

# Twin Cities Campus



# **Encyclopedia of Muscle & Strength**

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# **Encyclopedia of Muscle & Strength**

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# Training Essentials

**S**trength training can be traced back to the beginning of recorded time. As early as 2000 B.C.E., the ancient Egyptians lifted sacks of sand to strength-train for hunting and military duty. According to military records, the Chinese also used strength training for their military personnel as early as 700 B.C.E. But the historical association that most people are familiar with is the ancient Greeks. Many of the athletes who competed in the ancient Olympics lifted heavy stones to develop strength and boost their athletic performance. Besides those functional results, strength training provided the development of a muscular physique. This masculine physique was honored in classic Greek art and writing. In fact, it may be the ancient Greek culture's celebration of muscle that is responsible for spawning the modern sport of bodybuilding. Several famous athletes during that period, such as Milo and Heracles, often performed feats of strength and displayed their muscularity to spectators who gathered to watch. In the 19th century, the appreciation by the masses for heavily muscled physiques made celebrities out of many performing strongmen of that time. The most famous was Eugen Sandow, who is considered the father of bodybuilding.

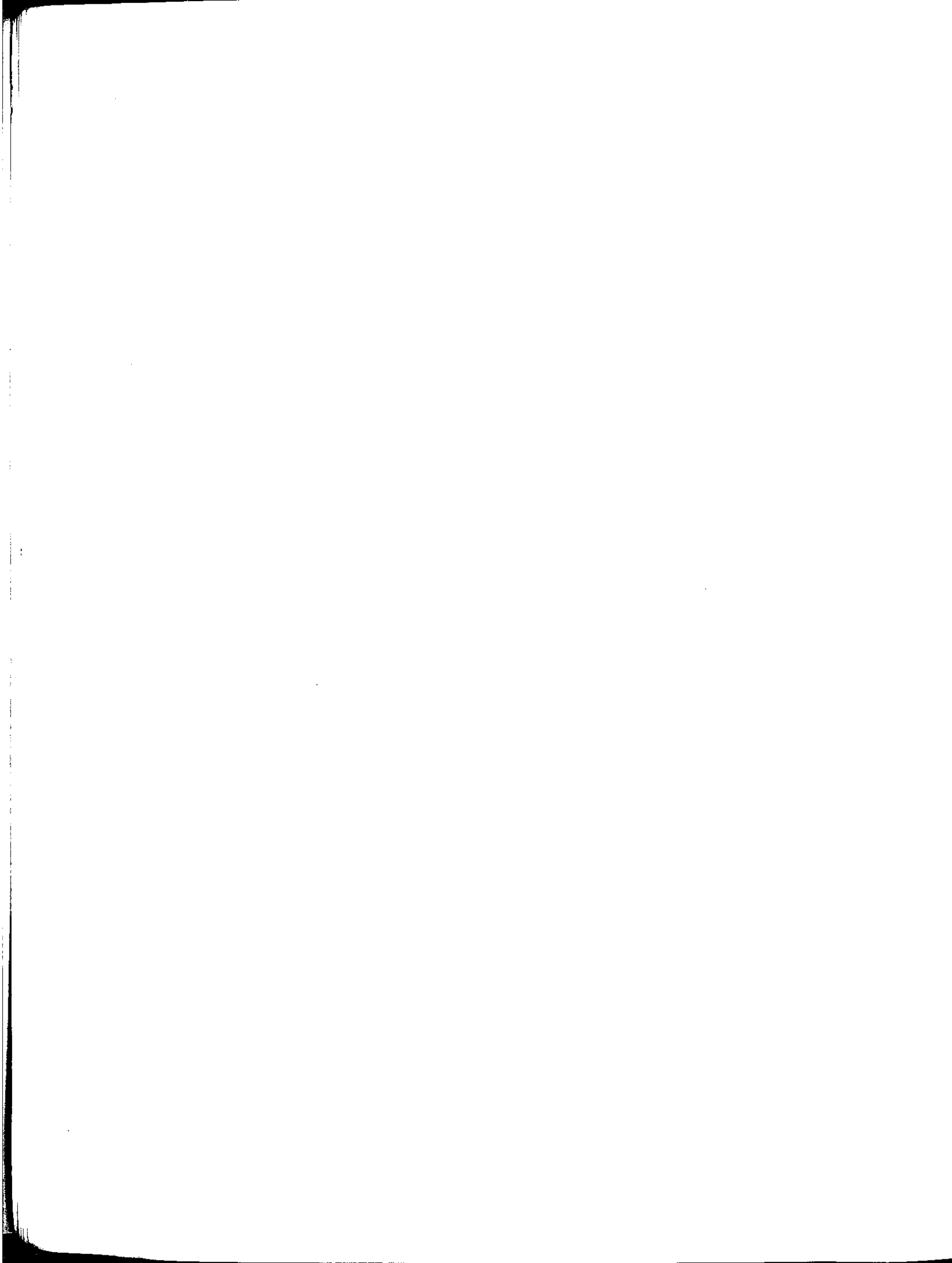
Despite the fact that humans have a longstanding fascination with strength and muscularity, the concept of strength training is one that few have familiarized themselves with. Even during the

