Lifetime Physical Fitness & Wellness
A Personalized Program

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Muscular Strength and Endurance

“Progressive resistance strength training provides significant improvements in functional capacity, fitness, health, and overall well-being.”

Objectives

▶ Explain the importance of adequate muscular strength levels in maintaining good health and well-being.
▶ Clarify misconceptions about strength fitness.
▶ Define muscular strength and muscular endurance.
▶ Be able to assess muscular strength and endurance and learn to interpret test results according to health fitness and physical fitness standards.
▶ Identify the factors that affect strength.
▶ Understand the principles of overload and specificity of training for strength development.
▶ Learn dietary guidelines for optimum strength development.
▶ Become familiar with core strength training and realize its importance for overall quality of life.
▶ Become acquainted with two distinct strength-training programs—with weights and without weights.

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**FAQ**

**Which is more important for good health: aerobic fitness or muscular strength?** They are both important. During the initial fitness boom in the 1970s and 1980s, the emphasis was almost exclusively on aerobic fitness. We now know that both aerobic fitness and muscular strength contribute to health, fitness, work capacity, and overall quality of life. Among many health benefits, aerobic fitness is important in the prevention of cardiovascular diseases and some types of cancer; whereas muscular fitness will build strong muscles and bones, increase functional capacity, prevent osteoporosis and type 2 diabetes, and decrease the risk for low back pain and other musculoskeletal injuries.

**Should I do aerobic exercise or strength training first?** Ideally, allow some recovery hours between the two types of training. If you can’t afford the time, the training order should be based on your fitness goals and preferences. Unless extremely exhausting, aerobics provides a good lead into strength training. Excessive fatigue can lead to bad form while lifting and may result in injury. If your primary goal is strength development, lift first, as you’ll be less fatigued and will end up with a more productive workout. On the other hand, if you are trying to develop the cardiorespiratory system or enhance caloric expenditure for weight-loss purposes, heavy lower body lifting will make it very difficult to sustain a good cardio workout thereafter. Thus, evaluate your goals, and select the training order accordingly.

**Do big muscles turn into fat when the person stops training?** Muscle and fat tissue are two completely different types of tissue. Just as an apple will not turn into an orange, muscle tissue cannot turn into fat or vice versa. Muscle cells increase and decrease in size according to your training program. If you train quite hard, muscle cells increase in size. This increase is limited in women due to hormonal differences compared with men. When one stops training, muscle cells again decrease in size. If the person maintains a high caloric intake without physical training, however, fat cells will increase in size as weight (fat) is gained.

**What strength-training exercises are best to get an abdominal “six-pack”?** Most men tend to store body fat around the waist, while women do so around the hips. There are, however, no “miracle” exercises to spot-reduce. Multiple sets of abdominal curl-ups, crunches, reverse crunches, or sit-ups performed three to five times per week will strengthen the abdominal musculature but will not be sufficient to allow the muscles to appear through the layer of fat between the skin and the muscles. The total energy (caloric) expenditure of a few sets of abdominal exercises will not be sufficient to lose a significant amount of weight (fat). If you want to get a “washboard stomach” (or, for women, achieve shapely hips), you need to engage in a moderate to vigorous aerobic and strength-training program combined with a moderate reduction in daily caloric intake (diet).

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**Real Life Story**

**Jason’s Experience**

When I lifted weights with my friends before taking my fitness class, I would show off by trying to lift more than they could. I was really competitive and would do whatever it took to lift as much or more weight than my friends. I was even using really bad form to beat them. When I would do a biceps curl, I would lift my elbows and arch my back and use the momentum to swing the weight up. On the bench press, I would arch my back and bounce the weight off my chest to lift it up. And with squats, I would cheat by doing a shallow squat, not really bending my legs that much. When we covered strength training in class, we talked about proper form and going through the full range of motion. In the weight room, my instructor helped me use correct form. I finally realized that the mistakes I was making were actually keeping me from getting stronger. I made the corrections that my instructor showed me. I didn’t like that I had to decrease the amount of weight I was using at first, but eventually I improved and increased my strength. Now I am able to lift more than I did before, this time using correct form!
Personal Understanding of Muscular Fitness Concepts

I. Good muscular strength is not a critical component for adequate health fitness. _______ Yes _______ No

II. Even though body weight may not drop or even increase as a result of a progressive resistance strength-training program, circumference measurements (inches) and percent body fat may decrease. _______ True _______ False

III. Performing at least one set within the RM zone for each exercise produces substantial strength development. _______ Yes _______ No

IV. A periodized strength-training program is frequently used to maximize muscular strength and endurance gains. _______ Yes _______ No

V. Single-joint exercises are more effective than multiple-joint exercises for strength development. _______ Yes _______ No

The benefits of strength training or resistance training on health and well-being are well documented. The need for strength fitness is not confined to highly trained athletes, fitness enthusiasts, and individuals who have jobs that require heavy muscular work.

Benefits of Strength Training

A well-planned strength-training program leads to increased muscle strength and endurance, power, muscle tone, and tendon and ligament strength—all of which help to improve and maintain everyday functional physical capacity. Strength is a basic health-related fitness component and is an important wellness component for optimal performance in daily activities such as sitting, walking, running, lifting and carrying objects, doing housework, and enjoying recreational activities. Strength also is of great value in improving posture, personal appearance, and self-image; in developing sports skills; in promoting stability of joints; and in meeting certain emergencies in life.

From a health standpoint, increasing strength helps to increase or maintain muscle and a higher resting metabolic rate; encourages weight loss and maintenance, preventing obesity; lessens the risk for injury; reduces chronic low back pain; alleviates arthritic pain; aids in childbearing; improves bone density, preventing osteoporosis; improves cholesterol levels, decreases triglyceride levels, and reduces high blood pressure, thus reducing the risk for cardiovascular disease; and promotes psychological well-being.

Regular strength training also helps control blood sugar. Much of the blood glucose from food consumption goes to the muscles, where it is stored as glycogen. When muscles are not used, muscle cells may become insulin resistant, and glucose cannot enter the cells, thereby increasing the risk for type 2 diabetes. Following 16 weeks of strength training, a group of diabetic men and women improved their blood sugar control, gained strength, increased lean body mass, lost body fat, and lowered blood pressure.\(^1\)

Furthermore, with time, the heart rate and blood pressure response to lifting a heavy resistance (a weight) decreases. This adaptation reduces the demands on the cardiovascular system when you perform activities such as carrying a child, the groceries, or a suitcase.

Muscular Strength and Aging

In the older adult population, muscular strength may be the most important health-related component of physical fitness. Although proper cardiorespiratory endurance is necessary to help maintain a healthy heart, good strength contributes more to independent living than any other fitness component. Older adults with good strength levels can successfully perform most activities of daily living.

A common occurrence as people age is sarcopenia, the loss of lean body mass, strength, and function.

Key Terms

- **Strength training** A program designed to improve muscular strength and/or endurance through a series of progressive resistance (weight) training exercises that overload the muscle system and cause physiological development.
- **Resistance training** See Strength training.
- **Activities of daily living** Everyday behaviors that people normally do to function in life (cross the street, carry groceries, lift objects, do laundry, sweep floors).
- **Sarcopenia** Age-related loss of lean body mass, strength, and function.
How much of this loss is related to the aging process itself or to actual physical inactivity and faulty nutrition is unknown. And whereas thinning of the bones from osteoporosis renders them prone to fractures, the gradual loss of muscle mass and ensuing frailty are what lead to falls and subsequent loss of function in older adults. Strength training helps to slow the age-related loss of muscle function. Protein deficiency, seen in some older adults, also contributes to loss of lean tissue.

More than anything else, older adults want to enjoy good health and to function independently. Many of them, however, are confined to nursing homes because they lack sufficient strength to move about. They cannot walk very far, and many have to be helped in and out of beds, chairs, and tubs.

A strength-training program can enhance quality of life tremendously, and nearly everyone can benefit from it. Only people with advanced heart disease are advised to refrain from strength training. Inactive adults between the ages of 56 and 86 who participated in a 12-week strength-training program increased their lean body mass by about 3 pounds, lost about 4 pounds of fat, and increased their resting metabolic rate by almost 7 percent. In other research, leg strength improved by as much as 200 percent in previously inactive adults over age 90. As strength improves, so does the ability to move about, the capacity for independent living, and enjoyment of life during the “golden years.” More specifically, good strength enhances quality of life in that it

- improves balance and restores mobility,
- makes lifting and reaching easier,
- decreases the risk for injuries and falls, and
- stresses the bones and preserves bone mineral density, thereby decreasing the risk for osteoporosis.

Another benefit of maintaining a good strength level is its relationship to human metabolism. A primary outcome of a strength-training program is an increase in muscle mass or size (lean body mass), known as muscle hypertrophy.

Muscle tissue uses more energy than does fatty tissue. That is, your body expends more calories to maintain muscle than to maintain fat. All other factors being equal, if two individuals both weigh 150 pounds but have different amounts of muscle mass, the one with more muscle mass will have a higher resting metabolism. Even small increases in muscle mass have a long-term positive effect on metabolism.

Loss of lean tissue also is thought to be a primary reason for the decrease in metabolism as people grow older. Contrary to some beliefs, metabolism does not have to slow down significantly with aging. It is not so much that metabolism slows down, it’s that we slow down. Lean body mass decreases with sedentary living, which in turn slows down the resting metabolic rate. Thus, if people continue eating at the same rate as they age, body fat increases.

Daily energy requirements decrease an average of 360 calories between age 26 and age 60. Participating in a strength-training program can offset much of the decline and prevent and reduce excess body fat. One research study found an increase in resting metabolic rate of 35 calories per pound of muscle mass in older adults who participated in a strength-training program.

**Gender Differences**

A common misconception about physical fitness concerns women in strength training. Because of the increase in muscle mass typically seen in men, some women think that a strength-training program will result in their developing large musculature.

Even though the quality of muscle in men and women is the same, endocrinological differences do not allow women to achieve the same amount of muscle hypertrophy (size) as men. Men also have more muscle fibers, and because of the sex-specific male hormones, each individual fiber has more potential for hypertrophy. On the average, following 6 months of training, women can achieve up to a 50-percent increase in strength but only a 10-percent increase in muscle size.

The idea that strength training allows women to develop muscle hypertrophy to the same extent as men is as false as the notion that playing basketball will turn women into giants. Masculinity and femininity are established by genetic inheritance, not by the amount of physical activity. Variations in the extent of masculinity and femininity are determined by individual differences in hormonal secretions of androgen, testosterone, estrogen, and progesterone. Women with a bigger-than-average build often are inclined to participate in sports because of their natural physical advantage. As a result, many people have associated women’s participation in sports and strength training with large muscle size.

As the number of females who participate in sports has increased steadily, the myth of strength training in women leading to large increases in muscle size has abated somewhat. For example, per pound of body weight, female gymnasts are among the strongest athletes in the world. These athletes engage regularly in vigorous strength-training programs. Yet, female gymnasts have some of the most well-toned and graceful figures of all women.

Improved body appearance has become the rule rather than the exception for women who participate in strength-training programs. Some of the most attractive female movie stars also train with weights to further improve their personal image.

Nonetheless, you may ask, “If weight training does not masculinize women, why do so many women body
builders develop such heavy musculature?” In the sport of body building, the athletes follow intense training routines consisting of two or more hours of constant weight lifting with short rest intervals between sets. Many body-building training routines call for back-to-back exercises using the same muscle groups. The objective of this type of training is to pump extra blood into the muscles. This additional fluid makes the muscles appear much bigger than they do in a resting condition. Based on the intensity and the length of the training session, the muscles can remain filled with blood, appearing measurably larger for an hour or longer after completing the training session. Performing such routines is a common practice before competitions. Therefore, in real life, these women are not as muscular as they seem when they are participating in a contest.

In the sport of body building (among others), a big point of controversy is the use of anabolic steroids and human growth hormones. These hormones produce detrimental and undesirable side effects, even more so in women (such as hypertension, fluid retention, decreased breast size, deepening of the voice, and whiskers and other atypical body hair growth), which some women deem tolerable. Anabolic steroid use in general—except for medical reasons and when carefully monitored by a physician—can lead to serious health consequences.

Use of anabolic steroids by female body builders and female track-and-field athletes is not uncommon. Athletes use anabolic steroids to remain competitive at the highest level. During the 2004 Olympic Games in Athens, Greece, two women shot putters, including the gold medal winner (later stripped of the medal), were expelled from the games for using steroids. Women who take steroids undoubtedly will build heavy musculature, and if they take them long enough, the steroids will produce masculinizing effects.

**Key Terms**

**Metabolism** All energy and material transformations that occur within living cells; necessary to sustain life.

**Hypertrophy** An increase in the size of the cell, as in muscle hypertrophy.

**Resting metabolism** Amount of energy (expressed in milliliters of oxygen per minute or total calories per day) an individual requires during resting conditions to sustain proper body function.

**Anabolic steroids** Synthetic versions of the male sex hormone testosterone, which promotes muscle development and hypertrophy.
To prevent steroid use, the International Federation of Body Building instituted a mandatory steroid-testing program for women participating in the Miss Olympia contest. When drugs are not used to promote development, improved body image is the rule rather than the exception among women who participate in body building, strength training, and sports in general.

**Changes in Body Composition**

A benefit of strength training, accentuated even more when combined with aerobic exercise, is a decrease in adipose or fatty tissue around muscle fibers themselves. This decrease is often greater than the amount of muscle hypertrophy (see Figure 7.1). Therefore, losing inches but not body weight is common.

