Increasing Cardiorespiratory Endurance

Objectives
After completing this chapter, you will be able to do the following:
- Identify and define the health-related components of physical fitness.
- Discuss the principles of conditioning.
- Calculate your target heart rate for exercise by two methods.
- Identify and discuss the health benefits of consistent participation in exercise.
- Describe the problems associated with exercise in hot and cold weather.

Online Learning Center
Log on to our Online Learning Center (OLC) for access to these additional resources:
- Chapter key term flashcards
- Learning objectives
- Additional goals for behavior change
- Concentration game
- Self-scoring chapter quizzes
- Additional lab activities

The OLC also offers Web links for study and exploration of wellness topics. Access these links through www.mhhe.com/anspaugh7e.

Goals for Behavior Change
- List three physical activities you normally do every week (exclusive of structured, planned exercise) and find and implement ways of making them more challenging.
- If you do not exercise regularly, list several factors that will motivate you to begin a cardiorespiratory endurance program. Begin a simple walking or other exercise program with these factors in mind.
- If you are physically active, list the main factors that will encourage you to improve the frequency, intensity, or duration of your activity. To help you stay motivated, post this list in a place where you will see it every day.
- Choose a piece of home exercise equipment that seems well suited to your exercise preferences and goals.

Key Terms
- aerobic
- aerobic capacity
- cardiorespiratory endurance
- cross-training
- exercise
- health-related fitness
- hyperthermia
- hyponatremia
- hypothermia
- performance-related fitness
- physical activity
- physical fitness
Technology has affected the lives of Americans by increasing productivity while reducing and in some cases eliminating the amount of physical work for the labor force. Therefore, physical fitness for most of the population can no longer be attained on the job, and leisure hours represent the only time for its development. Dozens of physical activities, exercise regimens, sports, games, and household and other physical chores that may contribute to health enhancement and fitness development are available. These activities are sufficiently different from each other, running the gamut from low- to high-skill requirement, so that almost anyone can find one or two enjoyable, fun, and challenging activities. This chapter focuses on the principles and concepts that have evolved for developing cardiorespiratory endurance for the purposes of health enhancement and physical fitness.

Components of Physical Fitness

According to the American College of Sports Medicine (ACSM), physical fitness is defined “as a set of attributes that people have or achieve that relates to the ability to perform physical activity.”

Physical activity is an umbrella term defined as “bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure.”

Exercise is a subset of physical activity. It is defined as “planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness.”

Physical activity includes exercise and all other types of human movements, such as mowing the lawn, raking leaves, vacuuming the floors, climbing stairs, washing the car by hand, chopping wood, and shoveling snow. These activities, many of which are daily chores, may improve physical fitness for some unfit sedentary people, but when engaged in regularly, are health-enhancing for most people. Health improvement can be attained with regular participation in lower-intensity physical activities, whereas higher-intensity physical activities that sustain an exercise target heart rate are necessary for improving physical fitness. In addition to the development of a higher level of physical fitness, the extra effort involved in more vigorous exercise includes a significant bonus. Greater exercise intensity lowers the risk for heart disease, more so than lower-intensity levels.

Most physical fitness experts have accepted the concept of performance-related and health-related fitness. Performance-related fitness, or sports fitness, consists of the following components: speed, power, balance, coordination, agility, and reaction time. These are essential for sports performance, but they may or may not contribute significantly to those activities performed for health enhancement (see Just the Facts: What’s the Difference?).

Speed is velocity, or the ability to move rapidly. Power is the product of force and velocity and the rate at which work is performed. Balance, or equilibrium, is the ability to maintain a desired body position, either statically or dynamically. Coordination is the harmonious integration of the body parts to produce smooth, fluid motion. Agility is the ability to change direction rapidly. Reaction time is the time required (usually measured in hundredths of a second) to respond to a stimulus.

The components of health-related fitness are cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition. In this text the exercise emphasis is on health-related fitness.

Performance-related and health-related fitness, although different, clearly are not mutually exclusive.
For example, competitive athletes require an abundance of the performance-related components of fitness, but the natures of their sports may also require the simultaneous development of the health-related components. Athletes who play racquetball, tennis, basketball, soccer, and handball are some that fall within this category. Conversely, the same sports are appropriate for health and fitness enthusiasts who prefer to achieve their goals through friendly competition.

However, the development and maintenance of health-related fitness do not necessarily depend on athletic ability or activities high in the performance components. Fitness for health purposes can be achieved with minimal psychomotor ability through activities such as walking, jogging, cycling, hiking, backpacking, orienteering, swimming, rope jumping, and weight training. These are self-paced activities; that is, the exerciser selects a relatively comfortable pace that can be sustained for a minimum of 10 minutes. No competing opponent pushes the exerciser beyond his or her physiological limits.

Remember the adage “No pain, no gain”? Trying to comply with it has done more harm than good to sedentary people attempting to become physically active. The health benefits of exercise begin to occur when exercise is somewhat uncomfortable but not painful. Only the most dedicated health enthusiasts and competitors can face exercise that constantly produces pain. Although exercise for health enhancement should stress cardiorespiratory development, the other components of fitness should not be neglected. Flexibility exercises can be a part of warm-up and cooldown procedures. Flexibility exercises may be performed three to five times per week, and the best results occur during the cooldown period following the cardiorespiratory workout. Stretching is most effective at this time because muscle temperature is elevated. Warm muscles respond well to stretching, and the likelihood of muscle injury while stretching is decreased. Resistance/strength training plays an important role and should be an integral part of a well-rounded fitness program.

As with all components of wellness, developing and sustaining an exercise program are the responsibilities of each individual. This text provides convincing evidence of the need for regular exercise and provides guidelines for initiating a sound program or reinforcement for those currently exercising.

**Cardiorespiratory Endurance**

Cardiorespiratory endurance is the ability to take in, deliver, and extract oxygen for physical work—that is, the ability to persevere at a physical task at a given intensity level. Cardiorespiratory endurance improves with regular participation in aerobic activities, such as speed walking, jogging, cycling, swimming, cross-country skiing, and many others. The term aerobic means “with oxygen,” but when applied to exercise, it refers to activities in which oxygen demand can be met continuously during performance. Aerobic performance depends on a continuous and sufficient supply of oxygen to burn the carbohydrates and fats needed to fuel such activities. In other words, someone performing aerobically has the capacity to sustain the intensity or the energy requirement for longer than a couple of minutes, a phenomenon known as steady state. Steady state can be achieved only during aerobic exercise, and it represents a level of exertion that feels relatively comfortable to the exerciser. It is also referred to as a pay as you go system, in that the oxygen cost of an activity is paid in full by the body during the activity. Steady state oxygen consumption can be maintained for an average of 10 to 60 minutes during submaximal continuous exercise. This may not apply for exercise during hot and humid weather. The stress of exercising during these conditions causes a steady upward drift in oxygen consumption.

Cardiorespiratory endurance is also referred to as aerobic capacity, or maximum oxygen consumption. Symbolized by “VO₂ max.” It is the most important component of physical fitness and is the foundation of total fitness.

The physiological changes that result from cardiorespiratory training are referred to as the long-term, or chronic, effects of exercise. The effects of training are measurable and predictable.

**Heart Rate**

A few months of aerobic training lowers the resting heart rate by 10 to 15 beats per minute (bpm). It also lowers the heart rate for a given workload. For example, a slow jog may produce a heart rate of 165 beats per minute before training and 140 beats per minute after a few months of training. The trained heart is a stronger, more efficient pump capable of delivering the required blood and oxygen with fewer beats.

**Stroke Volume**

Stroke volume is the amount of blood that the heart can eject in one beat. Aerobic training increases the stroke volume by (1) increasing the size of the cavity of the ventricles, which results in more blood filling the heart, and (2) increasing the contractile strength of the ventricular wall, so contraction is more forceful and a greater amount of blood is ejected from the ventricles. The increase in stroke volume, both at rest and during exercise, is one of the primary effects of endurance.
training and one of the major mechanisms responsible for improvement in aerobic fitness. See Just the Facts: Stroke Volume.

**Cardiac Output**

Cardiac output is the amount of blood ejected by the heart in one minute. Cardiac output ($Q$) is the product of heart rate ($HR$) and stroke volume ($SV$) ($Q = HR \times SV$). Cardiac output increases with aerobic training during maximal effort—it does not increase at rest or during submaximal exercise. Cardiac output does not change during rest or submaximal exercise because the lowered resting heart rate compensates for the increase in stroke volume. What does change is the manner in which cardiac output is achieved. This is illustrated by the following example: An untrained 25-year-old man has a resting heart rate of 72 bpm and a stroke volume of 70 mL of blood per beat. His cardiac output at rest is calculated as follows:

\[
Q = HR \times SV \\
= 72 \times 70 \\
= 5,060 \text{ mL (5.1 L)}
\]

The same person after two years of aerobic training has the same cardiac output at rest, but it is achieved differently: The resting heart rate is now decreased to 55 bpm and the stroke volume is increased to 92 mL of blood per beat.

\[
Q = 55 \times 92 \\
= 5,060 \text{ mL (5.1 L)}
\]

The average cardiac output at rest is 4 to 6 liters of blood per minute. During maximal exertion, cardiac output reaches values of 18 to 20 liters of blood per minute for the average person but may reach as much as 40 liters per minute for large, well-conditioned athletes—what an incredible piece of work by an organ that weighs less than a pound! To put this in perspective, imagine 40 1-liter cola bottles filled with blood. This is the amount that the hearts of some highly conditioned people can pump in one minute. Maximal cardiac output improves with training primarily because of the resulting increase in stroke volume. However, maximal heart rate declines with age by about 1 bpm per year after age 20. Training cannot stop the decline; it can only slow the process.