fitness boom of the 1970s in the United States, most Americans participated in some form of aerobic exercise but neglected the strength component of physical fitness. Over the years, with help from pioneers of strength training (such as Bob Hoffman, Joe Weider, and Charles Atlas) and through advances in research on the developing science of resistance training, strength became viewed as a necessary component of physical fitness and athletic performance. And participation in strength training grew faster than participation in any other physical activity.

As the popularity of strength training grew, so did awareness that this practice was a complicated science that participants must fully understand in order to reap the true benefits. That is why this part of the book is so important for anyone interested in strength training at any level. Unless you clearly understand the principles of strength training, you will never fully comprehend how to implement an effective strength training program.

So before you skip ahead to one of the strength training programs in parts II and III, be sure you have a decent grasp of the fundamentals presented in these first four chapters. Armed with this background, you will have a much fuller understanding of the exercises, techniques, and programs presented in the other chapters. You also will be more capable of individualizing these techniques to create specialized programs for yourself and for others.





# Core Concepts

**S**trength training is performed by a wide range of people for a variety of reasons. Most are interested in gaining muscle strength and muscle mass with a concomitant loss of body fat. In addition, many people expect these physical adaptations to carry over into improvements in performance of athletic endeavors and daily life activities. Strength training can provide these adaptations as long as you follow certain principles, which are discussed here to help you realize your strength training goals. These principles are integral to understanding how strength training works, how to individualize it to meet your needs and goals, and how to change it to continue making adaptations as you progress.

In addition to understanding the concepts of strength training, you must be familiar with the terminology that is often used in discussions of strength training. Having the ability to understand and use this lexicon will help you to learn the fundamentals of strength training and to communicate with others who participate in strength training. To familiarize yourself with this vocabulary, refer to the glossary on pages 381 to 386.

Before we can discuss the principles of strength training, we must define the major terms that will be discussed throughout this book. First and foremost is the actual term *strength training*. If you've done a fair share of reading on the topic of strength training—be it on the Internet, in magazines, or in other books—you've probably discovered that the terms *strength training*, *weight training*, and *resistance training* are often used interchangeably. While there are definite similarities in the three terms, a more precise interpretation of the definitions points out the differences. *Resistance training* is the broadest of the three terms. It describes any type of training in which the body must move in some direction against some type of force that resists

that movement. This could include lifting free weights, pushing against a hydraulic apparatus, or running up a set of stairs. Strength training is a type of resistance training (although not all types of resistance training are strength training). Specifically, strength training refers to any type of training that involves the body moving in some direction against a force that specifically induces changes in muscle strength or hypertrophy (muscle growth). This could include lifting free weights or moving against a hydraulic apparatus, but not running up a set of stairs. Weight training is also a type of resistance training and can be a type of strength training. By strict terms of its definition, it refers to any type of training in which the body moves in some direction against a force that resists that movement and is supplied by some type of weight. This could include free weights and weight machines but not training with a hydraulic apparatus or running up a set of stairs. See table 1.1 for a list of training methods that are categorized under each of these types of training.

This book covers strength training (most of it will be weight training), because it best describes the types of training that we are interested in—exercise that involves the body moving against a force in an effort to induce changes in muscle strength or hypertrophy.

