity.

Using Technology

Use a variety of sources to evaluate several heart rate monitors. Consider cost, reliability, and ease of use, then decide which monitor would be the best buy.

Summary of Benefits

As noted in the previous sections, regular physical activity benefits many different body systems. A summary of these benefits is presented in figure 8.5.

Cardiorespiratory Assessment

You might be curious about your own cardiorespiratory endurance. How good is it? Several tests can help you find the answer.

You can assess the fitness of your cardiorespiratory systems in two settings: in the laboratory and in the field (such as in a gym and or on an athletic field). Two types of laboratory test are the **maximal oxygen uptake** test (also referred to as the $\dot{V}O_2$max test) and the **graded exercise test**.

The maximal oxygen uptake test is considered the best for assessing fitness of the cardiovascular and respiratory systems. It measures how much oxygen you can use when you're exercising very vigorously. To take the test, you run on a treadmill while connected to a special gas meter (figure 8.6). The difficulty increases as the treadmill goes faster

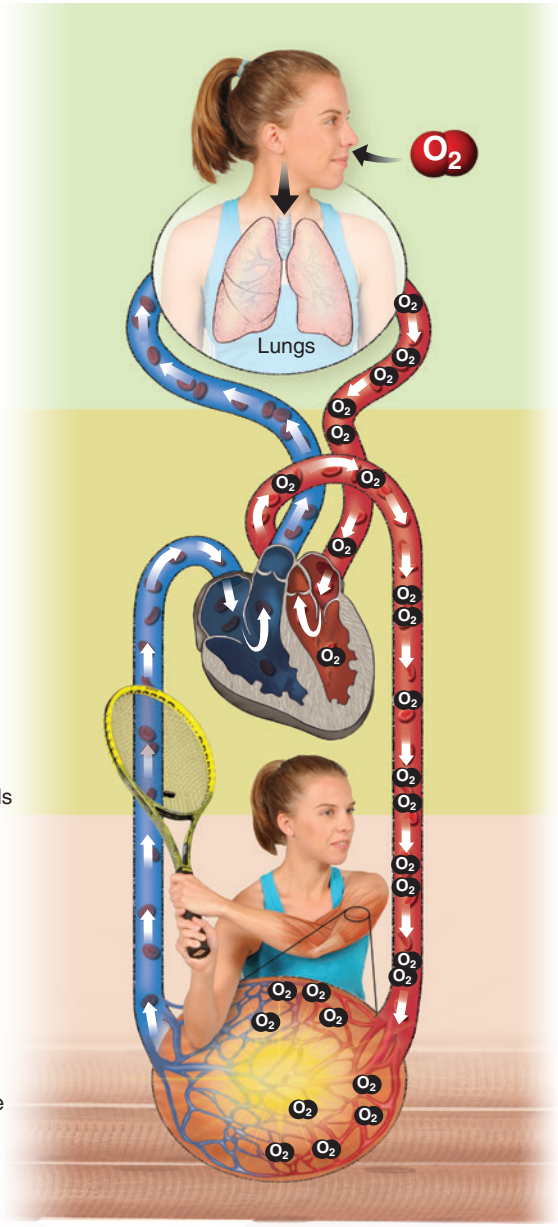

FIGURE 8.5 Benefits of physical activity for the cardiovascular and respiratory systems.

FIGURE 8.6 The maximal oxygen uptake test measures the amount of oxygen you use while running on a treadmill.

and you begin to run uphill. As you exercise, the gas meter measures the amount of oxygen you use each minute. The amount (volume) of oxygen you can use during the hardest minute of exercise is considered your $\dot{V}O_2$max score (see Science in Action).

Medical doctors and exercise physiologists sometimes use another laboratory test called a graded exercise test (or an exercise stress test). This test is used to detect potential heart problems. During the test, your heart is monitored by means of an electrocardiogram while you run on a treadmill.

Both the graded exercise test and the maximal oxygen uptake test are done in a laboratory and require special equipment and people who are trained to administer them. Most people, however, assess their cardiorespiratory endurance using practical nonlaboratory tests called field tests. These tests require little equipment and can be done at home or at school. Scores are determined based on your ability to function (your functional fitness) rather than on the amount of oxygen you can use. Examples include the PACER, the walking test, the step test, and the one-mile run test.