**Blood Volume**

Aerobic training increases total blood volume, plasma volume (the liquid portion of the blood), and blood solids (the red blood cells, white blood cells, and blood platelets). The increase is greatest in plasma volume, so the blood becomes more liquid. The increase in the ratio of plasma volume to red blood cell volume is an adaptation to exercise that lowers the viscosity, or thickness and stickiness, of the blood. This change decreases the resistance to blood flow, allowing it to circulate more easily through the blood vessels.

Blood is automatically shunted by the body to areas of greatest need. At rest, a significant amount is sent to the digestive system and kidneys. During vigorous exercise, as much as 85 percent of the blood is sent to the working muscles, reducing the amount sent to the digestive and urinary systems.

**Heart Volume**

The muscles of the body respond to exercise by growing larger and stronger. As a muscular pump, the heart’s volume and weight increase with endurance training. Training that lowers the resting heart rate stimulates greater filling of the ventricles, whose muscle fibers respond to the increased pool of blood by stretching. This produces a recoil effect in the muscle fibers, which results in a stronger contraction with more blood ejected per beat. Continued training causes the ventricles to enlarge and grow stronger, so the weight and the size of the heart increase. The hypertrophied (enlarged) heart is a normal response to endurance training that has no long-term detrimental effects. Although maintaining this effect for life is beneficial, several months of inactivity will reduce heart weight and size to pretraining levels. The atrophy (wasting away) associated with physical inactivity is inevitable.
Respiratory Responses

The chest muscles that support breathing improve in both strength and endurance with exercise. Vital capacity, the amount of air that can be expired maximally following a maximal inspiration, increases slightly. A corresponding decrease occurs in “dead space” air, or residual volume, the amount of air remaining in the lungs after a maximal expiration.

Training substantially increases maximal pulmonary ventilation (the amount of air moved in and out of the lungs). Before training, the lungs can ventilate approximately 110 liters of air per minute. Pulmonary ventilation increases to about 135 liters of air following a few months of training. Highly trained athletes commonly ventilate 180 to 200 liters of air per minute.

Blood flow to the lungs, particularly to the upper lobes, appears to increase after training. This results in a larger and more efficient surface for the exchange of oxygen and carbon dioxide.

Metabolic Responses

Aerobic endurance training improves aerobic capacity by 5 to 25 percent in previously untrained, healthy adults. The magnitude of improvement is primarily dependent on the initial level of physical fitness. The lower the fitness level, the greater the gain from aerobic training. A gain of 15 to 20 percent in aerobic capacity is typical for an average person who trains at 75 percent of maximal oxygen intake (VO₂ max), three days per week, for 30 minutes per workout over a six-month training period. Two to three years of highly intense training of greater frequency and longer duration has resulted in increases in VO₂ max in excess of 40 percent.

The improvement in aerobic capacity is the result of several physiological adaptations that increase the body’s production of energy. First, adenosine triphosphate (ATP), the actual unit of energy for muscular contraction, is produced in greater quantities. The mitochondria, specialized organelles responsible for manufacturing ATP, respond to training by increasing in size and number to increase their output. Second, oxidative enzymes within the mitochondria that accelerate the production of ATP increase in quantity. Third, cardiac output and blood perfusion of the muscles performing the work increase. Fourth, training facilitates and increases the extraction of oxygen by the exercising muscles. These are some of the major adaptations that combine to enhance aerobic endurance.

Effects of Heredity on VO₂ Max

Aerobic capacity (VO₂ max) is limited by heredity and is finite. Studies of identical and fraternal twins and studies that examined family groups (parents and children) have produced estimates of the role of genetics in the development of maximal cardiorespiratory endurance. Separating the influence of genetics from the influence of training is very complex. As a result, the estimates of the genetic predisposition for maximal cardiorespiratory endurance ranges from a low of 25 percent to a high of 93 percent.

At this point, the majority of the evidence indicates that the genetic component is probably closer to 40 to 50 percent. Whatever the actual percentage turns out to be, the consensus among exercise scientists is that the role of genetics represents a substantial potential for the development of maximal cardiorespiratory endurance. The sensitivity of the VO₂ max response to aerobic training is to a significant degree dependent on heredity. If those who inherit the genetic potential for endurance events also train diligently, they become capable of exceptionally high levels of performance. Diligent training with an average genetic potential results in average or slightly above-average performance. Only a select few inherit the ability to produce world-class endurance performances. The majority of people are in the average category, but all can achieve their aerobic potential with training. However, the expectation that regularity of training will produce a fitness payback that is proportional to the effort is logical, albeit inaccurate. The relationship between genetics and sensitivity to training is complicated by the fact that some people are “responders” (capable of making significant improvement from consistent training), while others are “nonresponders” (their improvement is minimal, even though they are exposed to the same training program).

Therefore, two people who are the same age, height, weight, and gender who train together and are equally compliant may obtain results that are very different, based on their response to training. The sensitivity to training is genetic, and evidence indicates that it is dependent on mitochondrial mass and mitochondrial DNA. Evidence also indicates that the mother’s genes are responsible for mitochondrial mass.

Genetic potential is extremely important for those who aspire to become serious competitors in endurance events. But it is essentially unimportant for those who are exercising for health and physical fitness purposes. The bottom line is that almost everyone can benefit physically, emotionally, and mentally from exercise regardless of their inheritance. So find an activity or activities that you enjoy and participate regularly.

Three methods for assessing your cardiorespiratory endurance are presented in the Assessment Activities. These include the Rockport Fitness Walking Test, the 1.5-Mile Run/Walk Test, and the 3-Minute Bench Step Test. Each is accompanied by norms, so you can compare your performance against the standards.
Effects of Training on VO\textsubscript{2} Max

Aerobic capacity reaches a peak after six months to two years of steady endurance training. At this point, it levels off and remains unchanged for a number of years, even if training is intensified. However, aerobic performance continues to improve with harder training, because a higher percentage of the aerobic capacity can be maintained for a longer period. For example, six months of appropriate training may allow you to jog 3 miles at 60 percent of your aerobic capacity. Another year of harder training may allow you to run 3 miles at 85 percent of your capacity. Capacity has changed little, if at all during this time, but physiological adaptations have occurred that enable the body to function at progressively higher percentages of maximum capacity.

Effects of Deconditioning on VO\textsubscript{2} Max

The effects of training persist as long as training continues. Training of moderate intensity may increase the VO\textsubscript{2} max by 10 to 20 percent. However, the VO\textsubscript{2} max returns to pretraining levels within a few months if training is discontinued.\textsuperscript{29} Most of the decline occurs during the first month and slows down during the next two months. Fitness developed through years of continuous training can be lost in months if training is interrupted or discontinued. Highly conditioned athletes respond to detraining in a similar manner. In a study, subjects who suspended training for 84 days after 10 years of active participation experienced a significant decline in aerobic capacity after three weeks of inactivity. They returned to pretraining levels in most fitness parameters by the end of the study. The exceptions to complete reversal were muscle capillary density and mitochondrial enzymes, which remained 50 percent higher than levels measured in sedentary control subjects. This study indicated that the results of inactivity are variable and affect some systems more quickly than others. Physical decline with physical inactivity cannot be prevented.

Effects of Age on VO\textsubscript{2} Max

Aerobic capacity decreases with age. During adulthood, peak aerobic energy steadily declines by an average of about 1 percent per year between the ages of 25 and 75.\textsuperscript{30} A significant portion of the decline is related to the lack of physical activity that accompanies aging: Those who are physically active throughout their lifetimes experience declines in aerobic capacity but not at the same rate as those who are inactive. See Wellness for a Lifetime: Exercise Is for Everyone for more details about the impact of exercising on aging.

Cardiorespiratory Endurance and Wellness

Most Americans believe that exercise is good for them, but the majority cannot explain how or why. This section provides some of the answers.

Wellness for a Lifetime

Exercise Is for Everyone

The ability of the body to take in, transport, and extract oxygen for physical work and exercise declines with age. On the average, aerobic capacity declines by about 8 to 10 percent every decade after the age of 25 in both males and females. One of the major sources of this decline in the United States is the decreasing level of physical activity that tends to accompany aging. This trend toward inactivity also results in a loss of muscle weight, an increase in fat weight, and a decrease in metabolic rate, all of which contribute to the decline in aerobic capacity. Although physiological aging does lower aerobic capacity, at least 50 percent of the decline is due to “disuse atrophy” caused by inactivity\textsuperscript{31} but recent studies have indicated that aging may have less effect than the deconditioning that accompanies inactivity as people age.\textsuperscript{32}

Biological aging cannot be stopped. We cannot live forever. However, exercise comes as close to an antiaging pill as anything else available. Even older people who have been sedentary for decades can benefit from aerobic exercise and weight training.\textsuperscript{33}

The beneficial outcomes of regular exercise for older people include an increase in energy, a favorable change in body composition (loss of fat, gain of muscle), an increase in muscular strength and endurance, an increase in metabolism, and significant improvements in cardiovascular and musculoskeletal health.\textsuperscript{34} All of these changes translate into a higher quality of life and longevity.