Because muscle tissue is more dense than fatty tissue (and despite the fact that inches are lost during a combined strength-training and aerobic program), people, especially women, often become discouraged because they cannot see the results readily on the scale. They can offset this discouragement by determining body composition regularly to monitor their changes in percent body fat rather than simply measuring changes in total body weight (see Chapter 4).

**Assessment of Muscular Strength and Endurance**

Although muscular strength and endurance are interrelated, they do differ. **Muscular strength** is the ability to exert maximum force against resistance. **Muscular endurance** is the ability of a muscle to exert submaximal force repeatedly over time.

Muscular endurance (also referred to as “localized muscular endurance”) depends to a large extent on muscular strength. Weak muscles cannot repeat an action several times or sustain it. Based on these principles, strength tests and training programs have been designed to measure and develop absolute muscular strength, muscular endurance, or a combination of the two.

Muscular strength is usually determined by the maximal amount of resistance (weight)—**one repetition maximum** or **1 RM**—that an individual is able to lift in a single effort. Although this assessment yields a good measure of absolute strength, it does require considerable time, because the 1 RM is determined through trial and error. For example, strength of the chest muscles is frequently measured through the bench press exercise. If an individual has not trained with weights, he may try 100 pounds and lift this resistance easily. After adding 50 pounds, he fails to lift the resistance. Then he decreases resistance by 20 or 30 pounds. Finally, after several trials, the 1 RM is established.

Using this method, a true 1 RM might be difficult to obtain the first time an individual is tested, because fa-
Muscular Strength and Endurance

The maximum amount of muscular strength is the ability of a muscle to exert maximum force against resistance (e.g., 1 repetition maximum [or 1 RM] on the bench press exercise). Muscular endurance is the ability of a muscle to exert submaximal force repeatedly over time. One repetition maximum (1 RM) is the maximum amount of resistance an individual is able to lift in a single effort.

Procedure for the Hand Grip Strength Test.

1. Adjust the width of the dynamometer* so the middle bones of your fingers rest on the distant end of the dynamometer grip.
2. Use your dominant hand for this test. Place your elbow at a 90° angle and about 2 inches away from the body.
3. Now grip as hard as you can for a few seconds. Do not move any other body part as you perform the test (do not flex or extend the elbow, do not move the elbow away or toward the body, and do not lean forward or backward during the test).
4. Record the dynamometer reading in pounds (if reading is in kilograms, multiply by 2.2046).
5. Three trials are allowed for this test. Use the highest reading for your final test score. Look up your percentile rank for this test in Table 7.1.
6. Based on your percentile rank, obtain the hand grip strength fitness category according to the following guidelines:

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Fitness Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥90</td>
<td>Excellent</td>
</tr>
<tr>
<td>70–80</td>
<td>Good</td>
</tr>
<tr>
<td>50–60</td>
<td>Average</td>
</tr>
<tr>
<td>30–40</td>
<td>Fair</td>
</tr>
<tr>
<td>≤20</td>
<td>Poor</td>
</tr>
</tbody>
</table>

*A Lafayette model 78010 dynamometer is recommended for this test (Lafayette Instruments Co., Sagamore and North 9th Street, Lafayette, IN 47903).

Changes in muscular strength are more difficult to evaluate with the Hand Grip Strength Test. Most strength-training programs are dynamic in nature (body segments are moved through a range of motion), whereas this test provides an isometric assessment. Further, grip-strength exercises seldom are used in strength training, and increases in strength are specific to the body parts exercised. This test, however, can be used to supplement the following strength tests.

Muscular Endurance Test

Three exercises were selected to assess the endurance of the upper body, lower body, and midbody muscle groups (see Figure 7.3). The advantage of the Muscular Endurance Test is that it does not require strength-training equipment—only a stopwatch, a metronome, a bench or gymnasium bleacher 16¼ inches high, a cardboard strip 3½ inches wide by 30 inches long, and a
partner. A percentile rank is given for each exercise according to the number of repetitions performed (see Table 7.2). An overall endurance rating can be obtained by totaling the number of points obtained on each exercise. Record the results of this test in Activity 7.1 and Appendix A.

**Muscular Strength and Endurance Test**

In the Muscular Strength and Endurance Test, you will lift a submaximal resistance as many times as possible using the six strength-training exercises listed in Figure 7.4. The resistance for each lift is determined according to selected percentages of body weight shown in Figure 7.4 and Activity 7.1.

With this test, if an individual does only a few repetitions, primarily absolute strength will be measured. For those who are able to do a lot of repetitions, the test will be an indicator of muscular endurance. If you are not familiar with the different lifts, see the illustrations provided at the end of this chapter.

A strength/endurance rating is determined according to the maximum number of repetitions you are able to perform on each exercise. Fixed-resistance strength units are necessary to administer all but the abdominal exercises in this test (see “Dynamic Training” on pages 238–239 for an explanation of fixed-resistance equipment).

A percentile rank for each exercise is given based on the number of repetitions performed (see Table 7.3). As with the Muscular Endurance Test, an overall muscular strength/endurance rating is obtained by totaling the number of points obtained on each exercise.

If no fixed-resistance equipment is available, you can still perform the test using different equipment. In that case, though, the percentile rankings and strength fitness categories may not be completely accurate because a certain resistance (e.g., 50 pounds) is seldom the same on two different strength-training machines (e.g., Universal Gym versus Nautilus). The industry has no standard calibration procedure for strength equipment. Consequently, if you lift a certain resistance for a specific exercise (e.g., bench press) on one machine, you may or may not be able to lift the same amount for this exercise on a different machine.

Even though the percentile ranks may not be valid across different equipment, test results can be used to evaluate changes in fitness. For example, you may be able to do 7 repetitions during the initial test, but if you can perform 14 repetitions after 12 weeks of training, that’s a measure of improvement. Results of the Muscular Strength and Endurance Test can be recorded in Activity 7.1.

---

**Table 7.1** Scoring Table for Hand Grip Strength Test

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>153</td>
<td>101</td>
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<tr>
<td>95</td>
<td>145</td>
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<td>80</td>
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<td>70</td>
<td>132</td>
<td>80</td>
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<td>60</td>
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<td>50</td>
<td>122</td>
<td>74</td>
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<td>40</td>
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<td>30</td>
<td>110</td>
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<td>91</td>
<td>60</td>
</tr>
<tr>
<td>5</td>
<td>76</td>
<td>58</td>
</tr>
</tbody>
</table>

The hand grip tests strength.
Three exercises are conducted on this test: bench jumps, modified dips (men) or modified push-ups (women), and bent-leg curl-ups or abdominal crunches. All exercises should be conducted with the aid of a partner. The correct procedure for performing each exercise is as follows:

**Bench jump.** Using a bench or gymnasium bleacher 16\( \frac{1}{4} \) high, attempt to jump up onto and down off of the bench as many times as possible in 1 minute. If you cannot jump the full minute, you may step up and down. A repetition is counted each time both feet return to the floor.

**Modified dip.** Men only: Using a bench or gymnasium bleacher, place the hands on the bench with the fingers pointing forward. Have a partner hold your feet in front of you. Bend the hips at approximately 90° (you also may use three sturdy chairs: Put your hands on two chairs placed by the sides of your body and place your feet on the third chair in front of you). Lower your body by flexing the elbows until they reach a 90° angle, then return to the starting position (also see Exercise 6 at the end of this chapter). Perform the repetitions to a two-step cadence (down-up) regulated with a metronome set at 56 beats per minute. Perform as many continuous repetitions as possible. Do not count any more repetitions if you fail to follow the metronome cadence.

**Modified push-up.** Women only: Lie down on the floor (face down), bend the knees (feet up in the air), and place the hands on the floor by the shoulders with the fingers pointing forward. The lower body will be supported at the knees (as opposed to the feet) throughout the test (see Figure 7.3c). The chest must touch the floor on each repetition. As with the modified dip exercise (above), perform the repetitions to a two-step cadence (up-down) regulated with a metronome set at 56 beats per minute. Perform as many continuous repetitions as possible. Do not count any more repetitions if you fail to follow the metronome cadence.

**Bent-leg curl-up.** Lie down on the floor (face up) and bend both legs at the knees at approximately 100°. The feet should be on the floor, and you must hold them in place throughout the test. Cross the arms in front of the chest, each hand on the opposite shoulder. Now raise the head off the floor, placing the chin against the chest. This is the starting and finishing position for each curl-up (see Figure 7.3d). The back of the head must not come in contact with the floor, the hands cannot be removed from the shoulders, nor may the feet or hips be raised off the floor at any time during the test. The test is terminated if any of these four conditions occur.

When you curl up, the upper body must come to an upright position before going back down (see Figure 7.3e). The repetitions are performed to a two-step cadence (up-down) regulated with the metronome set at 40 beats per minute. For this exercise, you should allow a brief practice period of 5 to 10 seconds to familiarize yourself with the cadence (the up movement is initiated with the first beat, then you must wait for the next beat to initiate the down movement; one repetition is accomplished every two beats of the metronome). Count as many repetitions as you are able to perform following the proper cadence. The test is also terminated if you fail to maintain the appropriate cadence or if you accomplish 100 repetitions. Have your partner check the angle at the knees throughout the test to make sure to maintain the 100° angle as close as possible.

**Abdominal crunch.** This test is recommended only for individuals who are unable to perform the bent-leg curl-up test because of susceptibility to low back injury. Exercise form must be carefully monitored during the test. Several authors and researchers have indicated that proper form during this test is extremely difficult to control. Subjects often slide their bodies, bend their elbows, or shrug their shoulders during the test. Such actions facilitate the performance of the test and misrepresent the actual test results. Biomechanical factors also limit the ability to perform this test. Further, lack of spinal flexibility keeps some individuals from being able to move the full 3\( \frac{1}{2} \) range of motion. Others are unable to keep their heels on the floor during the test. The validity of this test as an effective measure of abdominal strength or abdominal endurance has also been questioned through research.

Tape a 3\( \frac{1}{2} \) × 30" strip of cardboard onto the floor. Lie down on the floor in a supine position (face up) with the knees bent at approximately 100°. The feet should be on the floor, and you must hold them in place throughout the test. Straighten out your arms and place them on the floor alongside the trunk with the palms down and the fingers fully extended. The fingertips of both hands should barely touch the closest edge of the cardboard (see Figure 7.3f). Bring the head off the floor until the chin is 1 to 2" away from your chest. Keep the head in this position during the entire test (do not move the head by flexing or extending the neck). You are now ready to begin the test.

Perform the repetitions to a two-step cadence (up-down) regulated with a metronome set at 60 beats per minute. As you curl up, slide the fingers over the cardboard until the fingertips reach the far edge (3\( \frac{1}{2} \)) of the board (see Figure 7.3g), then return to the starting position.

Allow a brief practice period of 5 to 10 seconds to familiarize yourself with the cadence. Initiate the up movement with the first beat and the down movement with the next beat. Accomplish one repetition every two beats of the metronome. Count as many repetitions as you are able to perform following the proper cadence. You may not count a repetition if the fingertips fail to reach the distant edge of the cardboard.

Terminate the test if you (a) fail to maintain the appropriate cadence, (b) bend the elbows, (c) shrug the shoulders, (d) slide (continued)
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Figure 7.3  Muscular Endurance Test. (continued)

the body, (e) lift heels off the floor, (f) raise the chin off the chest, (g) accomplish 100 repetitions, or (h) no longer can perform the test. Have your partner check the angle at the knees throughout the test to make sure that the 100° angle is maintained as closely as possible.

For this test you may also use a Crunch-Ster Curl-Up Tester, available from Novel Products.* An illustration of the test performed with this equipment is provided in Figures 7.3h and 7.3i.

According to the results, look up your percentile rank for each exercise in the far left column of Table 7.2 and determine your muscular endurance fitness category according to the following classification:

<table>
<thead>
<tr>
<th>Average Score</th>
<th>Fitness Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥90</td>
<td>Excellent</td>
<td>5</td>
</tr>
<tr>
<td>70–80</td>
<td>Good</td>
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<tr>
<td>≤20</td>
<td>Poor</td>
<td>1</td>
</tr>
</tbody>
</table>

Look up the number of points assigned for each fitness category above. Total the number of points and determine your overall strength endurance fitness category according to the following ratings:

<table>
<thead>
<tr>
<th>Total Points</th>
<th>Strength Endurance Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥13</td>
<td>Excellent</td>
</tr>
<tr>
<td>10–12</td>
<td>Good</td>
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<td>7–9</td>
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<tr>
<td>4–6</td>
<td>Fair</td>
</tr>
<tr>
<td>≤3</td>
<td>Poor</td>
</tr>
</tbody>
</table>

*Novel Products, Inc. Figure Finder Collection, P.O. Box 408, Rockton, IL 61072-0408. 1-800-323-5143, Fax 815-624-4866.

Table 7.2  Muscular Endurance Scoring Table

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bench Jumps</td>
<td>Modified Dips</td>
</tr>
<tr>
<td>99</td>
<td>66</td>
<td>54</td>
</tr>
<tr>
<td>95</td>
<td>63</td>
<td>50</td>
</tr>
<tr>
<td>90</td>
<td>62</td>
<td>38</td>
</tr>
<tr>
<td>80</td>
<td>58</td>
<td>32</td>
</tr>
<tr>
<td>70</td>
<td>57</td>
<td>30</td>
</tr>
<tr>
<td>60</td>
<td>56</td>
<td>27</td>
</tr>
<tr>
<td>50</td>
<td>54</td>
<td>26</td>
</tr>
<tr>
<td>40</td>
<td>51</td>
<td>23</td>
</tr>
<tr>
<td>30</td>
<td>48</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>47</td>
<td>17</td>
</tr>
<tr>
<td>10</td>
<td>40</td>
<td>11</td>
</tr>
<tr>
<td>5</td>
<td>34</td>
<td>7</td>
</tr>
</tbody>
</table>

[Table image]

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1. Familiarize yourself with the six lifts used for this test: lat pull-down, leg extension, bench press, bent-leg curl-up or abdominal crunch,* leg curl, and arm curl. Graphic illustrations for each lift are given at the end of this chapter. For the leg curl exercise, the knees should be flexed to 90°. A description and illustration of the bent-leg curl-up and the abdominal crunch exercises are provided in Figure 7.3. On the leg extension lift, maintain the trunk in an upright position.