FIT FACT

Studies show that endurance athletes—such as cross-country skiers, cyclists, and distance runners—typically have very high aerobic capacity and score well on field tests of cardiorespiratory endurance.

Interpreting Self-Assessment Results

Self-assessments are not as accurate as laboratory tests of fitness; therefore, you should perform more than one self-assessment for cardiorespiratory endurance. However, self-assessments do give a good estimate of your fitness level, and each assessment has its own strengths and weaknesses. For example, the results of the PACER and the one-mile run (included in this chapter) are influenced by your motivation; if you don't try very hard, you won't get an accurate score. Because these tests require a high level of exertion, they may not be the best tests for people who have not been exercising regularly or who have low fitness.

The walking test, on the other hand, is a good indicator of fitness for most people but is not best for assessing very fit people. It would be a good test for a beginner. The step test (included in this chapter) uses heart rate; therefore, motivation does not influence its results as much as it does some other assessments. But step test results can be distorted if you've done other exercise that might elevate your heart rate before doing the assessment. Your heart rate can also be influenced by emotional factors (stress) and nutritional factors (caffeine) that cause it to be higher than normal. Finally, your results may vary depending on the time of day the assessment is done. For example, fatigue associated with daily activities may result in poorer scores late in the day.

Regardless of which tests you do, practice them before using them to assess your fitness. Practice allows you to pace yourself properly during the test and enables you to perform the tests properly so that you get accurate assessments. Because you may get different ratings on different tests of cardiorespiratory endurance, consider the strengths and weaknesses of each test when making decisions

SCIENCE IN ACTION: Aerobic Capacity

After extensive research, the Institute of Medicine recommended the use of the term *cardiorespiratory endurance* for performance on field tests such as the PACER. Because of this recommendation, we use the term *cardiorespiratory endurance* in this book rather than some of the other commonly used terms (such as *cardiovascular fitness* or *aerobic fitness*). Cardiorespiratory endurance reflects a person's functional fitness—the ability to perform tasks of daily life such as enjoying leisure-time activities and the ability to meet emergencies without undue fatigue.

As noted earlier, the term **aerobic capacity** is similar to, but not exactly the same as, cardiorespiratory endurance. The only true measure of aerobic capacity is your score on a laboratory based maximal oxygen uptake test. Your score on the maximal oxygen uptake test ($\dot{V}O_2$max test) is recorded in liters of oxygen per minute. You may want to adjust your aerobic capacity score (in liters) to account for body size because big people use more liters of oxygen simply because of their size. So aerobic capacity scores are commonly reported as milliliters of oxygen per kilogram of body weight per minute (mL/kg/min).

You can also get an idea of your aerobic capacity in other ways. For example, when used with the Fitnessgram report card, your cardiorespiratory endurance score is converted to an estimated aerobic capacity score. You can find more information and tables for estimating aerobic capacity from PACER scores at the student section of the Fitness for Life website.

Student Activity

Estimate your aerobic capacity score in milliliters of oxygen per kilogram of body weight per minute (mL/kg/min) using your PACER score. Tables for converting PACER scores to aerobic capacity scores are available in the student section of the Fitness for Life website.

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about which score best represents your fitness. After you've done regular exercise over time, test yourself again to see how much you've improved.

How Much Cardiorespiratory Endurance Is Enough?

To get the health and wellness benefits associated with cardiorespiratory endurance, you should achieve the good fitness zone in the rating charts that accompany each self-assessment in this book. Health benefits are associated with moving out of the low and marginal zones and into the good fitness zone. The risk of hypokinetic diseases is greatest for people in the low fitness zone.

Some people aim for especially high cardiorespiratory endurance because they want to perform at a high level in a sport or a physically demanding job, such as being a Marine or a police officer. To be properly fit for such challenges, you must train harder than most people. Achieving the high performance zone will be difficult for some people, and doing so is not necessary in order to get many of the health benefits of fitness. Nevertheless, the higher your cardiorespiratory endurance score, the lower your risk of hypokinetic disease.

Lesson Review

1. What are some health and wellness benefits of cardiorespiratory endurance?
2. How does physical activity affect the various parts of your cardiovascular and respiratory systems?
3. What are some methods for assessing cardiorespiratory endurance and aerobic capacity, and how are they done?
4. How much cardiorespiratory endurance is enough?