Physically fit 60- and 70-year-olds have the aerobic capacity of unfit 25-year-olds.\textsuperscript{35} This means that physically fit elderly people have the energy to live independently during their later years. The ability to perform the daily chores of living and to participate in an active lifestyle with energy to spare develops confidence that contributes to the enjoyment of life.
Consistent participation in exercise is necessary to improve health status. Sporadic exercise does not promote physical fitness or contribute to health enhancement. Infrequent participation increases the risk for sudden death during the time of exercise. Physical inactivity is a major risk factor for coronary heart disease. The risk is approximately equal to that imposed by cigarette smoking, high blood pressure, and elevated serum cholesterol. Forty-two percent of American adults are marginally active—that is, they do not exercise a minimum of 30 minutes per day for at least five days per week. Another 28 percent report that they are completely inactive. Therefore, 70 percent of the adult population is either inactive or not active enough for physical activity to improve their health. About 25 percent of 12- to 21-year-olds participate in light to moderate physical activity, such as walking and cycling nearly every day. About 50 percent state that they regularly engage in vigorous physical activity. Approximately 25 percent report no vigorous physical activity and 14 percent report no physical activity at all. The number of physically inactive people exceeds these numbers, promoting regular exercise for the general public should be an important priority of public health policy.

Coronary heart disease is rarely responsible for sudden cardiac death during or after exercise among people under the age of 30. Congenital heart defects or other cardiac abnormalities, such as faulty valves, enlarged hearts, heart muscle disease, and fatal cardiac arrhythmias are the usual culprits for this age group. Most exertional deaths occur among older Americans and are due to coronary heart disease and cardiomyopathy (wasting of cardiac muscle due to disease). New evidence indicates that a substantial proportion of sudden exertional deaths among asymptomatic people are due to coronary plaque rupturing. The increased rate of blood flow during physical exertion results in greater bending and flexing of the coronary arteries. This exaggerated arterial motion leads to the cracking of atherosclerotic plaque, the formation of a blood clot, and subsequent heart attack. A study by Harvard medical researchers found that heavy physical exertion, such as shoveling snow, gardening, walking fast, jogging, playing softball, and playing tennis, can trigger a heart attack. For the physically unfit, the risk of incurring a heart attack during and in the first hour after strenuous exertion increased by 107 times. The risk for physically fit people increased only 2.7 times.

Adult males have been the subject of most investigations of cardiac death due to physical exertion because males are more susceptible to this phenomenon than females. Even so, exertional deaths among males occur infrequently, yielding one death per 1.51 million hours of vigorous exertion. The Nurses Health Study with nearly 85,000 subjects found that the rate of exertional deaths among adult females is one per 36.5 million hours of moderate to vigorous physical activity. A common finding between males and females was that regular exercisers were less likely to experience sudden exertional death than nonexercisers and were less likely to die prematurely of any cause.

The benefits received from physical training far outweigh the minimal risk associated with one bout of strenuous exercise. A similar study conducted at the same time in Germany found amazingly similar results. One and one-half million heart attacks occur every year in the United States. The Harvard researchers concluded that 75,000 of these are exertional and they usually occur after strenuous exercise. Most of these heart attacks occur among those who are physically inactive and at high risk. See Just the Facts: Exercise-Related Considerations for some tips on reducing the hazards associated with regular exercise. Some selected health benefits of regular exercise are listed in Table 3-1. If these benefits could be distilled and sold in pill form, the American public would line up to pay any reasonable price to attain them, yet all of these benefits are readily available to anyone willing to commit the time and effort. While millions of people are exercising, 70 percent of the adult population is either inactive or marginally active.

**Principles of Conditioning**

Becoming familiar with the principles of exercise is necessary to maximize the results of a physical fitness program. Your objectives can be met through the appropriate manipulation of intensity, frequency, duration, overload, progression, and specificity. Setting of objectives, warm-up, cooldown, and careful selection of activity are important elements that add to the enjoyment and effectiveness of exercise.

**Intensity**

*Intensity* refers to the degree of vigorousness of a single session of exercise. In 1995, the American College of Sports Medicine (ACSM) and the Centers for Disease Control and Prevention (CDC) developed and promoted the following recommendation for exercise: Every U.S. adult should accumulate 30 minutes or more of moderately intense physical activity on most and preferably all days of the week. The recommendation refers to *physical activity* rather than *exercise*. This is an umbrella term that includes many types of physical exertion, including structured exercise. *Moderate*
**JUST THE FACTS**

**Exercise-Related Considerations**

Many health, fitness, and cosmetic benefits occur to those who exercise on a regular basis. Although they are outweighed by the benefits, risks are associated with such behavior. Despite precautions, injuries occasionally occur. Beginning exercisers are particularly susceptible to injury because of their lack of knowledge about training coupled with their misguided attempts to achieve their goals too quickly. The following suggestions should result in safer workouts:

1. Dress according to the weather: shorts, T-shirt, mesh baseball-type cap in warm weather; layers of light clothing, hat, gloves, ear protection, and windbreaker in cold weather.

2. Wear appropriate shoes for the activity in which you participate: jogging shoes, walking shoes, aerobic shoes, or cross-trainers. In general, exercise shoes should be ½ to ¾ of an inch longer than your longest toe. There should also be room enough for the toes to spread out. The soles of most exercise shoes consist of three layers. The outer sole that contacts the floor or ground should be made of hard rubber. The next layer is the midsole, which protects the midfoot and toes. The last layer is made of a thick, spongy substance that absorbs most of the shock when the foot strikes the surface.

3. Warm up and cool down properly before and after exercise.

4. Exercise within your capacity—it should feel a little uncomfortable but not painful. According to the American College of Sports Medicine (ACSM), the initial stage of an exercise program should last a minimum of four weeks at a low intensity (50 to 60 percent of the maximal heart rate, or HR_max). Each exercise session should last for 15 to 20 minutes during the first week and increase to 25 to 30 minutes during the fourth week. At this point, the exerciser is ready to increase the intensity, frequency, and duration of each session.

5. While following these simple guidelines reduces the possibility of incurring pain or injury, beginning exercisers may experience, as a result of overuse, shin splints, side stitch, blisters, chafing, muscle cramps, muscle soreness, Achilles tendon injuries, and lower-back pain.

   a. Muscle soreness following exercise usually occurs among beginners who have yet to adapt to physical exertion or to those at any level of fitness who exceed their physical capabilities. Following the ACSM guidelines reduces exposure to muscle pain.

   b. Side stitches occur primarily among walkers and joggers. They consist of severe pain in the upper right quadrant of the abdomen. Side stitches may be caused by reduced blood flow to the diaphragm (a large, dome-shaped muscle that separates the abdominal cavity from the chest cavity), or they may be due to the collection of gas in the intestines. In either case, deep breathing and direct pressure applied with both hands at the site of the pain may provide relief. Sometimes, stopping the activity for a few minutes is required for the pain to subside.

   c. A common injury occurring among beginners is shin splints. Shin splints produce a burning pain that radiates along the inner surface of the large bones of the lower leg. These are nagging, painful injuries better prevented than treated. The causes of shin splints include training demands that exceed a person’s capacity to perform. High-impact activities, such as jogging or aerobics to music; poor-quality exercise shoes; hard exercise surfaces; and walking or jogging on hilly surfaces are other contributing causes. Treatment includes applying ice, resting, wrapping or taping the affected shin, and placing heel lifts in the shoes.

intensity refers to walking at a 3- to 4-mile-per-hour pace (15 to 20 minutes per mile) or engaging in any activity that burns a similar number of calories at a similar rate. The 30 minutes of activity can be split up into two or three bouts of 10 to 15 minutes each throughout the day. Table 3-2 provides a summary of the ACSM-CDC exercise principles and their application to the enhancement of health and physical fitness.

The recommendation for health enhancement is a minimum guideline designed to motivate and recruit the 70 percent of the population not physically active. It is not intended to lower the standard for those who currently exercise at a higher level or whose primary goal is the development of physical fitness. Programs designed primarily to improve health may not improve or may minimally improve physical fitness. It takes higher-intensity exercise to significantly improve physical fitness. In fact, intensity is the most important principle for the development and maintenance of physical fitness. The higher the intensity, the greater the return.
### TABLE 3-1  
**Health-Related Benefits Associated with Regular Aerobic Exercise**

<table>
<thead>
<tr>
<th>Reduces the Risk of Cardiovascular Disease</th>
<th>Helps Control Diabetes</th>
<th>Develops Stronger Bones Less Susceptible to Injury</th>
<th>Promotes Joint Stability</th>
<th>Contributes to Fewer Lower-Back Problems</th>
<th>Acts as a Stimulus for Other Lifestyle Changes</th>
<th>Improves Self-Concept</th>
<th>May Delay the Onset of Alzheimer’s Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increases HDL cholesterol</td>
<td>• Makes cells less resistant to insulin</td>
<td>• Reduces body fat</td>
<td>• Increases muscular strength</td>
<td>• Increases strength of the ligaments, tendons, cartilage, and connective tissue</td>
<td>• Acts as a Stimulus for Other Lifestyle Changes</td>
<td>• Improves Self-Concept</td>
<td>• May Delay the Onset of Alzheimer’s Disease</td>
</tr>
<tr>
<td>• Decreases LDL cholesterol</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Favorably changes the ratios between total cholesterol and HDL-C and between LDL-C and HDL-C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Decreases triglyceride levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Promotes relaxation; relieves stress and tension</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Decreases body fat and favorably changes body composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduces blood pressure, especially if it is high</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Makes blood platelets less sticky</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Decreases the incidence of cardiac dysrythmias</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increases myocardial efficiency</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Lowers resting heart rate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Increases stroke volume</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increases oxygen-carrying capacity of the blood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reduces the risk for colon cancer and breast cancer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


### TABLE 3-2  
**Summary of Exercise Principles for the Development of Physical Fitness and Health**

<table>
<thead>
<tr>
<th>Exercise Principles</th>
<th>To Develop and Improve Level of Physical Fitness (1998 Guidelines)</th>
<th>To Develop and Improve Health Status (1995 Guidelines)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intensity</strong></td>
<td>• 55/65 to 90% of HR$_{max}$</td>
<td>• Moderate (walking 3 to 4 MPH)</td>
</tr>
<tr>
<td></td>
<td>• 55 to 64% of HR$_{max}$ for sedentary beginners</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 40/50 to 85% of the cardiac reserve or</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 40/50 to 85% of the VO$_2$ reserve*</td>
<td></td>
</tr>
<tr>
<td><strong>Frequency</strong></td>
<td>• 3–5 days per week</td>
<td>• Most, preferably all, days of the week</td>
</tr>
<tr>
<td><strong>Duration (time)</strong></td>
<td>• 20–60 minutes at 60 to 90% of HR$_{max}$</td>
<td>• 30 minutes or more</td>
</tr>
<tr>
<td></td>
<td>• 200–300 calories per exercise session</td>
<td></td>
</tr>
<tr>
<td><strong>Overload</strong></td>
<td>• Should not exceed 10% of the previous workout</td>
<td>• NA**</td>
</tr>
<tr>
<td><strong>Progression</strong></td>
<td>• Based on physiological readiness</td>
<td>• NA</td>
</tr>
<tr>
<td></td>
<td>• According to the schedule of overload</td>
<td></td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>• For competitors training for maximal performance</td>
<td>• NA</td>
</tr>
</tbody>
</table>

*The VO$_2$ reserve is VO$_2$ max minus VO$_2$ rest.