2. Determine your body weight in pounds.

3. Determine the amount of resistance to be used on each lift. To obtain this number, multiply your body weight by the percent given below for each lift.

<table>
<thead>
<tr>
<th>Lift</th>
<th>Percent of Body Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat Pull-Down</td>
<td>.70 .45</td>
</tr>
<tr>
<td>Leg Extension</td>
<td>.65 .50</td>
</tr>
<tr>
<td>Bench Press</td>
<td>.75 .45</td>
</tr>
<tr>
<td>Bent-Leg Curl-Up or Abdominal Crunch*</td>
<td>NA** NA**</td>
</tr>
<tr>
<td>Leg Curl</td>
<td>.32 .25</td>
</tr>
<tr>
<td>Arm Curl</td>
<td>.35 .18</td>
</tr>
</tbody>
</table>

*The abdominal crunch exercise should be used only by individuals who suffer or are susceptible to low back pain.
**NA = not applicable—see Figure 7.3.

4. Perform the maximum continuous number of repetitions possible.

5. Based on the number of repetitions performed, look up the percentile rank for each lift in the left column of Table 7.3.

6. The individual strength fitness category is determined according to the following classification:

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Fitness Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥90</td>
<td>Excellent</td>
<td>5</td>
</tr>
<tr>
<td>70–80</td>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>50–60</td>
<td>Average</td>
<td>3</td>
</tr>
<tr>
<td>30–40</td>
<td>Fair</td>
<td>2</td>
</tr>
<tr>
<td>≤20</td>
<td>Poor</td>
<td>1</td>
</tr>
</tbody>
</table>

7. Look up the number of points assigned for each fitness category under item 6 above. Total the number of points and determine your overall strength fitness category according to the following ratings:

<table>
<thead>
<tr>
<th>Total Points</th>
<th>Strength Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥25</td>
<td>Excellent</td>
</tr>
<tr>
<td>19–24</td>
<td>Good</td>
</tr>
<tr>
<td>13–18</td>
<td>Average</td>
</tr>
<tr>
<td>7–12</td>
<td>Fair</td>
</tr>
<tr>
<td>≤6</td>
<td>Poor</td>
</tr>
</tbody>
</table>

8. Record your results in Activity 7.1.

---

**Table 7.3: Muscular Strength and Endurance Scoring Table**

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Men</th>
<th>Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>95</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>90</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>80</td>
<td>16</td>
<td>15</td>
</tr>
<tr>
<td>70</td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>60</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>50</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>40</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>30</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>20</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

---

**Figure 7.4: Muscular Strength and Endurance Test.**

1. Familiarize yourself with the six lifts used for this test: lat pull-down, leg extension, bench press, bent-leg curl-up or abdominal crunch,* leg curl, and arm curl. Graphic illustrations for each lift are given at the end of this chapter. For the leg curl exercise, the knees should be flexed to 90°. A description and illustration of the bent-leg curl-up and the abdominal crunch exercises are provided in Figure 7.3. On the leg extension lift, maintain the trunk in an upright position.

2. Determine your body weight in pounds.

3. Determine the amount of resistance to be used on each lift. To obtain this number, multiply your body weight by the percent given below for each lift.

<table>
<thead>
<tr>
<th>Lift</th>
<th>Percent of Body Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat Pull-Down</td>
<td>.70 .45</td>
</tr>
<tr>
<td>Leg Extension</td>
<td>.65 .50</td>
</tr>
<tr>
<td>Bench Press</td>
<td>.75 .45</td>
</tr>
<tr>
<td>Bent-Leg Curl-Up or Abdominal Crunch*</td>
<td>NA** NA**</td>
</tr>
<tr>
<td>Leg Curl</td>
<td>.32 .25</td>
</tr>
<tr>
<td>Arm Curl</td>
<td>.35 .18</td>
</tr>
</tbody>
</table>

*The abdominal crunch exercise should be used only by individuals who suffer or are susceptible to low back pain.
**NA = not applicable—see Figure 7.3.

4. Perform the maximum continuous number of repetitions possible.

5. Based on the number of repetitions performed, look up the percentile rank for each lift in the left column of Table 7.3.

6. The individual strength fitness category is determined according to the following classification:

<table>
<thead>
<tr>
<th>Percentile Rank</th>
<th>Fitness Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥90</td>
<td>Excellent</td>
<td>5</td>
</tr>
<tr>
<td>70–80</td>
<td>Good</td>
<td>4</td>
</tr>
<tr>
<td>50–60</td>
<td>Average</td>
<td>3</td>
</tr>
<tr>
<td>30–40</td>
<td>Fair</td>
<td>2</td>
</tr>
<tr>
<td>≤20</td>
<td>Poor</td>
<td>1</td>
</tr>
</tbody>
</table>

7. Look up the number of points assigned for each fitness category under item 6 above. Total the number of points and determine your overall strength fitness category according to the following ratings:

<table>
<thead>
<tr>
<th>Total Points</th>
<th>Strength Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥25</td>
<td>Excellent</td>
</tr>
<tr>
<td>19–24</td>
<td>Good</td>
</tr>
<tr>
<td>13–18</td>
<td>Average</td>
</tr>
<tr>
<td>7–12</td>
<td>Fair</td>
</tr>
<tr>
<td>≤6</td>
<td>Poor</td>
</tr>
</tbody>
</table>

8. Record your results in Activity 7.1.
Muscular Strength and Endurance Assessment

Name: ____________________________ Date: __________

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

I. Hand Grip Strength Test
Instructions are provided in Figure 7.2, page 229. Perform the test according to the instructions and look up your results in Table 7.1, page 230.

Hand used: □ Right   □ Left
Reading: __________ lbs.
Fitness category (see Figure 7.2, page 229): ______________________

II. Muscular Endurance Test
Conduct this test using the guidelines provided in Figure 7.3, pages 231–232, and Table 7.2, page 232. Record your repetitions, fitness category, and points in the spaces provided below.

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Metronome Cadence</th>
<th>Repetitions</th>
<th>Fitness Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench jumps</td>
<td>none</td>
<td>__________</td>
<td>__________</td>
<td>______</td>
</tr>
<tr>
<td>Modified dips—men only</td>
<td>56 bpm</td>
<td>__________</td>
<td>__________</td>
<td>______</td>
</tr>
<tr>
<td>Modified push-ups—women only</td>
<td>56 bpm</td>
<td>__________</td>
<td>__________</td>
<td>______</td>
</tr>
<tr>
<td>Bent-leg curl-ups</td>
<td>40 bpm</td>
<td>__________</td>
<td>__________</td>
<td>______</td>
</tr>
<tr>
<td>Abdominal crunches</td>
<td>60 bpm</td>
<td>__________</td>
<td>__________</td>
<td>______</td>
</tr>
</tbody>
</table>

Total Points: __________

Overall muscular endurance fitness category (see end of Figure 7.3, page 232): ____________________________
**Muscular Strength and Endurance Assessment (continued)**

### III. Muscular Strength and Endurance Test

Perform the Muscular Strength and Endurance Test according to the procedure outlined in Figure 7.4, page 233. Record the results, fitness category, and points in the appropriate blanks provided below.

**Body weight:** [ ] lbs.

<table>
<thead>
<tr>
<th>Lift</th>
<th>Percent of Body Weight (pounds)</th>
<th>Resistance</th>
<th>Repetitions</th>
<th>Fitness Category</th>
<th>Points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lat pull-down</td>
<td>.70</td>
<td>.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg extension</td>
<td>.65</td>
<td>.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bench press</td>
<td>.75</td>
<td>.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bent-leg curl-up or abdominal crunch</td>
<td>NA*</td>
<td>NA*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg curl</td>
<td>.32</td>
<td>.25</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm curl</td>
<td>.35</td>
<td>.18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Not applicable—no resistance required. Use test described in Figure 7.3, pages 231–232.

Overall muscular strength fitness category (see Figure 7.4, page 233): [ ]

### IV. Muscular Strength and Endurance Goals

Indicate the muscular strength/endurance category that you would like to achieve by the end of the term: [ ]

**Behavior Modification**

Briefly state your feelings about your current strength level and indicate how you are planning to achieve your strength objective:

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
Strength-Training Prescription

The capacity of muscle cells to exert force increases and decreases according to the demands placed upon the muscular system. If muscle cells are overloaded beyond their normal use, such as in strength-training programs, the cells increase in size (hypertrophy) and strength. If the demands placed on the muscle cells decrease, such as in sedentary living or required rest because of illness or injury, the cells atrophy and lose strength. A good level of muscular strength is important to develop and maintain fitness, health, and total well-being.

Factors That Affect Strength

Several physiological factors combine to create muscle contraction and subsequent strength gains: neural stimulation, type of muscle fiber, overload, specificity of training, training volume, and periodization. Basic knowledge of these concepts is important to understand the principles involved in strength development.

Neural Function

Within the neuromuscular system, single motor neurons branch and attach to multiple muscle fibers. The motor neuron and the fibers it innervates (supplies with nerves) form a motor unit. The number of fibers that a motor neuron can innervate varies from just a few in muscles that require precise control (e.g., eye muscles) to as many as 1,000 or more in large muscles that do not perform refined or precise movements.

Stimulation of a motor neuron causes the muscle fibers to contract maximally or not at all. Variations in the number of fibers innervated and the frequency of their stimulation determine the strength of the muscle contraction. As the number of fibers innervated and frequency of stimulation increase, so does the strength of the muscular contraction.

Neural adaptations are prominent in the early stages of strength training. In novice participants, significant strength increases seen during the first two to three weeks of training are largely related to enhanced neural function by increasing motor neuron stimulation and muscle fiber recruitment (skill acquisition). Long-term strength development is primarily related to increased physiological adaptation within the muscle(s) and to a lesser extent to continued neural adaptations.

Types of Muscle Fiber

The human body has two basic types of muscle fibers: (a) slow-twitch or red fibers and (b) fast-twitch or white fibers. Slow-twitch fibers have a greater capacity for aerobic work. Fast-twitch fibers have a greater capacity for anaerobic work and produce more overall force. The latter are important for quick and powerful movements commonly used in strength-training activities.

The proportion of slow- and fast-twitch fibers is determined genetically and consequently varies from one person to another. Nevertheless, training increases the functional capacity of both types of fiber, and more specifically, strength training increases their ability to exert force.

During muscular contraction, slow-twitch fibers always are recruited first. As the force and speed of muscle contraction increase, the relative importance of the fast-twitch fibers increases. To activate the fast-twitch fibers, an activity must be intense and powerful.

Overload

Strength gains are achieved in two ways:

1. Through increased ability of individual muscle fibers to generate a stronger contraction
2. By recruiting a greater proportion of the total available fibers for each contraction

These two factors combine in the overload principle. The demands placed on the muscle must be increased systematically and progressively over time, and the resistance must be of a magnitude significant enough to cause physiological adaptation. In simpler terms, just like all other organs and systems of the human body, to increase in physical capacity, muscles have to be taxed repeatedly beyond their accustomed loads. Because of this principle, strength training also is called progressive resistance training.

Several procedures can be used to overload in strength training:

1. Increasing the intensity (resistance of amount of weight used)
2. Increasing the number of repetitions at the current intensity
3. Increasing or decreasing the speed at which the repetitions are performed
4. Decreasing the rest interval for endurance improvements (with lighter resistances) or lengthening the rest interval for strength and power development (with higher resistances)
5. Increasing the volume (sum of the repetitions performed multiplied by the resistance used)
6. Using any combination of the above

Specificity of Training

Training adaptations are specific to the impetus applied. In strength training, the principle of specificity of training holds that for a muscle to increase in strength or endurance, the training program must be specific to obtain the desired effects (see also the discussion on resistance on pages 240–241).

The principle of specificity also applies to activity or sport-specific development and is commonly referred to as specific adaptation to imposed demand (SAID) training. The SAID principle implies that if an individual is attempting to improve specific sport skills, the
Muscular Strength and Endurance

The combination of a motor neuron and the nerves connecting the central nervous system to the muscle fibers with greater aerobic potential and slow speed of contraction.

Training Volume

**Volume** is the sum of all the repetitions performed multiplied by the resistances used during a strength-training session. Volume is used to quantify the amount of work performed in a given training session. For example, an individual who does three sets of six repetitions with 150 pounds has performed a training volume of 2,700 (3 × 6 × 150) for this exercise. The total training volume can be obtained by totaling the volume of all exercises performed.

The volume of training done in a strength-training session can be modified by changing the total number of exercises performed, the number of sets done per exercise, or the number of repetitions performed per set. Athletes typically use high training volumes and low intensities to achieve muscle hypertrophy, and low volumes and high intensities to increase strength and power.

Periodization

The concept of periodization (variation) entails systematically altering training variables over time to keep the program challenging and lead to greater strength development. Periodization means cycling one’s training objectives (hypertrophy, strength, and endurance), with each phase of the program lasting anywhere from 2 to 12 weeks. Training variables altered include resistance (weight lifted), number of repetitions, number of sets, and/or number of exercises performed.