**Not applicable.**
Those who exercise for physical fitness purposes also derive health benefits in a two-for-one deal. It takes a higher level of training to achieve both.

In September 2001, the Institute of Medicine (IOM), a private, nonprofit organization established by the U.S. Congress 150 years ago to advise the federal government on matters requiring technical and scientific expertise, issued an exercise recommendation of 60 minutes of brisk physical activity per day. This recommendation was based on evidence indicating that successful maintenance of body weight occurs at this level of physical activity. Brisk exercise was defined as walking 4 miles per hour (a 15-minute-per-mile pace). The IOM also suggested that the cumulative effect of exercise is important for weight loss, so the 60 minutes does not have to be performed continuously—that is, it can be broken into segments scattered throughout the day. The caveat is that all segments need to be performed at a brisk intensity level. The issuance of this recommendation produced some confusion on the part of the general public. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day. Then in 2005, the Department of Agriculture issued “Dietary Guidelines for Americans.” The department produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The ACSM recommended the cumulative effect of exercise produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The IOM also suggested that the cumulative effect of exercise is important for weight loss, so the 60 minutes does not have to be performed continuously—that is, it can be broken into segments scattered throughout the day. The caveat is that all segments need to be performed at a brisk intensity level. The issuance of this recommendation produced some confusion on the part of the general public. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day. Then in 2005, the Department of Agriculture issued “Dietary Guidelines for Americans.” The department produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day. Then in 2005, the Department of Agriculture issued “Dietary Guidelines for Americans.” The department produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day. Then in 2005, the Department of Agriculture issued “Dietary Guidelines for Americans.” The department produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day. Then in 2005, the Department of Agriculture issued “Dietary Guidelines for Americans.” The department produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day. Then in 2005, the Department of Agriculture issued “Dietary Guidelines for Americans.” The department produces these guidelines every five years. One of the recommendations is that 60 minutes of moderate to vigorous intensity activity on most days of the week is needed to prevent gradual weight gain in adulthood. The ACSM recommended 30 minutes per day; the IOM recommended 60 minutes per day.
to count your pulse rate for 15 seconds while in the sitting position immediately after waking in the morning. You should repeat this for four or five consecutive days and average the readings for a relatively accurate representation of your resting heart rate. Next, you should estimate your level of fitness based on your exercise habits and select a category from Table 3-3 to determine the appropriate exercise intensity level. If you cannot decide which category is the most appropriate, take one of the fitness tests at the end of this chapter. Your performance on these should place you in a category that reflects your physical fitness level.

The Karvonen formula is

\[
THR = (MHR - RHR) \times TI\% + RHR
\]

where \( THR \) is the training heart rate, or the heart rate that should be maintained during exercise; \( MHR \) is the maximum heart rate; \( RHR \) is the resting heart rate; and \( TI\% \) is the training intensity (see Table 3-3). Therefore, the exercise heart rate for a 25-year-old with a resting heart rate of 75 beats per minute and an average fitness level is calculated as follows:

\[
\frac{220}{25} - 195 (HR_{max})
\]

\[
THR = (195 - 75) \times 0.70 + 75
\]

\[
= 120 \times 0.70 + 75
\]

\[
= 84 + 75
\]

\[
= 159
\]

The training heart rate for this 25-year-old subject is 159 beats per minute. Assessment Activity 3-4 will enable you to determine your target heart rate for exercise.

Learning to take the pulse rate quickly and accurately is necessary to monitor exercise intensity by heart rate. Two of the most commonly used sites for taking the pulse rate are the radial artery on the thumb side of the wrist and the carotid artery at the side of the neck (Figure 3-1a and 3-1b). Use the first two fingers of your preferred hand to palpate (examine by touch or feel) the pulse. At the wrist, the pulse is located at the base of the thumb when the hand is held palm up. To find the carotid pulse, slide your fingers downward at the angle of the jaw below the earlobe to the side of the neck. You apply only enough pressure to feel the pulse, particularly at the carotid artery. Excessive pressure at this point stimulates specialized receptors that automatically slow the heart rate, leading to an underestimation of the rate achieved during exercise. The wrist is the preferred site for palpation of the pulse rate. Palpate the carotid pulse if you cannot feel your pulse at the wrist.

Locate and count the pulse rate immediately after exercise stops. Count the beats for 10 seconds and multiply by 6 to get beats per minute. Regardless of which site you use, be consistent in its application. Some practice is required to locate the pulse quickly and count it accurately.

Another method for monitoring the intensity of exercise is to rate your subjective perception of the effort. On some days, exercise seems easier than normal, and on other days it may seem more difficult; therefore, it is important to adjust the intensity according to the perception of the effort. According to the ACSM, “the appropriate exercise intensity is one that is safe, is compatible with a long-term active lifestyle for that individual, and achieves the desired caloric output given the time constraints for the exercise session.”

The “Talk Test” is a simple subjective estimate that clearly demonstrates whether the individual is exercising too intensely. The intensity is excessive when the exerciser is unable to carry on a conversation without gasping for breath between each word or two. The remedy for such an occurrence is simple—slow down the pace.

**TABLE 3-3** Guidelines for Selecting Exercise Intensity Level

<table>
<thead>
<tr>
<th>Fitness Level</th>
<th>Intensity Level (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>60</td>
</tr>
<tr>
<td>Fair</td>
<td>65</td>
</tr>
<tr>
<td>Average</td>
<td>70</td>
</tr>
<tr>
<td>Good</td>
<td>75</td>
</tr>
<tr>
<td>Excellent</td>
<td>80–90</td>
</tr>
</tbody>
</table>

**FIGURE 3-1** Sites for Taking a Pulse

The two sites for measuring pulse are (a) at the neck (carotid artery) and (b) at the wrist (radial artery).
Frequency

The frequency of exercise is the number of days of participation each week. The latest ACSM guidelines for improving physical fitness recommend that exercise be pursued three to five days per week for optimal results. Optimal results are the greatest gain for the time invested. Fewer than three days is an inadequate stimulus for developing fitness, and conversely, more than five days per week represents a point of diminishing returns from exercise and increases the likelihood of injury. Those who are exercising for health reasons and following the 1995 guidelines are advised to engage in physical activities on most, preferably all, days of the week.

You can overdo exercise—too much results in staleness or overtraining. The signs of overtraining include:

- Chronic fatigue and listlessness
- Inability to make further fitness gains or regression of the level of fitness
- Sudden loss of weight
- An increase of five beats per minute in the resting heart rate
- Loss of enthusiasm for working out
- Increase in the risk for injury
- Irritability, anger, and depression

Treatment requires that you cut back on training or stop completely for one to two weeks. When you resume exercise, it must be of lower intensity, frequency, and duration. You must rebuild and regain fitness gradually. Prevention is the best treatment for overtraining because people for whom exercise is a way of life are reluctant to discontinue training, even temporarily, for fear that they will lose their fitness edge. Convincing them that continuing to exercise is the worst possible action is extremely difficult.

Time (Duration)

Duration refers to the length of each exercise session. Intensity and duration are inversely related—the more intense the exercise, the shorter its duration. Some fitness experts employ the acronym “FIT Principle” as a means for people to remember the first three principles of exercise: F = frequency; I = intensity; and T = time/duration. Intensity is the most important consideration for the development of physical fitness. But reducing the intensity somewhat while increasing the frequency and duration is the safest and most beneficial method for novice exercisers to attain physical fitness and health enhancement. In 1990, the ACSM recommended 20 to 60 minutes of continuous or noncontinuous aerobic activity. The 1995 guidelines suggest the accumulation of 30 minutes or more of physical activity per day.61

Another way to monitor duration is to calculate the number of calories expended per exercise session. The ACSM recommends that, if you expend 300 calories per exercise session, you should exercise three times per week; if you expend only 200 calories per exercise session, you should exercise four times per week. These guidelines are sufficient for health benefits to accrue, but for fitness purposes, they should be viewed as a minimal level of exercise. There is a dose-response relationship between the amount of energy expended by exercising and all-cause mortality. The greater the dose, the greater the response and concomitantly the less the risk. One thousand calories expended per week will reduce all-cause mortality by 30 percent, and higher caloric expenditures further decrease the risk.62,63 (Table 8-3 in Chapter 8 discusses the way to determine how long you need to engage in the activities of your choice to achieve these goals.)

Progression, Overload, and Specificity

As people attain a level of fitness that meets their needs and when further improvement is not desired, the program switches from developing fitness to maintaining it. At this point, the principles of overload and progression may be set aside, but both are necessary for the improvement phase of fitness. Overload involves subjecting the body to unaccustomed stress. Challenging the body to periodically accept a slightly increased level of work forces it to adapt by attaining a higher level of fitness. Deciding when to impose each new challenge involves the principle of progression. The workload is increased only when the exerciser is ready to accept a new challenge. For aerobic exercise, target heart rate or perceived exertion may be used to establish criteria for scheduling the progression. For example, if you jog, swim, or cycle a certain distance, the exercise heart rate will decrease over time as your body adapts to training. When the exercise heart rate drops to a predetermined level or the effort required becomes comfortable, you should adjust the pace or distance to return to the original target zone. However, the new physical challenge should not exceed the current amount of exercise by more than 10 percent. This should ensure that the new workload is not excessive.

The principle of specificity of training suggests that the body adapts according to the specific type of stress placed on it. The muscles involved in any activity are the ones that adapt, and they do so in the specific way in which they are used. For example, jogging prepares one for jogging but is poor preparation for cycling. Cycling does not prepare one for swimming. Although these activities stress the cardiorespiratory system, they are sufficiently different in that there is little fitness carryover among them.
The principle of specificity is particularly important for competitive athletes. Competitors attempt to maximize the returns from their training effort; therefore, runners must train by running, swimmers must swim, and cyclists must cycle. The focus is on maximal improvement in one activity, so that the body is trained in a specific manner. This locks athletes into regimented training programs, but noncompetitors who exercise for health and physical fitness reasons are not under such constraints. They can vary activities and prevent the boredom of participating in the same activity day after day, week after week. Cycling, jogging, swimming, racquetball, cross-country skiing, weight training, and other activities may be used in any combination or order for the development of physical fitness. This is the essence of cross-training. Not only does cross-training relieve boredom, but it may reduce the incidence of injury because it does not stress the same muscles in the same way during every workout.  

Cross-training has many advantages and is an excellent technique for attaining the health benefits of exercise. Variety, the major attraction of cross-training, can also be a disadvantage, however. By participating in many different activities, you seldom become proficient in any one. However, if the objective is physical fitness or health enhancement, proficiency is incidental.

Identifying goals provides some direction for the activities selected and the way the principles of exercise are to be manipulated to increase the probability of success. Only one or two major goals should be selected, and these should be as specific as possible, so that an effective exercise program can be devised. Activities, objectives, and exercise principles must match.

When you have identified the objectives and know what you wish to achieve from an exercise program, identify the means for sustaining the program. The resolve to exercise is shakiest during the early stages of the program, usually because people push untrained bodies beyond their limits. This results in sore muscles, stiffness, and possible injury. Consequently, the dropout rate is highest in the beginning of any exercise program. The irony is that the greatest return for the effort is attained during this phase. Some tips for sustaining that effort are presented in Just the Facts: Motivational Tips.

**Other Exercise Considerations**

**Warming Up for Exercise**

Warming up prepares the body for physical action. The process involves physical activities that gradually heat the muscles and elevate the heart rate. It is a transitional stage that bridges the gap between rest and physical activity. For aerobic activities, the procedure involves physical movements that gradually raise muscle temperature, increase heart rate, and increase circulation. The intensity of the warm-up should be gradually increased over 5 to 10 minutes, ultimately reaching 50 percent of the planned exercise intensity. Breaking out in a sweat is usually an indicator that the appropriate intensity has been achieved. The suggested warm-up for simple repetitive activities, such as jogging, cycling, and brisk walking, is to perform the specific activity at a lower intensity. For example, joggers should jog at a slower than exercise pace during

**JUST THE FACTS**

**Motivational Tips**

Follow these tips to stay motivated to exercise:

- Exercise with a friend. Make sure both of you have compatible goals and are similar in fitness level. Friends can help each other sustain a program, particularly during busy times when the temptation is high to push exercise out of an already crowded schedule.
- Exercise with a group. Exchange ideas and literature about exercise with group members.
- Elicit the support of friends and family. Their support is a powerful source of reinforcement.
- Associate with other exercisers. They represent an enthusiastic, positive, and informative group—and their values are contagious.
- Join an exercise class or a fitness club. This gives you a place to go and meet people who want to exercise.
- Keep a progress chart. This will give you an objective account of your improvement.
- Exercise to music. Music makes the effort appear easier.
- Set a definite time and place to exercise. This is particularly important during the early days of the program. Schedule exercise as you would any other activity of importance and then commit to the schedule.
- Participate in a variety of activities. Cross-training is excellent for the person who exercises for health or recreation.
- Do not become obsessive about exercise. Skipping exercise is not a good practice normally, but skipping is appropriate at times. Do not exercise when you are sick or overtired. Do not feel guilty about missing exercise for a day or two. Resume exercise as soon as you can.
the warm-up, gradually increasing the pace as the warm-up progresses. This procedure gradually warms up the muscles that are to be used during exercise in the specific way in which they are to be used. Additionally, it reduces the oxygen deficit that normally occurs at the beginning of exercise. The oxygen deficit is the result of the body’s inability to meet the oxygen demand of the exercise. It takes two to three minutes for the aerobic system to catch up and thus supply the oxygen needed to support the exercise. At this point, the exercise will feel more comfortable and can be maintained for a period of time. The oxygen deficit can be attenuated and possibly eliminated with a well-structured warm-up.

Increasing the heart rate gradually during the warm-up is most important. This allows the circulatory system to adjust to the load. If the heart rate elevates suddenly, circulation cannot adjust rapidly enough to meet the oxygen and nutrient demands of the heart muscle. The effects of this lag time are abolished in about two minutes, but increasing the heart rate quickly can be hazardous even during those two minutes, particularly for those with compromised circulation. Even a healthy heart may be affected when the gradual phase of warm-up has been eliminated. Abnormal electrocardiographic (ECG) responses were reported in several studies when the exercise sessions were not preceded by an active warm-up. Sudden strenuous physical exertion produced temporary left ventricular dysfunction and possible ventricular arrhythmias that were evident on the ECG. However, another study failed to confirm the cardiovascular abnormalities cited in the previous studies. The reason for the disparity in the results may very well be the difference in the assessment techniques used. In light of the equivocal nature of these data, a proper warm-up should precede exercise. The logic of this position has not been refuted.

Passive warm-up techniques, such as massage, sauna baths, steam baths, hot showers, hot towels, and heating pads, should not be used as substitutes for an active warm-up. These techniques may precede an active warm-up if a person feels stiff and sore from the previous workout.

Stretching exercises may be performed after the warm-up is completed. At this point, muscle temperature is elevated, so that stretching is more effective and muscle, tendon, and joint injuries are less likely to occur. Stretching performed prior to exercise may not reduce the risk of musculoskeletal injury during exercise. The evidence in support or against this supposition is equivocal at best. Stretching is most effective during the cooldown following the workout because (1) muscles are heated and receptive to stretching and (2) muscles that have contracted repeatedly during exercise need to be stretched. Figures 5-1 through 5-8 in Chapter 5 illustrate some typical stretching exercises that may be used before and after the workout period.

**Cooling Down from Exercise**

The cooldown is as important as the warm-up. Cooldown should last 8 to 10 minutes and consist of two phases. The first phase involves approximately 5 minutes of walking or other light activities to prevent blood from pooling in the muscles that have been working. Light activity causes rhythmic contractions of the muscles, which in turn act as a stimulus to circulate blood from the muscles to the heart for redistribution throughout the body. This boost to circulation following exercise, often referred to as the muscle pump, is essential for recovery and shares some of the burden of circulation with the heart. The muscle pump effect does not occur if a period of inactivity follows exercise. An inactive cooldown forces the heart to work at a high rate to compensate for the reduced volume of blood returning to it because of blood pooling in the muscles. Exercisers run the risk of a hypotensive response (a sharp drop in blood pressure), which may result in dizziness and fainting. Also, elevated blood levels of catecholamines (epinephrine and norepinephrine) during the first couple of minutes of recovery may produce fatal heart arrhythmias.

Light physical activity after exercise also speeds the removal of lactic acid that has accumulated in the muscles. Lactic acid is a fatiguing metabolite resulting from the incomplete breakdown of sugar. It is produced by exercise of high intensity or of long duration.

The second phase of cooldown should focus on the stretching exercises performed during the warm-up. Most participants find that stretching after exercise is more comfortable and more effective because the muscles are heated and more elastic.

**Type of Activity**

Many activities contribute to one or more components of health-related physical fitness. Activity selections should be based on objectives, skill level, availability of equipment, facilities, instruction, climate, and interest. Any rhythmic, continuous aerobic activity that uses large muscle groups and can be performed for an extended period is suitable for the attainment of health and fitness.

The President’s Council on Physical Fitness and Sports (PCPFS) enlisted the aid of seven experts to evaluate 14 popular physical activities for their contribution to physical fitness and general well-being. Although this assessment occurred several years ago, the ratings are as valid today as when they were originally conceived. A summary of these appears in Table 3-4.
Selected sports have also been evaluated for their contribution to the health-related components of physical fitness. These appear in Table 3-5. Lifetime sports (such as tennis, badminton, and racquetball) are more easily accessible than are team sports (such as volleyball, soccer, softball, and basketball) because fewer players are needed. Ideally, fitness should be developed and maintained primarily through self-paced activities (for example, jogging, cycling, walking, and swimming), but the challenge inherent in sports may be necessary to sustain motivation for some people. Lifetime sports are challenging and fun, and they offer variety. However, fitness attained from these activities depends on skill level and a willingness to exert maximal effort in competition. The orthopedic demands of these activities may be greater than a sedentary beginner can tolerate.