The periodized training approach is popular among athletes and is frequently used to prevent overtraining. Training volume should not increase by more than 5 percent from one phase to the next. Periodization now is popular among fitness participants who wish to achieve maximal strength gains. Over the long run, for intermediate and advanced participants, the periodized approach has been shown to be superior to nonperiodized training (using the same exercises, sets, and repetitions repeatedly).

Three types of periodized training, based on program design and objectives, are commonly used. These are:

- **Classical Periodization.** The classical or linear model is used by individuals seeking maximal strength development. It starts with an initial high volume of training using low resistances. In subsequent cycles, the program gradually switches to a lower volume and higher resistances.
- **Reverse Periodization.** A model used primarily by individuals seeking greater muscular endurance.
- **Undulating Periodization.** This model uses a combination of volumes and resistances within a cycle by alternating in a nonlinear fashion (randomly or systematically) among the muscular fitness components: strength, hypertrophy, power, and endurance. The undulating model compares favorably, and in some cases, it is even superior to the classical and reverse models.

Understanding all five training concepts that affect strength (neural stimulation, muscle fiber types, overload, specificity, and periodization) discussed thus far is required to design an effective strength-training program.

**Principles Involved in Strength Training**

Because muscular strength and endurance are important in developing and maintaining overall fitness and well-being, the principles necessary to develop a strength-training program are as follows:

- **Atrophy** Decrease in the size of a cell.
- **Motor neurons** Nerves connecting the central nervous system to the muscle.
- **Motor unit** The combination of a motor neuron and the muscle fibers that neuron innervates.
- **Slow-twitch fibers** Muscle fibers with greater aerobic potential and slow speed of contraction.
- **Fast-twitch fibers** Muscle fibers with greater anaerobic potential and fast speed of contraction.
- **Overload principle** Training concept that the demands placed on a system (cardiorespiratory or muscular) must be increased systematically and progressively over time to cause physiological adaptation (development or improvement).
- **Specificity of training** Principle that training must be done with the specific muscle(s) the person is attempting to improve.
- **Specific adaptation to imposed demand (SAID) training** Training principle stating that, for improvements to occur in a specific activity, the exercises performed during a strength-training program should resemble as closely as possible the movement patterns encountered in that particular activity.
- **Volume (in strength training)** The sum of all repetitions performed multiplied by the resistance used during a training session.
- **Periodization** A training approach that divides the season into cycles using a systematic variation in intensity and volume of training to enhance fitness and performance.
- **Overtraining** An emotional, behavioral, and physical condition marked by increased fatigue, decreased performance, persistent muscle soreness, mood disturbances, and feelings of “staleness” or “burnout” as a result of excessive physical training.
training program have to be understood, just as in the prescription for cardiorespiratory endurance. These principles are mode, resistance, sets, frequency, and volume of training. The key factor in successful muscular strength development, however, is the individualization of the program according to these principles and the person’s goals, as well as the magnitude of the individual’s effort during training itself.7

Mode of Training

Two types of training methods are used to improve strength: isometric (static) and dynamic (previously called “isotonic”). In isometric training, muscle contractions produce little or no movement, such as pushing or pulling against an immovable object or holding a given position against resistance for a given period of time. In dynamic training, the muscle contractions produce movement, such as extending the knees with resistance on the ankles (leg extension). The specificity of training principle applies here, too. To increase isometric versus dynamic strength, an individual must use static instead of dynamic training to achieve the desired results.

Isometric Training

Isometric training does not require much equipment. Because strength gains with isometric training are specific to the angle of muscle contraction, this type of training is beneficial in a sport such as gymnastics, which requires regular static contractions during routines. As presented in Chapter 8, however, isometric training is a critical component of health conditioning programs for the low back (see “Preventing and Rehabilitating Low Back Pain,” pages 284–288) and for spinal-stabilization musculature and healthy posture. Selected exercises, in particular core exercises, are recommended as a part of a comprehensive strength-training program.

In isometric training, muscle contraction produces little or no movement.

Dynamic Training

Dynamic training is the most common mode for strength training. The primary advantage is that strength is gained through the full range of motion. Most daily activities are dynamic in nature. We are constantly lifting, pushing, and pulling objects, and strength is needed through a complete range of motions. Another advantage is that improvements are measured easily by the amount lifted.

Dynamic training consists of two action phases when an exercise is performed: (1) concentric or positive resistance and (2) eccentric or negative resistance. In the concentric phase, the muscle shortens as it contracts to overcome the resistance. In the eccentric phase, the muscle lengthens to overcome the resistance. For example, during a bench press exercise, when the person lifts the resistance from the chest to full-arm extension, the triceps muscle on the back of the upper arm shortens to extend (straighten) the elbow. During the eccentric phase, the same triceps muscle is used to lower the weight during elbow flexion, but the muscle lengthens slowly to avoid dropping the resistance. Both motions work the same muscle against the same resistance.

Eccentric muscle contractions allow us to lower weights in a smooth, gradual, and controlled manner. Without eccentric contractions, weights would be suddenly dropped on the way down. Because the same muscles work when you lift and lower a resistance, always be sure to execute both actions in a controlled manner. Failure to do so diminishes the benefits of the training program and increases the risk for injuries. Eccentric contractions seem to be more effective in producing muscle hypertrophy but result in greater muscle soreness.8

Dynamic training programs can be conducted without weights; using exercise bands; and with free weights, fixed-resistance machines, variable-resistance machines, or isokinetic equipment. When you perform dynamic exercises without weights (e.g., pull-ups and push-ups), with free weights, or with fixed-resistance machines, you...
move a constant resistance through a joint’s full range of motion. The greatest resistance that can be lifted equals the maximum weight that can be moved at the weakest angle of the joint. This is because of changes in length of muscle and angle of pull as the joint moves through its range of motion. This type of training is also referred to as dynamic constant external resistance or DCER.

As strength training became more popular, new strength-training machines were developed. This technology brought about isokinetic training and variable-resistance training programs, which require special machines equipped with mechanical devices that provide differing amounts of resistance, with the intent of overloading the muscle group maximally through the entire range of motion. A distinction of isokinetic training is that the speed of the muscle contraction is kept constant because the machine provides resistance to match the user’s force through the range of motion. The mode of training that an individual selects depends mainly on the type of equipment available and the specific objective the training program is attempting to accomplish.

The benefits of isokinetic and variable-resistance training are similar to those of the other dynamic training methods. Theoretically, strength gains should be better because maximum resistance is applied at all angles. Research, however, has not shown this type of training to be more effective than other modes of dynamic training.

Free Weights versus Machines in Dynamic Training

The most popular weight-training devices available during the first half of the 20th century were plate-loaded barbells (free weights). Strength-training machines were developed in the middle of the century but did not become popular until the 1970s. With subsequent technological improvements to these machines, a debate arose over which of the two training modalities was better.

Free weights require that the individual balance the resistance through the entire lifting motion. Thus, one could logically assume that free weights are a better training modality because additional stabilizing muscles are needed to balance the resistance as it is moved through the range of motion. Research, however, has not shown any differences in strength development between the two exercise modalities.9

Key Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Isometric training</strong></td>
<td>Strength-training method referring to a muscle contraction that produces little or no movement, such as pushing or pulling against an immovable object.</td>
</tr>
<tr>
<td><strong>Range of motion</strong></td>
<td>Entire arc of movement of a given joint.</td>
</tr>
<tr>
<td><strong>Dynamic training</strong></td>
<td>Strength-training method referring to a muscle contraction with movement.</td>
</tr>
<tr>
<td><strong>Concentric</strong></td>
<td>Describes shortening of a muscle during muscle contraction.</td>
</tr>
<tr>
<td><strong>Positive resistance</strong></td>
<td>The lifting, pushing, or concentric phase of a repetition during a strength-training exercise.</td>
</tr>
<tr>
<td><strong>Eccentric</strong></td>
<td>Describes lengthening of a muscle during muscle contraction.</td>
</tr>
<tr>
<td><strong>Negative resistance</strong></td>
<td>The lowering or eccentric phase of a repetition during a strength-training exercise.</td>
</tr>
<tr>
<td><strong>Free weights</strong></td>
<td>Barbells and dumbbells.</td>
</tr>
<tr>
<td><strong>Fixed resistance</strong></td>
<td>Type of exercise in which a constant resistance is moved through a joint’s full range of motion (dumbbells, barbells, machines using a constant resistance).</td>
</tr>
<tr>
<td><strong>Variable resistance</strong></td>
<td>Training using special machines equipped with mechanical devices that provide differing amounts of resistance through the range of motion.</td>
</tr>
<tr>
<td><strong>Dynamic constant external resistance (DCER)</strong></td>
<td>See Fixed resistance.</td>
</tr>
<tr>
<td><strong>Isokinetic training</strong></td>
<td>Strength-training method in which the speed of the muscle contraction is kept constant because the equipment (machine) provides an accommodating resistance to match the user’s force (maximal) through the range of motion.</td>
</tr>
</tbody>
</table>
Advantages of Free Weights
Following are the advantages of using free weights instead of machines in a strength-training program:

- Cost: Free weights are much less expensive than most exercise machines. On a limited budget, free weights are a better option.
- Variety: A bar and a few plates can be used to perform many exercises to strengthen most muscles in the body.
- Portability: Free weights can be easily moved from one area or station to another.
- Coordination: Free weights require greater muscular coordination that mimic movement requirements of specific tasks.
- Balance: Free weights require that a person balance the weight through the entire range of motion. This feature involves additional stabilizing muscles to keep the weight moving properly.
- One size fits all: People of almost all ages can use free weights. A drawback of machines is that individuals who are at the extremes in terms of height or limb length often do not fit into the machines. In particular, small women and adolescents are at a disadvantage.

Advantages of Machines
Strength-training machines have the following advantages over free weights:

- Safety: Machines are safer because spotters are rarely needed to monitor exercises.
- Selection: A few exercises—such as hip flexion, hip abduction, leg curls, lat pull-downs, and neck exercises—can be performed only with machines.
- Variable resistance: Most machines provide variable resistance. Free weights provide only fixed resistance.
- Isolation: Individual muscles are better isolated with machines because stabilizing muscles are not used to balance the weight during the exercise.
- Time: Exercising with machines requires less time because you can set the resistance quickly by using a selector pin instead of having to manually change dumbbells or weight plates on both sides of a barbell.
- Flexibility: Most machines can provide resistance over a greater range of movement during the exercise, thereby contributing to more flexibility in the joints. For example, a barbell pullover exercise provides resistance over a range of 100 degrees, whereas a weight machine may allow for as much as 260 degrees.
- Rehabilitation: Machines are more useful during injury rehabilitation. A knee injury, for instance, is practically impossible to rehab using free weights, whereas with a weight machine, small loads can be easily selected through a limited range of motion.
- Skill acquisition: Learning a new exercise movement—and performing it correctly—is faster because the machine controls the direction of the movement.

Although each modality has pros and cons, muscles do not know whether the source of a resistance is a barbell, a dumbbell, a Universal Gym machine, a Nautilus machine, or a simple cinder block. What determines the extent of a person’s strength development is the quality of the program and the individual’s effort during the training program itself—not the type of equipment used. Currently, the general recommendation is that both machines and free weights be used by beginners and intermediate participants, whereas advanced participants are encouraged to use primarily free weights.

Resistance

Resistance in strength training is the equivalent of intensity in cardiorespiratory exercise prescription. To stimulate strength development, the general recommendation has been to use a resistance of approximately 80 percent of the maximum capacity (1 RM). For example, a person with a 1 RM of 150 pounds should work with about 120 pounds (150 × .80).

The number of repetitions that one can perform at 80 percent of the 1 RM varies among exercises (i.e., bench press, lat pull-down, leg curl; see Table 7.4). Data indicate that the total number of repetitions performed at a certain percentage of the 1 RM depends on the amount of muscle mass involved (bench press versus triceps extension) and whether it is a single- or multi-joint exercise (leg press versus leg curl). In trained and untrained subjects alike, the number of repetitions is greater with larger muscle mass involvement and multi-joint exercises.10

Because of the time factor involved in constantly determining the 1 RM on each lift to ensure that the person is indeed working around 80 percent, the accepted rule for many years has been that individuals perform between 8 and 12 repetitions maximum (or 8 to 12 RM zone) for

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Trained Men</th>
<th>Trained Women</th>
<th>Untrained Men</th>
<th>Untrained Women</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leg press</td>
<td>19</td>
<td>22</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>Lat pull-down</td>
<td>12</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Bench press</td>
<td>12</td>
<td>14</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>Leg extension</td>
<td>12</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Sit-up*</td>
<td>12</td>
<td>12</td>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>Arm curl</td>
<td>11</td>
<td>7</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Leg curl</td>
<td>7</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
</tbody>
</table>

*Sit-up exercise performed with weighted plates on the chest and feet held in place with an ankle strap.

adequate strength gains. For instance, if a person is training with a resistance of 120 pounds and cannot lift it more than 12 times—that is, the person reaches volitional fatigue at or before 12 repetitions—the training stimulus (weight used) is adequate for strength development. Once the person can lift the resistance more than 12 times, the resistance is increased by 5 to 10 pounds and the person again should build up to 12 repetitions. This is referred to as progressive resistance training.

Strength development, however, also can occur when working with less than 80 percent of the 1 RM (60 percent to 80 percent). Although the 8 to 12 RM zone is the most commonly prescribed resistance training zone, benefits do accrue when working below 8 RM or above 12 RM. If the main objective of the training program is muscular endurance, 15 to 25 repetitions per set are recommended. Older adults and individuals susceptible to musculoskeletal injuries are encouraged to work with 10 to 15 repetitions using moderate resistances (about 50 percent to 60 percent of the 1 RM).

In both young and older individuals, all repetitions should be performed at a moderate velocity (about 1 second concentric and 1 second eccentric), as such yields the greatest strength gains. For advanced training, varying training velocity between sets, from very slow to fast, are recommended.

Elite strength and power athletes typically work between 1 and 6 RM, but they often shuffle training (periodized training) with a different number of repetitions and sets for selected periods (weeks) of time. Body builders tend to work with moderate resistance levels (60 to 85 percent of the 1 RM) and perform 8 to 20 repetitions to near fatigue. A foremost objective of body building is to increase muscle size. Moderate resistance promotes blood flow to the muscles, “pumping up the muscles” (also known as “the pump”), which makes them look much larger than they do in a resting state.

From a general fitness point of view, a moderate resistance of only about 50 percent should be used initially while learning proper form and lifting technique. Following the first two weeks of training, working near a 10-repetition threshold seems to improve overall performance most effectively. We live in a dynamic world in which muscular strength and endurance are both required to lead an enjoyable life. Working around 10 RM produces good results in terms of strength, endurance, and hypertrophy. To maximize training development, advanced participants are encouraged to cycle between 1 and 12 RM.

Sets

In strength training, a set is the number of repetitions performed for a given exercise. For example, a person lifting 120 pounds eight times has performed one set of eight repetitions (1 × 8 × 120). For general fitness, the recommendation is two to four sets per exercise (advanced participants often train with up to six sets per exercise).

When performing multiple sets using the RM zone with the same resistance, if the person truly performs 12 RM to muscle fatigue (or close to it), in subsequent sets fewer RM will be performed (perhaps 10, 9, and 7 RM). Because of the characteristics of muscle fiber, the number of sets the exerciser can do is limited. As the number of sets increases, so does the amount of muscle fatigue and subsequent recovery time.

When time is a factor, and although multiple-set training is most beneficial, single-set programs are still effective, as long as the single set is performed within the RM zone to muscular fatigue. You may also choose to do two sets for multi-joint exercises (bench press, leg press, lat pull-down) and a single RM-zone set for single-joint exercises (arm curl, triceps extension, knee extension).

A recommended program for beginners in their first year of training is one or two light warm-up sets per exercise, using about 50 percent of the 1 RM (no warm-up sets are necessary for subsequent exercises that use the same muscle group), followed by one to four sets to near fatigue per exercise. Maintaining a resistance and effort that will temporarily fatigue the muscle (volitional exhaustion) from the number of repetitions selected in at least one of the sets is crucial to achieve optimal progress. Because of the lower resistances used in body building, four to eight sets can be done for each exercise.

To avoid muscle soreness and stiffness, new participants ought to build up gradually to the three to four sets of maximal repetitions. They can do this by performing only one set of each exercise with a lighter resistance on the first day of training, two sets of each exercise on the second day—the first light and the second with the required resistance to volitional exhaustion. If you choose to do so, you can increase to three sets on the third day—one light and two heavy. After that, a person should be able to perform anywhere from two to four sets as planned.

The time necessary to recover between sets depends mainly on the resistance used during each set. In strength training, the energy to lift heavy weights is derived primarily from the system involving adenosine triphosphate (ATP) and creatine phosphate (CP) or phosphagen (see Chapter 3, “Energy (ATP) Production,” pages 107–108). Ten seconds of maximal exercise nearly depletes the CP stores in the exercised muscle(s). These stores are replenished in about 3 to 5 minutes of recovery.

Key Terms

Resistance Amount of weight lifted.
Progressive resistance training A gradual increase of resistance over a period of time.
Set A fixed number of repetitions; one set of bench press might be 10 repetitions.
Based on this principle, rest intervals between sets vary in length depending on the program goals and are dictated by the amount of resistance used in training. Short rest intervals of less than 2 minutes are commonly used when one is trying to develop local muscular endurance. Moderate rest intervals of 2 to 4 minutes are used for strength development. Long intervals of more than 4 minutes are used when one is training for power development. 

Using these guidelines, individuals training for health fitness purposes might allow 2 minutes of rest between sets. Body builders, who use lower resistances, should rest no more than 1 minute to maximize the “pumping” effect.

For individuals who are trying to maximize strength gains, the exercise program will be more time-effective if two or three exercises are alternated that require different muscle groups, called circuit training. In this way, an individual will not have to wait 2 to 3 minutes before proceeding to a new set on a different exercise. For example, the bench press, leg extension, and abdominal curl-up exercises may be combined so that the person can go almost directly from one exercise set to the next.

Men and women alike should observe the guidelines given previously. Many women do not follow them. They erroneously believe that training with low resistances and many repetitions is best to enhance body composition and maximize energy expenditure. Unless a person is seeking to increase muscular endurance for a specific sport-related activity, the use of low resistances and high repetitions is not recommended to achieve optimal strength-fitness goals and maximize long-term energy expenditure.

**Frequency**

In the early stages of training, strength training should be done through a total body workout two to three times a week. Training can be performed more frequently if using a split-body routine, that is, upper body one day and lower body the next. After a maximum strength workout, the trained muscles should be rested at least 2 days (about 48 hours) to allow adequate recovery. If not completely recovered in 2 to 3 days, the person most likely is overtraining and therefore not reaping the full benefits of the program. In that case, the person should do fewer sets of exercises than in the previous workout. A summary of strength-training guidelines for health fitness purposes is provided in Figure 7.5.

To achieve significant strength gains, a minimum of 8 weeks of consecutive training is necessary. After an individual has achieved a recommended strength level, from a health fitness standpoint, one to two training sessions per week will be sufficient to maintain it. Highly trained athletes have to train twice a week to maintain their strength levels.

Frequency of strength training for body builders varies from person to person. Because they use moderate resistance, daily or even two-a-day workouts are common.

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**Figure 7.5** Strength-training guidelines.

| Mode: | Select 8 to 10 dynamic strength-training exercises that involve the body’s major muscle groups and include opposing muscle groups (chest and upper back, abdomen and lower back, front and back of the legs). |
| Resistance: | Sufficient resistance to perform 8 to 12 repetitions maximum for muscular strength and 15 to 25 repetitions to near fatigue for muscular endurance. Older adults and injury prone individuals should use 10 to 15 repetitions with moderate resistance (50% to 60% of their 1 RM). |
| Sets: | 2 to 4 sets per exercise with 2 to 3 minutes recovery between sets for optimal strength development. Less than 2 minutes per set if exercises are alternated that require different muscle groups (chest and upper back) or between muscular endurance sets. |
| Frequency: | 2 to 3 days per week on nonconsecutive days. More frequent training can be done if different muscle groups are exercised on different days. (Allow at least 48 hours between strength-training sessions of the same muscle group.) |

**Exercise Variations**

Multiple-joint and single-joint exercises are used in strength training. Multiple-joint exercises, such as the squat, bench press, and lat pull down, require more skill and complex neural responses. Multiple-joint exercises allow you to lift more weight and develop more strength.

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**Table 7.5** Guidelines for Various Strength-Training Programs

<table>
<thead>
<tr>
<th>Strength-Training Program</th>
<th>Resistance</th>
<th>Sets</th>
<th>Rest Between Sets*</th>
<th>Frequency (workouts per week)**</th>
</tr>
</thead>
<tbody>
<tr>
<td>General fitness</td>
<td>8–12 reps</td>
<td>2–4</td>
<td>2–3 min</td>
<td>2–3</td>
</tr>
<tr>
<td>Muscular endurance</td>
<td>15–25 reps</td>
<td>2–4</td>
<td>1–2 min</td>
<td>2–3</td>
</tr>
<tr>
<td>Maximal strength</td>
<td>1–6 reps</td>
<td>2–5</td>
<td>3 min</td>
<td>2–3</td>
</tr>
<tr>
<td>Body building</td>
<td>8–20 reps</td>
<td>3–8</td>
<td>up to 1 min</td>
<td>4–12</td>
</tr>
</tbody>
</table>

*Recovery between sets can be decreased by alternating exercises that use different muscle groups. **Weekly training sessions can be increased by using a split-body routine.
Single-joint exercises, such as the arm curl or knee extension, are used to target specific muscles for further development. Both are recommended for a comprehensive training program.

Many strength-training exercises can be performed bilaterally and unilaterally. Muscle activation differs between the two modes. Unilateral training can enhance selected sport skills, such as single-leg jumping, high jumping, and single-arm throwing. Unilateral training is also used extensively in rehab programs. For example, bilateral concentric knee extension followed by unilateral eccentric knee flexion is strongly recommended for individuals with weak knees and to prevent potential knee problems (see Exercise 28B). Both modes of training are recommended to maximize strength gains.

Plyometrics

Strength, speed, and explosiveness are all crucial for success in athletics. All three of these factors are enhanced with a progressive resistance-training program, but greater increases in speed and explosiveness are thought to be possible with plyometric exercise. The objective is to generate the greatest amount of force in the shortest time. A solid strength base is necessary before attempting plyometric exercises.

Plyometric training is popular in sports that require powerful movements, such as basketball, volleyball, sprinting, jumping, and gymnastics. A typical plyometric exercise involves jumping off and back onto a box, attempting to rebound as quickly as possible on each jump. Box heights are increased progressively from about 12 to 22 inches.

The bounding action attempts to take advantage of the stretch-recoil and stretch reflex characteristics of muscle. The rapid stretch applied to the muscle during contact with the ground is thought to augment muscle contraction, leading to more explosiveness. Plyometrics can be used, too, for strengthening upper body muscles. An example is doing push-ups so the extension of the arms is forceful enough to drive the hands (and body) completely off the floor during each repetition.

A drawback of plyometric training is its higher risk for injuries compared with conventional modes of progressive resistance training. For instance, the potential for injury in rebound exercise escalates with the increase in box height or the number of repetitions.

Strength Gains

A common question by many strength-training participants is: How quickly can strength gains be observed? Strength-training studies have revealed that most of the strength gains are seen in the first 8 weeks of training. The amount of improvement, however, is related to previous training status. Increases of 40 percent are seen in individuals with no previous strength-training experience, 16 percent in previously strength-trained people, and 10 percent in advanced individuals.13 Adhering to a periodized strength-training program can yield further improvements (see “Periodization,” Chapter 9).

Critical Thinking

Your roommate started a strength-training program last year and has seen good results. He is now strength training on a nearly daily basis and taking performance-enhancing supplements hoping to accelerate results. What are your feelings about his program? • What would you say (and not say) to him?

Strength-Training Exercises

The strength-training programs introduced on pages 254–270 provide a complete body workout. The major muscles of the human body referred to in the exercises are pointed out in Figure 7.6 and with the exercises themselves at the end of the chapter.
Only a minimum of equipment is required for the first program, Strength-Training Exercises without Weights (Exercises 1 through 14). You can conduct this program in your own home. Your body weight is used as the primary resistance for most exercises. A few exercises call for a friend’s help or some basic implements from around your house to provide greater resistance.

Strength-Training Exercises with Weights (Exercises 15 through 37) require machines as shown in the accompanying photographs. These exercises can be conducted on either fixed-resistance or variable-resistance equipment. Many of these exercises also can be performed with free weights. The first 13 of these exercises (15 to 27) are recommended to get a complete workout. You can do these exercises as circuit training. If time is a factor, as a minimum perform the first nine (15 through 23) exercises. Exercises 28 to 37 are supplemental or can replace some of the basic 13 (e.g., substitute Exercise 29 or 30 for 15; 31 for 16; 33 for 19; 34 for 24; 35 for 26; 32 for 27). Exercises 38 to 46 are stability ball exercises that can be used to complement your workout. Some of these exercises can also take the place of others that you use to strengthen similar muscle groups.

Selecting different exercises for a given muscle group is recommended between training sessions (e.g., chest press for bench press). No evidence indicates that a given exercise is best for a given muscle group. Changing exercises works the specific muscle group through a different range of motion and may change the difficulty of the exercise. Alternating exercises is also beneficial to avoid the monotony of repeating the same training program each training session.

Dietary Guidelines for Strength Development

Individuals who wish to enhance muscle growth and strength during periods of intense strength training should increase protein intake from .8 gram per kilogram of body weight per day to about 1.5 grams per kilogram of body weight per day. An additional 500 daily calories are also recommended to optimize muscle mass gain. If protein intake is already at 1.5 grams per kilogram of body weight, the additional 500 calories should come primarily from complex carbohydrates to provide extra nutrients to the body and glucose for the working muscles.

The time of day when carbohydrates and protein are consumed in relation to the strength-training workout also plays a role in promoting muscle growth. Studies suggest that consuming a pre-exercise snack consisting of a combination of carbohydrates and protein is beneficial to muscle development. The carbohydrates supply energy for training, and the availability of amino acids (the building blocks of protein) in the blood during training enhances muscle building. A peanut butter, turkey, or tuna sandwich, milk or yogurt and fruit, or nuts and fruit consumed 30 to 60 minutes before training are excellent choices for a pre-workout snack.

Consuming a carbohydrate/protein snack immediately following strength training and a second snack an hour thereafter further promotes muscle growth and strength development. Post-exercise carbohydrates help restore muscle glycogen depleted during training and, in combination with protein, induce an increase in blood insulin and growth hormone levels. These hormones are essential to the muscle-building process.