### TABLE 3-4 Rating 14 Sports and Exercises

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Cardiorespiratory Endurance (Stamina)</th>
<th>Muscular Endurance</th>
<th>Muscular Strength</th>
<th>Flexibility</th>
<th>Balance</th>
<th>Weight Control</th>
<th>Muscle Definition</th>
<th>Digestion</th>
<th>Sleep</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jogging</td>
<td>21*</td>
<td>20</td>
<td>17</td>
<td>9</td>
<td>17</td>
<td>21</td>
<td>14</td>
<td>13</td>
<td>16</td>
<td>148</td>
</tr>
<tr>
<td>Bicycling</td>
<td>19</td>
<td>18</td>
<td>16</td>
<td>9</td>
<td>18</td>
<td>20</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>142</td>
</tr>
<tr>
<td>Swimming</td>
<td>21</td>
<td>20</td>
<td>14</td>
<td>15</td>
<td>12</td>
<td>15</td>
<td>14</td>
<td>13</td>
<td>16</td>
<td>140</td>
</tr>
<tr>
<td>Skating (ice or roller)</td>
<td>18</td>
<td>17</td>
<td>15</td>
<td>13</td>
<td>20</td>
<td>17</td>
<td>14</td>
<td>11</td>
<td>15</td>
<td>140</td>
</tr>
<tr>
<td>Handball/squash</td>
<td>19</td>
<td>18</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>19</td>
<td>11</td>
<td>13</td>
<td>12</td>
<td>140</td>
</tr>
<tr>
<td>Skiing—nordic</td>
<td>19</td>
<td>19</td>
<td>15</td>
<td>14</td>
<td>16</td>
<td>17</td>
<td>12</td>
<td>12</td>
<td></td>
<td>139</td>
</tr>
<tr>
<td>Skiing—alpine</td>
<td>16</td>
<td>18</td>
<td>15</td>
<td>14</td>
<td>21</td>
<td>15</td>
<td>14</td>
<td>9</td>
<td>12</td>
<td>134</td>
</tr>
<tr>
<td>Basketball</td>
<td>19</td>
<td>17</td>
<td>15</td>
<td>13</td>
<td>16</td>
<td>19</td>
<td>13</td>
<td>10</td>
<td>12</td>
<td>134</td>
</tr>
<tr>
<td>Tennis</td>
<td>16</td>
<td>16</td>
<td>14</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td>16</td>
<td>13</td>
<td>11</td>
<td>128</td>
</tr>
<tr>
<td>Calisthenics</td>
<td>10</td>
<td>13</td>
<td>16</td>
<td>19</td>
<td>15</td>
<td>12</td>
<td>18</td>
<td>11</td>
<td>12</td>
<td>126</td>
</tr>
<tr>
<td>Walking</td>
<td>13</td>
<td>14</td>
<td>11</td>
<td>7</td>
<td>8</td>
<td>13</td>
<td>11</td>
<td>11</td>
<td>14</td>
<td>102</td>
</tr>
<tr>
<td>Golf**</td>
<td>8</td>
<td>8</td>
<td>9</td>
<td>9</td>
<td>8</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>6</td>
<td>67</td>
</tr>
<tr>
<td>Softball</td>
<td>6</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>7</td>
<td>5</td>
<td>8</td>
<td>7</td>
<td>6</td>
<td>64</td>
</tr>
<tr>
<td>Bowling</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>51</td>
</tr>
</tbody>
</table>

*The ratings are on a scale of 0 to 3; thus, a rating of 21 is the maximum score that can be achieved (a score by 3 of all 7 panelists). Ratings were made on the following basis: frequency, four times per week minimal; duration, 30 to 60 minutes per session.

**The rating was made on the basis of using a golf cart or caddy. If you walk the course and carry your clubs, the values improve.

### TABLE 3-5 Rating Selected Sports

<table>
<thead>
<tr>
<th>Sport</th>
<th>Cardiorespiratory Endurance</th>
<th>Muscular Strength/Endurance</th>
<th>Flexibility</th>
<th>Body Composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Badminton</td>
<td>M-H*</td>
<td>L</td>
<td>M-H</td>
<td>M-H</td>
</tr>
<tr>
<td>Football (touch)</td>
<td>L-M</td>
<td>L-M</td>
<td>M</td>
<td>L-M</td>
</tr>
<tr>
<td>Ice hockey</td>
<td>H</td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Racquetball</td>
<td>H</td>
<td>M-H</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Rugby</td>
<td>H</td>
<td>L</td>
<td>M-H</td>
<td>M-H</td>
</tr>
<tr>
<td>Soccer</td>
<td>H</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Volleyball</td>
<td>M</td>
<td>M</td>
<td>M-L-M</td>
<td>M</td>
</tr>
<tr>
<td>Wrestling</td>
<td>H</td>
<td>H</td>
<td>M-H</td>
<td>H</td>
</tr>
</tbody>
</table>

*H, high; M, medium; L, low. The values in this table are estimates that vary according to the skill and motivation of the participants.
Choosing Fitness Equipment for the Home

I’m a working mother with two young children. My only chance to exercise is at home after the children have been put to bed. I’m most interested in purchasing a good piece of cardio equipment that will burn calories and increase my energy level. What advice can you give me for selecting such equipment?

Here are some helpful hints:

1. Some of the most effective cardio equipment includes motor-driven treadmills, stationary exercise bikes, stationary rowers, stair climbers, elliptical trainers, cross-country skiing machines, videotape aerobic workouts (with or without stepping benches), and jump ropes.

2. Selecting the right piece of equipment is important. Many well-intentioned home exercisers become bored with the equipment they purchase or find that it is not meeting their needs, so they quit exercising.

3. Try out a piece of equipment before buying it. Make sure it feels comfortable, is easy to use, and is the right size for you.

4. Give the equipment the three-week test: Before making your purchase, borrow or rent the piece of equipment and use it three to five times per week for three weeks. At the end of three weeks, you should know whether you enjoy it well enough to use it regularly and whether it will meet your needs and goals. The best equipment in the world is useless unless you use it regularly.

5. Check the construction of the equipment to make sure that it is sturdy. The machine should not rock or wobble, and it should perform smoothly.

6. Equipment made of lightweight sheet metal or with many plastic parts may not withstand regular use.

7. Do not buy the least expensive machine. Think of this purchase as a long-term investment. Usually a middle-of-the-line product will do very well. These carry a 90-day warranty for parts, and the warranty may be extended to also include service.

8. Shop at a reputable sports equipment store that has knowledgeable sales staff who can answer your questions and help you make the appropriate choice.

9. Make sure that the store will deliver and set up the equipment.

10. If marketing and promotional claims made for the equipment sound too good to be true, they probably are.

Environmental Conditions

People work and exercise in a variety of environmental conditions. Hot and cold weather produce unique problems for people who function outdoors. Their safety and comfort depend on their knowledge of the ways the body reacts to physical activity in different climatic conditions.

Heat is produced in the body as a by-product of metabolism. Physical activities significantly increase metabolism, generating more heat than normal. Heat must be dissipated efficiently, or it may build up, resulting in hyperthermia, abnormally high body temperature that can cause illness or even death. Human beings are homeotherms, which means that we function within a narrow range of internal body temperatures. Normal temperature ranges from 97° to 100° Fahrenheit (F). The average temperature is 98.6°F. Temperature control, or thermoregulation, represents a balance between heat produced by the body’s metabolically active tissues plus heat gained from the environment compared to loss. The hypothalamus (a brain structure that maintains a constant internal environment) functions as a thermostat by decreasing heat production when the body temperature rises and increasing heat production when it falls. When heat is gained more rapidly than it is lost—such as during vigorous exercise—the temperature may rise to the point where heat stress illnesses may occur. Proteins that build body tissues and direct virtually all chemical processes can tolerate only small fluctuations in body temperature or they get too hot, change shape, and stop functioning. At this juncture, heat stress illness may occur and may run the gamut from a relatively minor problem, heat syncope (loss of consciousness) to a major life-threatening medical emergency, heat stroke. Heat exhaustion is a serious condition but not an imminent threat to life. It is characterized by dizziness, fainting, rapid pulse, and cool skin. Treatment includes immediate cessation of activity. The victim should be moved to a cool, shady place; placed in a reclining position; and given cool fluids to drink.
Heat stroke is the most severe of the heat-induced illnesses. The symptoms include a high temperature (greater than 104°F) and dry skin caused by the cessation of sweating. These symptoms are accompanied by delirium, convulsions, or loss of consciousness. The early warning signs include chills, nausea, headache, and general weakness. Victims of heat stroke should be rushed immediately to the nearest hospital for treatment.

**Mechanisms of Heat Loss**

Heat is lost from the body by conduction, convection, radiation, and evaporation of sweat. Conduction, convection, and radiation are mechanisms responsible for heat loss and heat gain. These three depend on the difference between the temperature of the body and that of the environment. These mechanisms do not function alone to effect heat loss or gain.

Conduction occurs when direct physical contact is made between objects of which one is cooler than the other. The greater the difference in temperature between the objects, the greater the transfer of heat. An example is entering an air-conditioned room from outdoors on a summer day and sitting in a cool leather chair. Heat is lost through contact with the cooler chair, as well as the cooler air that is in contact with the skin. By the same token, sitting in a hot tub in which the temperature of the water is several degrees warmer than skin temperature results in the transfer of heat to the body rather than away from it.