Muscle fibers also absorb a greater amount of amino acids up to 48 hours following strength training. The first hour, nonetheless, seems to be the most critical. A higher level of circulating amino acids in the bloodstream immediately after training is believed to increase protein synthesis to a greater extent than amino acids made available later in the day. A ratio of 4 to 1 grams of carbohydrates to protein is recommended for a post-exercise snack—for example, a snack containing 40 grams of carbohydrates (160 calories) and 10 grams of protein (40 calories).

Core Strength Training

The trunk (spine) and pelvis are referred to as the “core” of the body. Core muscles include the abdominal muscles (rectus, transversus, and internal and external obliques), hip muscles (front and back), and spinal muscles (lower and upper back muscles). These muscle groups are responsible for maintaining the stability of the spine and pelvis.

Many of the major muscle groups of the legs, shoulders, and arms attach to the core. A strong core allows a person to perform activities of daily living with greater ease, improve sports performance through a more effective energy transfer from large to small body parts, and decrease the incidence of low back pain. Core strength training also contributes to better posture and balance.

Interest in core strength training programs has increased. A major objective of core training is to exercise the abdominal and lower back muscles in unison. Furthermore, individuals should spend as much time training the back muscles as they do the abdominal muscles. Besides enhancing stability, core training improves dynamic balance, which is often required during physical activity and participation in sports.

Key core training exercises include the abdominal crunch and bent-leg curl-up, reverse crunch, pelvic tilt, lateral bridge, prone bridge, leg press, seated back, lat pull-down, back extension, lateral trunk flexion, supine bridge, and pelvic clock (Exercises 4, 11, 12, 13, 14, 16, 20, 24, 36, and 37 in this chapter and Exercises 26 and 27 in Chapter 8, respectively). Stability ball exercises 38 through 46 are also used to strengthen the core.

When core training is used in athletic conditioning programs, athletes attempt to mimic the dynamic skills they use in their sport. To do so, they use special equipment such as balance boards, stability balls, and foam pads. Using this equipment allows the athletes to train the core while seeking balance and stability in a sport-specific manner.
Pilates exercises have become increasingly popular in recent years. Previously, Pilates training was used primarily by dancers, but now this exercise modality is embraced by a large number of fitness participants, rehab patients, models, actors, and even professional athletes. Pilates studios, college courses, and classes at health clubs are available nationwide.

Figure 7.6 Major muscles of the human body.

Pilates Exercise System

Pilates exercises have become increasingly popular in recent years. Previously, Pilates training was used primarily by dancers, but now this exercise modality is embraced by a large number of fitness participants, rehab patients, models, actors, and even professional athletes. Pilates studios, college courses, and classes at health clubs are available nationwide.

Key Terms

Core strength training A program designed to strengthen the abdominal, hip, and spinal muscles (the core of the body).

Pilates A training program that uses exercises designed to help strengthen the body's core by developing pelvic stability and abdominal control; exercises are coupled with focused breathing patterns.
Healthy Strength Training

- Make a progressive resistance strength-training program a priority in your weekly schedule.
- Strength train at least once a week; even better, twice a week.
- Find a facility where you feel comfortable training and where you can get good professional guidance.
- Learn the proper technique for each exercise.
- Train with a friend or group of friends.
- Consume a pre-exercise snack consisting of a combination of carbohydrates and some protein about 30 to 60 minutes before each strength-training session.
- Use a minimum of 8 to 10 exercises that involve all major muscle groups of your body.
- Perform at least one set of each exercise to near muscular fatigue.
- To enhance protein synthesis, consume one post-exercise snack with a 4-to-1 gram ratio of carbohydrates to protein immediately following strength training; and a second snack one hour thereafter.
- Allow at least 48 hours between strength-training sessions that involve the same muscle groups.

Try It Attend the school’s fitness or recreation center and have an instructor or fitness trainer help you design a progressive resistance strength-training program. Train twice a week for the next 4 weeks. Thereafter, evaluate the results and write down your feelings about the program.

The Pilates training system was originally developed in the 1920s by German physical therapist Joseph Pilates. He designed the exercises to help strengthen the body’s core by developing pelvic stability and abdominal control, coupled with focused breathing patterns.

Pilates exercises are performed either on a mat (floor) or with specialized equipment to help increase strength and flexibility of deep postural muscles. The intent is to improve muscle tone and length (a limber body) instead of increasing muscle size (hypertrophy). Pilates mat classes focus on body stability and proper body mechanics. The exercises are performed in a slow, controlled, precise manner. When performed properly, these exercises require intense concentration. Initially, Pilates training should be conducted under the supervision of certified instructors with extensive Pilates teaching experience.

Fitness goals of Pilates programs include better flexibility, muscle tone, posture, spinal support, body balance, low back health, sports performance, and mind–body awareness. Individuals with loose or unstable joints benefit from Pilates because the exercises are designed to enhance joint stability. The Pilates program is also used to help lose weight, increase lean tissue, and manage stress. Although Pilates programs are quite popular, more research is required to corroborate the benefits attributed to this training system.

Stability Exercise Balls

A stability exercise ball is a large flexible and inflatable ball used for exercises that combines the principles of Pilates with core strength training. Stability exercises are specifically designed to develop abdominal, hip, chest, and spinal muscles by addressing core stabilization while the exerciser maintains a balanced position over the ball. Particular emphasis is placed on correct movement and maintenance of proper body alignment to involve as much of the core as possible. Although the primary objective is core strength and stability, many stability exercises can be performed to strengthen other body areas as well.

Stability exercises are thought to be more effective than similar exercises on the ground. For instance, just sitting on the ball requires the use of stabilizing core muscles (including the rectus abdominis and the external and internal obliques) to keep the body from falling off the ball. Traditional strength-training exercises are primarily for strength and power development and do not contribute as much to body balance.

When performing stability exercises, choose a ball size based on your height. Your thighs should be parallel to the floor when you sit on the ball. A slightly larger ball may be used if you suffer from back problems. Several stability ball exercises are provided on pages 268–270. For best results, have a trained specialist teach you the proper technique and watch your form while you learn the exercises. Individuals who have a weak muscular system or poor balance or who are over the age of 65 should perform stability exercises under the supervision of a qualified trainer.

Elastic-Band Resistive Exercise

Elastic bands and tubing can also be used for strength training. This type of constant-resistance training has increased in popularity and can be used to supplement traditional strength training as it has shown to help increase strength, mobility, functional ability (particularly in older adults), and to aid in the rehab of many types of injuries. Some of the advantages to using this type of training include low cost, versatility (you can create resistance in almost all angles and directions of the range of motion), use of a large number of exercises to work all joints of the body, and they provide a great way to work out while traveling (exercise bands can be easily packed in a suitcase). This type of resistance training can also add variety to your routine workout.
Elastic-band resistive exercise workouts can be just as challenging as with free weights or machines. Due to the constant resistance provided by the bands or tubing, the training may appear more difficult to some individuals because the resistance is used both during the eccentric and concentric phases of the repetition. Additionally, the bands can be used by beginners and strength-trained individuals. That is because several different tension cords (up to eight bands) are available and all participants can progress through various resistance levels.

At the beginning, it may be a little confusing trying to determine how to use the bands and create the proper loops to grip the bands. The assistance of a training video, an instructor, or a personal trainer is helpful. The bands can be wrapped around a post, a door knob, or you can stand on them as well for some of the exercises. A few sample exercises with elastic-band resistive exercises are provided in Figure 7.7. Instructional booklets are available for purchase with your elastic band or tubing.

**Exercise Safety Guidelines**

As you prepare to design your strength-training program, keep the following guidelines in mind:

- Select exercises that will involve all major muscle groups: chest, shoulders, back, legs, arms, hip, and trunk.
- Select exercises that will strengthen the core. Use controlled movements and start with light-to-moderate resistances. (Later, athletes may use explosive movements with heavier resistances.)
- Never lift weights alone. Always have someone work out with you in case you need a spotter or help with an injury. When you use free weights, one to two spotters are recommended for certain exercises (e.g., bench press, squats, and overhead press).
- Prior to lifting weights, warm up properly by performing a light- to moderate-intensity aerobic activity (5 to 7 minutes) and some gentle stretches for a few minutes.
• Use proper lifting technique for each exercise. The correct lifting technique will involve only those muscles and joints intended for a specific exercise. Involving other muscles and joints to “cheat” during the exercise to complete a repetition or to be able to lift a greater resistance decreases the long-term effectiveness of the exercise and can lead to injury (such as arcing the back during the push-up, squat, or bench press exercises). Proper lifting technique also implies performing the exercises in a controlled manner and throughout the entire range of motion. Perform each repetition in a rhythmic manner and at a moderate speed. Avoid fast and jerky movements, and do not throw the entire body into the lifting motion. Do not arch the back when lifting a weight.

• Maintain proper body balance while lifting. Proper balance involves good posture, a stable body position, and correct seat and arm/leg settings on exercise machines. Loss of balance places undue strain on smaller muscles and leads to injuries because of the heavy resistances suddenly placed on them. In the early stages of a program, first-time lifters often struggle with bar control and balance when using free weights. This problem is overcome quickly with practice following a few training sessions.

• Exercise larger muscle groups (such as those in the chest, back, and legs) before exercising smaller muscle groups (arms, abdominals, ankles, and neck). For example, the bench press exercise works the chest, shoulders, and back of the upper arms (triceps), whereas the triceps extension works the back of the upper arms only.

• Exercise opposing muscle groups for a balanced workout. When you work the chest (bench press), also work the back (rowing torso). If you work the biceps (arm curl), also work the triceps (triceps extension).

• Breathe naturally. Inhale during the eccentric phase (bringing the weight down), and exhale during the concentric phase (lifting or pushing the weight up). Practice proper breathing with lighter weights when you are learning a new exercise.

• Avoid holding your breath while straining to lift a weight. Holding your breath increases the pressure inside the chest and abdominal cavity greatly, making it nearly impossible for the blood in the veins to return to the heart. Although rare, a sudden high intrathoracic pressure may lead to dizziness, blackout, stroke, heart attack, or hernia.

• Based on the program selected, allow adequate recovery time between sets of exercises (see Table 7.5).

• If you experience unusual discomfort or pain, discontinue training. The high tension loads used in strength training can exacerbate potential injuries. Discomfort and pain are signals to stop and determine what’s wrong. Be sure to evaluate your condition properly before you continue training.

• Use common sense on days when you feel fatigued or when you are performing sets to complete fatigue. Excessive fatigue affects lifting technique, body balance, muscles involved, and range of motion—all of which increase the risk for injury. A spotter is recommended when sets are performed to complete fatigue. The spotter’s help through the most difficult part of the repetition will relieve undue stress on muscles, ligaments, and tendons—and help ensure that you perform the exercise correctly.

• At the end of each strength-training workout, stretch out for a few minutes to help your muscles return to their normal resting length and to minimize muscle soreness and risk for injury.

Setting Up Your Own Strength-Training Program

The same pre-exercise guidelines outlined for cardiorespiratory endurance training apply to strength training (see Activity 1.3, “PAR-Q and Health History Questionnaire,” on page 34). If you have any concerns about your present health status or ability to participate safely in strength training, consult a physician before you start. Strength training is not advised for people with advanced heart disease.

Before you proceed to write your strength-training program, you should determine your stage of change for this fitness component in Activity 7.2 at the end of the chapter. Next, if you are prepared to do so, and depending on the facilities available, you can choose one of the training programs outlined in this chapter (use Activity 7.2). Once you begin your strength-training program, you may use the form provided in Activity 7.3 to keep a record of your training sessions.

You should base the resistance, number of repetitions, and sets you use with your program on your current strength-fitness level and the amount of time that you have for your strength workout. If you are training for reasons other than general health fitness, review Table 7.5 for a summary of the guidelines.
Designing Your Strength-Training Program

Name: ___________________________ Date: _____________

Course: ___________________ Section: __________ Gender: ________ Age: _______

I. Stage of Change for Muscular Strength or Endurance

Using Figure 2.5 (page 61) and Table 2.3 (page 60), identify your current stage of change for participation in a muscular strength or muscular endurance program:

II. Instructions

Select one of the two strength-training exercise programs. Perform all of the recommended exercises and, with the exception of the abdominal curl-up exercises, determine the resistance required to do approximately 10 repetitions maximum. For “Strength-Training Exercises without Weights,” simply indicate the total number of repetitions performed. For the abdominal crunches or curl-up exercises, perform or build up to about 20 repetitions.

1. Strength-Training Exercises without Weights

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Step-up</td>
<td></td>
</tr>
<tr>
<td>Rowing torso</td>
<td></td>
</tr>
<tr>
<td>Push-up</td>
<td></td>
</tr>
<tr>
<td>Abdominal crunch or bent-leg curl-up</td>
<td></td>
</tr>
<tr>
<td>Leg curl</td>
<td></td>
</tr>
<tr>
<td>Modified dip</td>
<td></td>
</tr>
<tr>
<td>Pull-up or arm curl</td>
<td></td>
</tr>
<tr>
<td>Heel raise</td>
<td></td>
</tr>
<tr>
<td>Leg abduction and adduction</td>
<td></td>
</tr>
<tr>
<td>Reverse crunch</td>
<td></td>
</tr>
<tr>
<td>Pelvic tilt</td>
<td></td>
</tr>
<tr>
<td>Lateral bridge</td>
<td></td>
</tr>
<tr>
<td>Prone bridge</td>
<td></td>
</tr>
</tbody>
</table>
Designing Your Strength-Training Program (continued)

2. Strength-Training Exercises with Weights

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Repetitions</th>
<th>Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench press, shoulder press, or chest press (select and circle one)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg press or squat (select one)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abdominal crunch or bent-leg curl-up</td>
<td>N/A</td>
<td></td>
</tr>
<tr>
<td>Rowing torso</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arm curl or upright rowing (select one)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg curl or seated leg curl (select one)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seated back</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heel raise</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lat pull-down or bent-arm pullover (select one)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rotary torso</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triceps extension or dip (select one)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leg extension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Back extension</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

III. Your Personalized Strength-Training Program

Once you have performed the strength-training exercises with or without weights (or both), and depending on your personal preference (strength versus endurance), design your strength-training program selecting a minimum of eight exercises. Indicate the number of sets, repetitions, and approximate resistance that you will use. Also state the days of the week, time, and facility that will be used for this program.

Strength-training days: M T W Th F Sa Su
Time of day: ____________
Facility: ____________

<table>
<thead>
<tr>
<th>Exercise</th>
<th>Sets / Reps / Resistance</th>
<th>Exercise</th>
<th>Sets / Reps / Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td>9.</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td>10.</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td>11.</td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td>12.</td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td>13.</td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td>15.</td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td></td>
<td>16.</td>
<td></td>
</tr>
</tbody>
</table>
**ACTIVITY 7.3**

**Strength-Training Record Form**

<table>
<thead>
<tr>
<th>Date</th>
<th>Exercise</th>
<th>Sets, Reps, Res*</th>
<th>Sets, Reps, Res*</th>
<th>Sets, Reps, Res*</th>
<th>Sets, Reps, Res*</th>
<th>Sets, Reps, Res*</th>
<th>Sets, Reps, Res*</th>
<th>Sets, Reps, Res*</th>
</tr>
</thead>
</table>

*Sets, Reps, Res* = Sets, Repetitions, and Resistance (e.g., 1/6/125 = 1 set of 6 repetitions with 125 pounds)
# Strength-Training Record Form (continued)

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date:</th>
<th>Course:</th>
<th>Section:</th>
<th>Gender:</th>
<th>Age:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Exercise | Date | Sets | Reps | Res* | Sets | Reps | Res* | Sets | Reps | Res* | Sets | Reps | Res* | Sets | Reps | Res* | Sets | Reps | Res* | Sets | Reps | Res* |
|----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
|          |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |      |

*Sets, Reps, and Resistance (e.g., 1/6/125 = 1 set of 6 repetitions with 125 pounds)
Chapter 7 Muscular Strength and Endurance

Assess Your Behavior

1. Are your strength levels sufficient to perform tasks of daily living (climbing stairs, carrying a backpack, opening jars, doing housework, mowing the yard) without requiring additional assistance or feeling unusually fatigued?

2. Do you regularly participate in a strength-training program that includes all major muscle groups of the body, and do you perform at least one set of each exercise to near fatigue?

Assess Your Knowledge

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

1. The ability of a muscle to exert submaximal force repeatedly over time is known as
   a. muscular strength.
   b. plyometric training.
   c. muscular endurance.
   d. isokinetic training.
   e. isometric training.

2. In older adults, each additional pound of muscle tissue increases resting metabolism by
   a. 10 calories.
   b. 17 calories.
   c. 23 calories.
   d. 35 calories.
   e. 50 calories.

3. The Hand Grip Strength Test is an example of
   a. an isometric test.
   b. an isotonic test.
   c. a dynamic test.
   d. an isokinetic test.
   e. a plyometric test.

4. A 70th-percentile rank places an individual in the __________ fitness category.
   a. excellent
   b. good
   c. average
   d. fair
   e. poor

5. During an eccentric muscle contraction,
   a. the muscle shortens as it overcomes the resistance.
   b. there is little or no movement during the contraction.
   c. a joint has to move through the entire range of motion.
   d. the muscle lengthens as it contracts.
   e. the speed is kept constant throughout the range of motion.

6. The training concept stating that the demands placed on a system must be increased systematically and progressively over time to cause physiological adaptation is referred to as
   a. the overload principle.
   b. positive-resistance training.
   c. specificity of training.
   d. variable-resistance training.
   e. progressive resistance.

7. A set in strength training refers to
   a. the starting position for an exercise.
   b. the recovery time required between exercises.
   c. a given number of repetitions.
   d. the starting resistance used in an exercise.
   e. the sequence in which exercises are performed.

8. For health fitness, the recommendation of the American College of Sports Medicine is that a person should perform a maximum of between
   a. 1 and 6 reps.
   b. 4 and 10 reps.
   c. 8 and 12 reps.
   d. 10 and 25 reps.
   e. 20 and 30 reps.

9. Plyometric training frequently is used to help with performance in
   a. gymnastics.
   b. basketball.
   c. volleyball.
   d. sprinting.
   e. all of these sports.

10. The posterior deltoid, rhomboids, and trapezius muscles can be developed with the
    a. bench press.
    b. lat pull-down.
    c. rotary torso.
    d. squat.
    e. rowing torso.

Correct answers can be found at the back of the book.
EXERCISE 1  STEP-UP

**Action:** Step up and down using a box or chair approximately 12 to 15 inches high (a). Conduct one set using the same leg each time you step up, and then conduct a second set using the other leg. You also could alternate legs on each step-up cycle. You may increase the resistance by holding a child or an object in your arms (b). Hold the child or object close to the body to avoid increased strain in the lower back.

**Muscles Developed:** Gluteal muscles, quadriiceps, gastrocnemius, and soleus

EXERCISE 2  ROWING TORSO

**Action:** Raise your arms laterally (abduction) to a horizontal position and bend your elbows to 90°. Have a partner apply enough pressure on your elbows to gradually force your arms forward (horizontal flexion) while you try to resist the pressure. Next, reverse the action, horizontally forcing the arms backward as your partner applies sufficient forward pressure to create resistance.

**Muscles Developed:** Posterior deltoid, rhomboids, and trapezius

EXERCISE 3  PUSH-UP

**Action:** Maintaining your body as straight as possible (a), flex the elbows, lowering the body until you almost touch the floor (b), then raise yourself back up to the starting position. If you are unable to perform the push-up as indicated, decrease the resistance by supporting the lower body with the knees rather than the feet (c).

**Muscles Developed:** Triceps, deltoid, pectoralis major, abdominals, and erector spinae
**EXERCISE 4 ABDOMINAL CRUNCH AND BENT-LEG CURL-UP**

**Action:** Start with your head and shoulders off the floor, arms crossed on your chest, and knees slightly bent (a). The greater the flexion of the knee, the more difficult the curl-up. Now curl up to about 30° (abdominal crunch—illustration b) or curl up all the way (abdominal curl-up—illustration c), then return to the starting position without letting the head or shoulders touch the floor or allowing the hips to come off the floor. If you allow the hips to raise off the floor and the head and shoulders to touch the floor, you most likely will “swing up” on the next crunch or curl-up, which minimizes the work of the abdominal muscles. If you cannot curl up with the arms on the chest, place the hands by the side of the hips or even help yourself up by holding on to your thighs (d and e). Do not perform the sit-up exercise with your legs completely extended, because this will strain the lower back.

**Muscles Developed:**
Abdominal muscles and hip flexors

**Note:** The abdominal curl-up exercise should be used only by individuals of at least average fitness without a history of lower back problems. New participants and those with a history of lower back problems should use the abdominal crunch exercise in its place.

**EXERCISE 5 LEG CURL**

**Action:** Lie on the floor face down. Cross the right ankle over the left heel (a). Apply resistance with your right foot while you bring the left foot up to 90° at the knee joint (b). Apply enough resistance so the left foot can only be brought up slowly. Repeat the exercise, crossing the left ankle over the right heel.

**Muscles Developed:**
Hamstrings (and quadriceps)

**EXERCISE 6 MODIFIED DIP**

**Action:** Place your hands on a box or gymnasium bleacher. The feet are supported and held in place by an exercise partner (a). Dip down at least to a 90° angle at the elbow joint (b), and then return to the starting position.

**Muscles Developed:**
Triceps, deltoid, and pectoralis major
**EXERCISE 7  PULL UP**

**Action:** Suspend yourself from a bar with a pronated (thumbs-in) grip (a). Pull your body up until your chin is above the bar (b), then lower the body slowly to the starting position. If you are unable to perform the pull-up as described, have a partner hold your feet to push off and facilitate the movement upward (c and d).

![Images of pull-up exercises](https://example.com/pull-up-exercises)

**Muscles Developed:**
Biceps, brachioradialis, brachialis, trapezius, and latissimus dorsi

**EXERCISE 8  ARM CURL**

**Action:** Using a palms-up grip, start with the arm completely extended and, with the aid of a backpack filled with books as needed (a), curl up as far as possible (b), then return to the initial position. Repeat the exercise with the other arm.

![Images of arm curl exercises](https://example.com/arm-curl-exercises)

**Muscles Developed:**
Biceps, brachioradialis, and brachialis

**EXERCISE 9  HEEL RAISE**

**Action:** From a standing position with feet flat on the floor or at the edge of a step (a), raise and lower your body weight by moving at the ankle joint only (b). For added resistance, have someone else hold your shoulders down as you perform the exercise.

![Images of heel raise exercises](https://example.com/heel-raise-exercises)

**Muscles Developed:**
Gastrocnemius and soleus
EXERCISE 10  LEG ABDUCTION AND ADDUCTION

Action: Both participants sit on the floor. The person on the left places the feet on the inside of the other person’s feet. Simultaneously, the person on the left presses the legs laterally (to the outside—abduction), while the person on the right presses the legs medially (adduction). Hold the contraction for 5 to 10 seconds. Repeat the exercise at all three angles, and then reverse the pressing sequence: The person on the left places the feet on the outside and presses inward while the person on the right presses outward.

Muscles Developed: Hip abductors (rectus femoris, sartori, gluteus medius and minimus) and adductors (pectineus, gracilis, dductor magnus, adductor longus, and adductor brevis)

EXERCISE 11  REVERSE CRUNCH

Action: Lie on your back with arms to the sides and knees and hips flexed at 90° (a). Now attempt to raise the pelvis off the floor by lifting vertically from the knees and lower legs (b). This is a challenging exercise that may be difficult for beginners to perform.

Muscles Developed: Abdominals

EXERCISE 12  PELVIC TILT

Action: Lie flat on the floor with the knees bent at about a 90° angle (a). Tilt the pelvis by tightening the abdominal muscles, flattening your back against the floor, and raising the lower gluteal area even so slightly off the floor (b). Hold the final position for several seconds.

Areas Stretched: Low back muscles and ligaments

Areas Strengthened: Abdominal and gluteal muscles

EXERCISE 13  LATERAL BRIDGE

Action: Lie on your side with legs bent (a: easier version) or straight (b: harder version) and support the upper body with your arm. Straighten your body by raising the hip off the floor and hold the position for several seconds. Repeat the exercise with the other side of the body.

Muscles Developed: Abdominals (obliques and transversus abdominus) and quadratus lumbarum (lower back)
EXERCISE 14 PRONE BRIDGE

Action: Starting in a prone position on a floor mat, balance yourself on the tips of your toes and elbows while attempting to maintain a straight body from heels to shoulders (do not arch the lower back [a]). You can increase the difficulty of this exercise by placing your hands in front of you and straightening the arms (b).

Muscles Developed: Anterior and posterior muscle groups of the trunk and pelvis

EXERCISE 15 BENCH (CHEST) PRESS

Muscles Developed: Pectoralis major, triceps, and deltoid

Free Weights: Lie on the bench with arms extended and have one or two spotters help you place the barbell directly over your shoulders (a). Lower the weight to your chest (b) and then push it back up until you achieve full extension of the arms. Do not arch the back during this exercise.

Machine: From a seated position, grasp the bar handles (a) and press forward until the arms are completely extended (b), then return to the original position. Do not arch the back during this exercise.
**EXERCISE 16  LEG PRESS**

**Action:** From a sitting position with the knees flexed at about 100° and both feet on the footrest (a), extend the legs fully (b), then return slowly to the starting position.

**Muscles Developed:** Quadriceps and gluteal muscles

---

**EXERCISE 17  ABDOMINAL CRUNCH**

**Action:** Sit in an upright position. Grasp the handles in front of the chest pad and crunch forward. Return slowly to the original position.

**Muscles Developed:** Abdominals

---

**EXERCISE 18A  ROWING TORSO**

**Action:** Sit in the machine and grasp the handles in front of you (a). Press back as far as possible, drawing the shoulder blades together (b). Return to the original position.

**Muscles Developed:** Posterior deltoid, rhomboids, and trapezius

---

**EXERCISE 18B  BENT-OVER LATERAL RAISE**

**Action:** Bend over with your back straight and knees bent at about 5 to 10° (a). Hold one dumbbell in each hand. Raise the dumbbells laterally to about shoulder level (b) and then slowly return them to the starting position.
EXERCISE 19  LEG CURL

**Action:** Lie with the face down on the bench, legs straight, and place the back of the feet under the padded bar (a). Curl up to at least 90° (b), and return to the original position.

**Muscles Developed:**
Hamstrings

EXERCISE 20  SEATED BACK

**Action:** Sit in the machine with your trunk flexed and the upper back against the shoulder pad. Place the feet under the padded bar and hold on with your hands to the bars on the sides (a). Start the exercise by pressing backward, simultaneously extending the trunk and hip joints (b). Slowly return to the original position.

**Muscles Developed:**
Erector spinae and gluteus maximus

EXERCISE 21  CALF PRESS

**Machine:** Start with your feet flat on the plate (a). Now extend the ankles by pressing on the plate with the balls of your feet (b).