Conductive heat loss occurs even more rapidly in water. Water is not an insulator but a conductor. It absorbs 26 times more heat than does air at the same temperature. Air is an excellent insulator but a poor conductor. This is the reason that sitting at poolside is more comfortable than sitting in the pool, even if the temperature of the water is several degrees warmer than skin temperature.

Heat loss by radiation is effective when the air temperature (ambient temperature) is well below skin temperature. This is one of the main reasons that outdoor exercise in cool weather is better tolerated than the same exercise in hot weather. Muscles fatigue more rapidly when exercise occurs in hot weather. Exercise is more difficult to sustain in hot weather because higher amounts of lactic acid are produced and greater amounts accumulate in the muscles, promoting fatigue and making muscle contraction more difficult. Temperatures in the upper 80s and 90s often result in heat gain by radiation.

Evaporation of sweat is the main method of heat loss during exercise, and this process is most effective when the humidity is low. High humidity significantly impairs the evaporative process because the air is saturated and cannot accept much moisture. If both temperature and humidity are high, losing heat is difficult by any of these processes. Under these conditions, adjusting the intensity and duration of exercise or moving indoors, where the climate can be controlled, may be beneficial.

Heat loss by evaporation occurs only when the sweat on the surface of the skin is vaporized—that is, converted to a gas. The conversion of liquid to a gas at the skin level requires heat supplied by the body. As liquid sweat absorbs heat from the skin, it changes to a gaseous vapor carried away by the surrounding air, resulting in the removal of heat generated from exercise. Small amounts of evaporative sweat remove large quantities of heat. For example, each pint of sweat that evaporates removes approximately 280 calories of heat. Beads of sweat that roll off the body do not contribute to the cooling process—only sweat that evaporates does.

Exercise in hot and humid conditions forces the body to divert more blood than usual from the working muscles to the skin in an effort to carry the heat accumulating in the deeper recesses to the outer shell. The result is that the exercising muscles are deprived of a full complement of blood and cannot work as long or as hard. Exercise is therefore more difficult in hot and humid weather.

Heat loss by evaporation is seriously impeded when a person wears nonporous garments, such as rubberized and plastic exercise suits. These garments encourage sweating, but their nonporous nature does not allow sweat to evaporate. This practice is dangerous because it may easily result in heat buildup and dehydration (excessive water loss), leading to heat stress illnesses. You should dress for hot-weather exercise by wearing shorts and a porous top. A mesh, baseball-type cap is optional. It is effective in blocking the absorption of radiant heat if you exercise in the middle of the day because the sun’s rays are vertical. You do not need to wear a cap when exercising in the cooler times of the day or if the sun is not shining.
Wellness  Concepts and Applications

Guidelines for Exercise in the Heat

Guidelines for exercising in heat and humidity have been developed for road races, but these guidelines can be applied to any strenuous physical activity performed outdoors during warm weather. Ambient conditions are considered safe when the temperature is below 70°F and the humidity is below 60 percent. Caution should be used and people sensitive to heat and humidity should reconsider exercising when the temperature is greater than 80°F or the humidity is over 60 percent. People who are trained and heat acclimated can continue to exercise in these conditions, but they should be aware of the potential hazards and take precautions to prevent heat illness.

The keys to exercising without incident in hot weather are acclimating to the heat and maintaining the body’s normal fluid level. Acclimation to heat is characterized by physiological adjustments that occur naturally from repeated exposure to exercise in the heat. Acclimation includes the early onset of sweating, an increase in the rate of sweating, and the reduction of sodium in sweat. These adjustments result in less cardiovascular strain and a lower body temperature for a specific amount of exercise. Most healthy people become fully acclimatized to heat in 10 to 14 days. The main consequence of dehydration (excessive fluid loss) is a reduction in blood volume. This results in sluggish circulation, which decreases the delivery of oxygen to the exercising muscles. Lowered blood volume results in less blood that can be sent to the skin to remove the heat generated by exercise. If too much of the blood volume is lost, sweating stops and the body temperature rises, leading to heat stress illness. Heat stress illness is a serious problem that can be avoided by following these guidelines designed to preserve the body’s fluid level:

Estimating Water Loss

- Weigh yourself nude before and after exercise.
- Towel off sweat completely after exercise and then weigh yourself.
- Each pound of weight loss represents about 1 pint of fluid loss. Be sure to drink that and more after exercise. See Just the Facts: Fluid Consumption Before, During, and After Exercise.

Other Considerations

- Modify the exercise program by (1) working out during cooler times of day, (2) choosing shady routes where water is available, (3) slowing the pace or shortening the duration of exercise on particularly oppressive days, and (4) wearing light, loose, porous clothing to facilitate the evaporation of sweat.
- Never take salt tablets. They are stomach irritants, they attract fluid to the gut, they sometimes pass through the digestive system undissolved, and they may perforate the stomach lining.
- Exercise must be prolonged, produce profuse sweating, and occur over a number of consecutive days to reduce potassium stores. For the average bout of exercise, you do not need to worry about depleting potassium or make a special effort to replace it. The daily consumption of fresh fruits and vegetables, as suggested by the food pyramid, is all that is needed (see Chapter 6).
- Remember to use a sunscreen lotion when the weather is sunny or hazy. Be sure that the sunscreen you select has a sun-protection factor (SPF) of at least 15, and apply it liberally over exposed skin.

Guidelines for Exercise in the Cold

Problems related to exercise in cold weather include frostbite and hypothermia (abnormally low body temperature). Frostbite can lead to permanent damage or loss of a body part from gangrene. This can be prevented by adequately protecting exposed areas, such as fingers, nose, ears, facial skin, and toes. Gloves, preferably...
mittens or thick socks, should be worn to protect the fingers, hands, and wrists. Blood vessels in the scalp do not constrict effectively, so a significant amount of heat is lost if a head covering is not worn. A stocking-type hat is the best head covering because it can be pulled down to protect the ears. In very cold or windy weather, use surgical or ski masks and scarves to keep facial skin warm and to moisten and warm inhaled air. All exposed or poorly protected flesh is vulnerable to frostbite when the temperature is low and the windchill high. Air temperature plus wind speed equals the windchill index. Hypothermia occurs when body heat is lost faster than it can be produced. This can be a life-threatening situation. The adjustments made by the body to avoid excessive heat loss include shivering, nonshivering thermogenesis, and peripheral vasoconstriction. Shivering is the involuntary contraction of muscles. These contractions increase the body’s heat production by four to five times that produced under normal resting conditions. Nonshivering thermogenesis raises body temperature through neural stimulation that increases metabolic rate. Peripheral vasoconstriction occurs from the neurally mediated contraction of smooth muscles located subcutaneously (beneath the skin). The contractions of these muscles constrict the small arteries beneath the skin, leading to decreased blood flow to the skin. This adjustment prevents unnecessary heat loss. However, hypothermia may still occur because these adjustments can be overcome by excessive exposure to cold.

Exercise in cold weather requires insulating layers of clothing to preserve normal body heat. Without this protection, body heat is quickly lost because of the large temperature gradient between the skin and environment.

JUST THE FACTS
Fluid Consumption Before, During, and After Exercise

The American College of Sports Medicine has issued the following recommendations about fluid consumption:

1. Make a special effort to drink plenty of fluid every day, so that you will be fully hydrated prior to exercise.
2. The daily water needs of most moderately fit active people range between 3 and 5 liters (a little more than 3 to 5 quarts).
3. It is a common occurrence that fluid losses exceed fluid replacement during intense physical exercise for a variety of reasons.
4. Drink fluids during exercise that contain carbohydrates (sugars) and sodium because these will enhance performance and delay fatigue more effectively than an equal amount of plain water for exercises lasting 45 to 30 minutes or during high-intensity intermittent exercises.
5. It is imperative to consume carbohydrate/sodium fluids during prolonged physical activity. Replacing with plain water, combined with sweat loss, reduces blood levels of sodium. If the sodium deficit becomes excessive, it will lead to exertional hyponatremia. The symptoms of hyponatremia include progressively worsening headache, confusion, disorientation, nausea, vomiting, aphasia (impairment of speech or understanding), muscle cramps, and muscle weakness. It sometimes results in death.
6. Women are at greater risk of incurring exertional hyponatremia because their fluid intake is more likely to exceed their sweat rate and because they have less body water than males and a smaller body mass that is more readily affected by overdrinking.
7. The general rule after exercise is to drink until thirst is satisfied and then drink a bit more in order to satisfy your tissue needs.
8. Rehydration after exercise requires fluid replacement of 125 to 150 percent of the loss of body mass (weight) during exercise. Each pound lost during exercise represents the loss of one pint of fluid. The loss of 3 pounds of body mass would require the consumption of 3.75 pints (125%) to 4.5 pints (150%) of fluid. The replacement fluid should be tasty and contain sugar, sodium, and possibly potassium and magnesium in amounts that can be found, for example, in sports drinks.
9. Caffeine, alcohol, and protein can modestly increase urine water loss and should not be consumed immediately after exercise. This is counterproductive because rapid and complete hydration is desirable at this point.
Summary

- Physical fitness is defined in terms of performance-related and health-related fitness.
- Cardiorespiratory endurance is the most important component of health-related fitness.
- The long-term effects of physical training include modifications in heart rate, stroke volume, cardiac output, blood volume, heart volume, respiration, and metabolism.
- Aerobic capacity is finite, improves by 5 to 25 percent with training, and decreases with aging; this decrease is slower in those who are physically fit.
- The training effect is lost in stages if exercise is interrupted or discontinued.
- Exercise affects cholesterol levels, blood pressure, and triglyceride levels; may reduce the risks for diabetes.
mellitus and stress; and is an alternative method for quitting use of tobacco products.

- The principles of exercise can be manipulated to meet any exercise objective.
- Exercising by varying the activities per exercise session or during exercise sessions is cross-training.

Review Questions

1. What are the physiological changes that occur from regular participation in aerobic exercise?
2. What are the health benefits that occur from regular participation in aerobic training?
3. Name and define the physiological changes that occur with exercise training.
4. Identify and define the principles of physical conditioning.
5. Define cross-training and give some examples.
6. Why should you warm up before exercise?
7. Identify and define the mechanisms of heat loss. Which of these is most important during exercise and why?
8. Describe fluid replacement before, during, and after exercise.

References

2. Ibid.
3. Ibid.
9. Ibid.
10. Ibid.
11. Ibid.
13. Ibid.
19. Ibid.
22. Ibid.
23. Ibid.
30. Ibid.
32. Ibid.
33. ACSM, 2006.
35. Ibid.
41. ACSM, 2006.
44. ACSM, 2006.
46. Whang et al., 2006.
47. Ibid.
49. Mittleman et al., 1993.
The immune system is very complex and very important. This article differentiates between nonspecific resistance (innate immunity) and specific resistance (acquired immunity). The role of exercise is examined and the evidence indicates that prolonged exercise that puts the body under stress can impair and reduce the effectiveness of the immune system. On the other hand, regular moderate intensity exercise strengthens the immune system.


Provides the rationale for including running in one's exercise program while also presenting barriers to running. Also includes a segment on maximizing running enjoyment while minimizing the risk of injury.


This special report discusses the need for aerobic as well as resistive exercises particularly as people age. Aerobics are needed to fuel the heart and lungs and resistive exercises are needed to build and maintain muscle mass and strength in order for older people to live a healthy and independent life. Nine ways to help people get started are explained and illustrated.

Editors. 2006. 10 ways to make exercise a lasting part of your life. Consumer Reports on Health 18(5):1, 4–6.

Emphasis is on a variety of techniques to sustain the motivation to exercise regularly. Also, it provides 10 health and physical fitness reasons to begin and follow a program of exercise.


The author covers the evidence that regular exercise lowers the risk of developing breast cancer by 20 percent and colon cancer by 30 to 40 percent; and men over 65 years of age who exercise are significantly less likely to die of prostate cancer. Evidence also indicates that inactivity and overweight account for 25 to 33 percent of breast, colon, endometrial, kidney, and esophageal cancers worldwide.
Assessment Activity 3-1

The Rockport Fitness Walking Test

**Directions:** This walking test estimates aerobic capacity based on the variables of age, gender, time required to walk 1 mile, and heart rate achieved at the end of the test. The guidelines for taking the test are as follows:

1. Count your heart rate for 15 seconds and multiply by 4 to get beats per minute.
2. The course should be flat and measured, preferably a 440-yard track.
3. Use a stopwatch or a watch with a second hand.
4. Warm up for 5 to 10 minutes before taking the test. Preparation for the test should include a 0.25-mile walk followed by the stretching exercises.
5. During the test, walk at a brisk pace, covering 1 mile as rapidly as possible.
6. Take your pulse rate immediately after the test. On the following pages, mark this rate on the chart that is appropriate for your age and gender.
7. Draw a vertical line through your time and a horizontal line through your heart rate. The point where the lines intersect determines your fitness level.

Rockport provides a series of 20-week walking-for-fitness programs based on the results of the walking test. These may be obtained for a nominal fee by sending a request to Rockport Fitness Walking Test, 72 Howe Street, Marlboro, MA 01752.

The charts on the following pages are designed to tell you how fit you are compared with other individuals of your age and gender. For example, if your coordinates place you in the “above average” section of the chart, you are in better shape than the average person in your category.

The charts are based on weights of 170 lbs. for men and 125 lbs. for women. If you weigh substantially more, your relative cardiovascular fitness level will be slightly overestimated. If you weigh substantially less, your relative cardiovascular fitness level will be slightly underestimated.
20- to 29-year-old men

30- to 39-year-old men

40- to 49-year-old men

50- to 59-year-old men

60-year-old and older men
Chapter 3  Increasing Cardiorespiratory Endurance

20- to 29-year-old women

30- to 39-year-old women

40- to 49-year-old women

50- to 59-year-old women

60-year-old and older women
Assessment Activity 3-2

The 1.5-Mile Run/Walk Test

Directions: Select a measured course, preferably a running track, so that the starting and finishing points are at the same location for ease of timing and recording. Cover the distance as rapidly as possible to attain a realistic estimate of fitness level. You will perform better if you take the opportunity to practice running the course first, so that you can learn how to pace yourself. If you cannot run the entire distance, walk until you recover enough to continue running again. Allow a 5-10 minute warm-up before the test and an equal amount of time for cooling down after the test. Use the following charts to compare your performance with the norm.

Aerobic Physical Fitness Classification

Men

<table>
<thead>
<tr>
<th>Fitness Category</th>
<th>13–19 Yrs.</th>
<th>20–29 Yrs.</th>
<th>30–39 Yrs.</th>
<th>40–49 Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poor</td>
<td>&gt; 15:31*</td>
<td>&gt; 16:01</td>
<td>&gt; 16:31</td>
<td>&gt; 17:31</td>
</tr>
<tr>
<td>Poor</td>
<td>12:11–15:30</td>
<td>14:01–16:00</td>
<td>14:46–16:30</td>
<td>15:36–17:30</td>
</tr>
<tr>
<td>Excellent</td>
<td>8:37–9:40</td>
<td>9:45–10:45</td>
<td>10:00–11:00</td>
<td>10:30–11:30</td>
</tr>
<tr>
<td>Superior</td>
<td>&lt; 8:37</td>
<td>&lt; 9:45</td>
<td>&lt; 10:00</td>
<td>&lt; 10:30</td>
</tr>
</tbody>
</table>

Women

<table>
<thead>
<tr>
<th>Fitness Category</th>
<th>13–19 Yrs.</th>
<th>20–29 Yrs.</th>
<th>30–39 Yrs.</th>
<th>40–49 Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very poor</td>
<td>&gt; 18:31*</td>
<td>&gt; 19:01</td>
<td>&gt; 19:31</td>
<td>&gt; 20:31</td>
</tr>
<tr>
<td>Superior</td>
<td>&lt; 11:50</td>
<td>&lt; 12:30</td>
<td>&lt; 13:00</td>
<td>&lt; 13:45</td>
</tr>
</tbody>
</table>

* > greater than; < less than
Assessment Activity 3-3

The 3-Minute Bench Step Test

Directions: The equipment needed includes a sturdy 12-inch-high bench; a metronome; a stopwatch; and, if possible, a stethoscope. The metronome should be set at 96 beats per minute for a total of 24 cycles. One cycle consists of four steps as follows: up left foot, up right foot, down left foot, down right foot.

Step up and down in time with each beat of the metronome for 3 full minutes. At the end of the 3 minutes, sit down on the bench immediately. Start the pulse count within the first 5 seconds and continue for 1 full minute. Do not count for 15 seconds and multiply by 4, because the heart rate will be higher than the actual minute heart rate. The 1-minute postexercise heart rate is the score for the test. Refer to the following chart for scoring.

Postexercise 1-Minute Heart Rate (Beats per Minute)

<table>
<thead>
<tr>
<th>Fitness Category</th>
<th>18–25 Yrs.</th>
<th>26–35 Yrs.</th>
<th>36–45 Yrs.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men</td>
<td>Women</td>
<td>Men</td>
</tr>
<tr>
<td>Excellent</td>
<td>70–78*</td>
<td>72–83</td>
<td>73–79</td>
</tr>
<tr>
<td>Above average</td>
<td>91–97</td>
<td>100–106</td>
<td>91–97</td>
</tr>
<tr>
<td>Very poor</td>
<td>131–164</td>
<td>141–155</td>
<td>130–164</td>
</tr>
</tbody>
</table>

*Count the pulse for 1 full minute after 3 minutes of stepping at 24 cycles/min. on a 12-inch bench.
Assessment Activity 3-4

Calculating Target Heart Rate

**Directions:** Use the Karvonen formula to determine your target heart rate for exercise by filling in the following chart.

Karvonen formula: $THR = \frac{(HR_{max} - RHR)}{TI\%} + RHR$

**Key**
- $THR$ = target heart rate
- $HR_{max}$ = maximum heart rate ($HR_{max} = 220 - age$)
- $RHR$ = resting heart rate
- $TI\%$ = training intensity

**Example**
- A 23-year-old man in good condition (0.75 training intensity from Table 3-3)

- $RHR = 66$ bpm (beats per minute)
- $HR_{max} = 220 - 23 = 197$ bpm
- $THR = 164$ bpm

$THR = \frac{(197 - 66) \times 0.75 + 66}{131 \times 0.75 + 66} = 164$ bpm

Your target heart rate:

$HR_{max} = 220 - age =$

$THR = (HR_{max} - RHR) \times TI\% + RHR$

$THR = (______ - ______) \times _____ + _____$

$THR = ______ \times _____ + _____$

$THR = ______ + _____$

$THR = _______ bpm$
Assessment Activity 3-5

Design an Exercise Program

Directions: Design an exercise program for yourself. First, identify your goals (weight loss, health enhancement, improved level of physical fitness, stress reduction, etc.) and, second, respond accordingly to each of the following five items.

1. Activity or activities: ________________________________
2. Frequency of exercise: ______________________________
3. Intensity of exercise: ________________________________
4. Duration of exercise: ________________________________
5. Activity schedule: Place the activity or activities in the following weekly calendar with the suggested amount of time devoted to each activity.

<table>
<thead>
<tr>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>