**Free Weights:** In a standing position, place a barbell across the shoulders and upper back. Grip the bar by the shoulders (a). Raise your heels off the floor or step box as far as possible (b) and then slowly return them to the starting position.

**Muscles Developed:**
Gastrocnemius, soleus
**EXERCISE 22** LEG (HIP) ADDUCTION

**Action:** Adjust the pads on the inside of the thighs as far out as the desired range of motion to be accomplished during the exercise (a). Press the legs together until both pads meet at the center (b). Slowly return to the starting position.

**Muscles Developed:** Hip adductors (pectineus, gracilis, adductor magnus, adductor longus, and adductor brevis)

**EXERCISE 23** LEG (HIP) ABDUCTION

**Action:** Place your knees together with the pads directly outside the knees (a). Press the legs laterally out as far as possible (b). Slowly return to the starting position.

**Muscles Developed:** Hip abductors (rectus femoris, sartori, gluteus medius, and minimus)

**EXERCISE 24** LAT PULL-DOWN

**Action:** Starting from a sitting position, hold the exercise bar with a wide grip (a). Pull the bar down in front of you until it reaches the upper chest (b), then return to the starting position.

**Muscles Developed:** Latissimus dorsi, pectoralis major, and biceps
EXERCISE 25 ROTARY TORSO

Action: Stand with your feet slightly apart. Place a barbell across your shoulders and upper back, holding on to the sides of the barbell. Now gently, and in a controlled manner, twist your torso to one side as far as possible and then do so in the opposite direction.

Muscles Developed: Internal and external obliques (abdominal muscles)

EXERCISE 26 TRICEPS EXTENSION

Muscles Developed: Triceps

Machine: Sit in an upright position and grasp the bar behind the shoulders (a). Fully extend the arms (b) and then return to the original position.

A B

Free Weights: In a standing position, hold a barbell with both hands overhead and with the arms in full extension (a). Slowly lower the barbell behind your head (b) and then return it to the starting position.

A B
**EXERCISE 27  ARM CURL**

**Machine:** Using a supinated (palms-up) grip, start with the arms almost completely extended (a). Curl up as far as possible (b), then return to the starting position.

**Free Weights:** Standing upright, hold a barbell in front of you at about shoulder width with arms extended and the hands in a thumbs-out position (supinated grip) (a). Raise the barbell to your shoulders (b) and slowly return it to the starting position.

**Muscles Developed:** Biceps, brachioradialis, and brachialis

---

**EXERCISE 28A  LEG EXTENSION**

**Action:** Sit in an upright position with the feet under the padded bar and grasp the handles at the sides (a). Extend the legs until they are completely straight (b), then return to the starting position.

**Muscles Developed:** Quadriceps

---

**EXERCISE 28B  UNILATERAL ECCENTRIC KNEE FLEXION**

**Action:** Using a moderate resistance, raise the padded bar by extending both knees (a and b). Next, remove the left foot from the padded bar while holding the bar in place with the right leg (c). Now slowly lower the resistance (padded bar) to about 45 degrees (d). Return the left foot to the padded bar and once again press the bar up to full knee extension. Alternate legs by releasing the right foot next and lower the resistance with the left foot. Repeat the exercise about 10 times with each leg. This exercise is quite helpful to strengthen weak knees and prevent potential future knee problems.

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EXERCISE 29  SHOULDER PRESS

Muscles Developed: Triceps, deltoid, and pectoralis major

Machine: Sit in an upright position and grasp the bar wider than shoulder width (a). Press the bar all the way up until the arms are fully extended (b), then return to the initial position.

Free Weights: Place a barbell on your shoulders (a) and press the weight overhead until complete extension of the arms is achieved (b). Return the weight to the original position. Be sure not to arch the back or lean back during this exercise.

EXERCISE 30  CHEST FLY

Muscles Developed: Pectoralis major and deltoid

Action: Start with the arms out to the side, and grasp the handle bars with the arms straight (a). Press the movement arms forward until they are completely in front of you (b). Slowly return to the starting position.

BENT-ARM FLY

Action: Lie down on your back on a bench and hold a dumbbell in each hand directly overhead (a). Keeping your elbows slightly bent, lower the weights laterally to a horizontal position (b) and then bring them back up to the starting position.
**EXERCISE 31 SQUAT**

**Machine:** Place the shoulders under the pads and grasp the handles in front of you (a). Slowly bend the knees to about 120° (b). Return to the starting position.

**Muscles Developed:** Quadriceps, gluteus maximus, erector spinae

**Free Weights:** From a standing position, and with a spotter to each side, support a barbell over your shoulders and upper back (a). Keeping your head up and back straight, bend at the knees and the hips until you achieve an approximate 120° angle at the knees (b). Return to the starting position. Do not perform this exercise alone. If no spotters are available, use a squat rack to ensure that you will not get trapped under a heavy weight.
**EXERCISE 32  UPRIGHT ROWING**

**Free Weights:** Hold a barbell in front of you, with the arms fully extended and hands in a thumbs-in (pronated) grip less than shoulder-width apart (a). Pull the barbell up until it reaches shoulder level (b) and then slowly return it to the starting position.

**Machine:** Start with the arms extended and grip the handles with the palms down (a). Pull all the way up to the chin (b), then return to the starting position.

**Muscles Developed:** Biceps, brachioradialis, brachialis, deltoid, and trapezius

---

**EXERCISE 33  SEATED LEG CURL**

**Action:** Sit in the unit and place the thigh pad over the upper thighs. With legs extended, place the back of the feet over the lower-leg pad (a). Flex the knees until you reach a 90° to 100° angle (b). Slowly return to the starting position.

**Muscles Developed:** Hamstrings

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Photos © Fitness & Wellness, Inc.
**EXERCISE 34 BENT-ARM PULLOVER**

*Action:* Lie on your back on an exercise bench with your head over the edge of the bench. Hold a barbell over your chest with the hands less than shoulder-width apart (a). Keeping the elbows shoulder-width apart, lower the weight over your head until your shoulders are completely extended (b). Slowly return the weight to the starting position.

*Muscles Developed:* Latissimus dorsi, pectoral muscles, deltoïd, and serratus anterior

**EXERCISE 35 DIP**

*Action:* Start with the elbows flexed (a), then extend the arms fully (b), and return slowly to the initial position.

*Muscles Developed:* Triceps, deltoïd, and pectoralis major

**EXERCISE 36 BACK EXTENSION**

*Action:* Place your feet under the ankle pad and the hips over the padded seat. Start with the trunk in a flexed position and the arms crossed over the chest (a). Slowly extend the trunk to a horizontal position (b), hold the extension for 2 to 5 seconds, then slowly flex (lower) the trunk to the original position.

*Muscles Developed:* Erector spinae, gluteus maximus, and quadratus lumborum (lower back)
EXERCISE 37  LATERAL TRUNK FLEXION

Action: Lie sideways on the padded seat with the right foot under the left side of the padded ankle pad (right knee slightly bent) and the left foot stabilized behind the vertical bar. Cross the arms over the abdomen or chest and start with the body in a straight line. Raise (flex) your upper body about 30 to 40º and then slowly return to the starting position.

Muscles Developed: Erector spinae, rectus abdominus, internal and external abdominal obliques, quadratus lumborum, gluteal muscles

EXERCISE 38  THE PLANK

Action: Place your knees or feet (increased difficulty) on the ball and raise your body off the floor to a horizontal position. Pull the abdominal muscles in and hold the body in a straight line for 5 to 10 seconds. Repeat the exercise 3 to 5 times.

Muscles Involved: Abdominals, erector spinae, lower back, hip flexors, gluteal, quadriceps, hamstrings, chest, shoulder, and triceps

EXERCISE 39  ABDOMINAL CRUNCHES

Action: On your back and with the feet slightly separated, lie with the ball under your back and shoulder blades. Cross the arms over your chest (a). Press your lower back into the ball and crunch up 20 to 30º. Keep your neck and shoulders in line with your trunk (b). Repeat the exercise 10 to 20 times (you may also do an oblique crunch by rotating the ribcage to the opposite hip at the end of the crunch [c]).

Muscles Involved: Rectus abdominus, internal and external abdominal obliques
**EXERCISE 40  SUPINE BRIDGE**

**Action:** With the feet slightly separated and knees bent, lie with your neck and upper back on the ball; hands placed on the abdomen. Gently squeeze the gluteal muscles while raising your hips off the floor until the upper legs and trunk reach a straight line. Hold this position for 5 to 10 seconds. Repeat the exercise 3 to 5 times.

**Muscles Involved:** Gluteal, abdominals, lower back, hip flexors, quadriceps, and hamstrings

**EXERCISE 41  REVERSE SUPINE BRIDGE**

**Action:** Lie face up on the floor with the heels on the ball. Keeping the abdominal muscles tight, slowly lift the hips off the floor and squeeze the gluteal muscles until the body reaches a straight line. Hold the position for 5 to 10 seconds. Repeat the exercise 3 to 5 times.

**Muscles Involved:** Gluteal, abdominals, lower back, erector spinae, hip flexors, quadriceps, and hamstrings

**EXERCISE 42  PUSH-UPS**

**Action:** Place the front of your thighs (knees or feet—more difficult) over the ball with the body straight, the arms extended, and the hands under your shoulders. Now bend the elbows and lower the upper body as far as possible. Return to the original position. Repeat the exercise 10 times.

**Muscles Involved:** Triceps, chest, shoulder, abdominals, erector spinae, lower back, hip flexors, quadriceps, and hamstrings

**EXERCISE 43  BACK EXTENSION**

**Action:** Lie face down with the hips over the ball. Keep the legs straight with the toes on the floor and slightly separated (a). Keep your arms to the sides and extend the trunk until the body reaches a straight position (b). Repeat the exercise 10 times.

**Muscles Involved:** Erector spinae, abdominals, and lower back
**EXERCISE 44  WALL SQUAT**

**Action:** Stand upright and position the ball between your lower back and a wall. Place your feet slightly in front of you, about a foot apart (a). Lean into the ball and lower your body by bending the knees until the thighs are parallel to the ground (b) (to avoid excessive strain on the knees, it is not recommended that you go beyond this point). Return to the starting position. Repeat the exercise 10 to 20 times.

**Muscles Involved:** Quadriceps, hip flexors, hamstrings, abdominals, erector spinae, lower back, gastrocnemius, and soleus

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**EXERCISE 45  JACKKNIVES**

**Action:** Lie face down with the hips on the ball and walk forward with your hands until the thighs are over the ball. Keep the arms fully extended, hands on floor, and the body straight (a). Now, pull the ball forward with your legs by bending at the knees and raising your hips while keeping the abdominal muscles tight (b). Repeat the exercise 10 times.

**Muscles Involved:** Hip flexors, abdominals, erector spinae, lower back, quadriceps, hamstrings, chest, and shoulder

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**EXERCISE 46  HAMSTRING ROLL**

**Action:** Lie on your back with your knees bent and the heels on the ball. Raise your hips off the floor, while keeping the knees bent (a). Tighten the abdominal muscles and roll the ball out with your feet to extend the legs (b). Now roll the ball back into the original position. Repeat the exercise 10 times.

**Muscles Involved:** Hamstrings, abdominals, erector spinae, lower back, hip flexors, quadriceps, and chest
Notes and Suggested Readings

This page contains notes for this chapter only

Chapter 7:

Notes

1. C. Castaneda et al., “A Randomized Controlled Trial of Resistance Exercise Training to Improve Glycemic Control in Older Adults with Type 2 Diabetes,” *Diabetes Care* 25 (2002): 2335-2341.


5. See note 2.


Suggested Readings


Answer Key

This page contains answers for this chapter only

Chapter 7
1. c  2. d  3. a  4. b  5. d  6. a  7. c  8. c  9. e  10. e
CHAPTER 7 FOR EASY REFERENCE
Strength-Training Guidelines

Mode: Select 8 to 10 dynamic strength-training exercises that involve the body's major muscle groups and include opposing muscle groups (chest and upper back, abdomen and lower back, front and back of the legs).

Resistance: Sufficient resistance to perform 8 to 12 repetitions maximum for muscular strength and 15 to 25 repetitions to near fatigue for muscular endurance. Older adults and injury prone individuals should use 10 to 15 repetitions with moderate resistance (50% to 60% of their 1 RM).

Sets: 2 to 4 sets per exercise with 2 to 3 minutes recovery between sets for optimal strength development. Less than 2 minutes per set if exercises are alternated that require different muscle groups (chest and upper back) or between muscular endurance sets.

Frequency: 2 to 3 days per week on nonconsecutive days. More frequent training can be done if different muscle groups are exercised on different days. (Allow at least 48 hours between strength-training sessions of the same muscle group.)

Adapted from American College of Sports Medicine, Guidelines for Exercise Testing and Prescription (Baltimore: Lippincott Williams & Wilkins, 2006).

CHAPTER 7 CHECK YOURSELF
Healthy Strength Training

- Make a progressive resistance strength-training program a priority in your weekly schedule.
- Strength train at least once a week; even better, twice a week.
- Find a facility where you feel comfortable training and where you can get good professional guidance.
- Learn the proper technique for each exercise.
- Train with a friend or group of friends.
- Consume a pre-exercise snack consisting of a combination of carbohydrates and some protein about 30 to 60 minutes before each strength-training session.
- Use a minimum of 8 to 10 exercises that involve all major muscle groups of your body.
- Perform at least one set of each exercise to near muscular fatigue.
- To enhance protein synthesis, consume one post-exercise snack with a 4-to-1 gram ratio of carbohydrates to protein immediately following strength training; and a second snack one hour thereafter.
- Allow at least 48 hours between strength-training sessions that involve the same muscle groups.