## DEFINITIONS OF STRENGTH

The basic definition of strength is the maximal amount of force a muscle or muscle group can generate in a specified movement pattern at a specified velocity (speed) of movement (Knuttgen and Kraemer 1987). But defining strength is not that simple. That's because strength has many manifestations. The following definitions are all forms of strength.

**Table 1.1 Categories and Methods of Training**

Type of training	Sample training methods
Resistance training	Free weights (including common objects) Weight machines (linear guided, cable or pulley system, cam based) Hydraulic machines Pneumatic machines Isokinetic machines Body-weight training Sled dragging Parachute running
Strength training	Free weights (including common objects) Weight machines (linear guided, cable or pulley system, cam based) Hydraulic machines Pneumatic machines Body-weight training
Weight training	Free weights (including common objects) Weight machines (linear guided, cable or pulley system, cam based)

**absolute strength**—The maximal amount of force a muscle can produce when all inhibitory and protective mechanisms are removed. Because of this, it is rare that a person could ever demonstrate his or her absolute strength. This can take place only under extreme measures such as during an emergency, under hypnosis, or with certain ergogenic aids.

**maximal strength**—The maximal amount of force a muscle or muscle groups can produce in a specific exercise for one repetition. This is also referred to as *one-repetition maximum*, or *1RM*. Some estimate that the 1RM usually amounts to only about 80 percent of absolute strength. This type of strength is important for powerlifters.

**relative strength**—The ratio between a person's maximal strength and his or her body weight. This is important when comparing the strength of athletes who are much different in body size. Relative strength is determined by dividing the 1RM by the body weight of the person. For example, a 200-pound (91-kilogram) athlete who can bench-press 400 pounds ( $400 \div 200 = 2$ ) has the same relative strength as a 100-pound (45-kilogram) athlete who can bench-press 200 pounds ( $200 \div 100 = 2$ ). This type of strength is important for powerlifters as well as for football players and other strength athletes who are often compared with other teammates as a means of predicting performance on the field.

**speed strength**—The ability to move the body or an object quickly. This term is more commonly known as *power*. This type of strength is important for most sports but is most critical in track and field events such as the shot put, javelin, and long jump.

**starting strength**—The ability to generate a sharp rise in power during the initial phase of the movement. This type of strength is important in Olympic weightlifting, deadlifts, boxing, martial arts, and offensive line positions in football, where strength must be generated immediately.

**acceleration strength**—The ability to continue the sharp rise in power throughout most of the movement of the exercise. This type of strength takes over after starting strength and is important for sports such as judo, wrestling, and sprinting.

**endurance strength**—The ability to maintain force production for a longer time or through multiple repetitions of an exercise. This type of strength is important in wrestling, cycling, swimming, and training for bodybuilding.

Considering these numerous types of strength that a person can train for specifically, it's easy to understand that the term *strength training* encompasses many types of training approaches. Regardless of whether you are training for maximal

strength, power, or endurance strength, you are following some form of strength training. Each of these types of strength is developed with the use of resistance of some type, be it free weights, machines, or body weight. Although this book focuses on strength training for muscle mass and strength, other muscle adaptations can take place with the use of strength training.

## TYPES OF MUSCLE ACTION

During a typical strength training session, muscles may contract from tens to hundreds of times to move the body or the implement they are training with. Neural stimulation of the muscle causes the contractile units of the muscle to attempt to shorten. But contraction does not always involve shortening of the muscle fibers. Depending on the load and the amount of force supplied by the muscle, three different muscle actions may occur during a muscle contraction:

1. *Concentric muscle action.* This type of muscle action occurs when the muscle force exceeds the external resistance, resulting in joint movement as the muscle shortens (see figure 1.1*a*). In other words, concentric contractions are those in which the muscle fibers shorten while contracting to lift the weight. This is demonstrated by the upward phase of a biceps curl and is often referred to as the *positive phase of the repetition*.

2. *Eccentric muscle action.* This type of muscle action occurs when the external resistance exceeds the force supplied by the muscle, result-

ing in joint movement as the muscle lengthens (see figure 1.1*b*). Eccentric muscle actions are demonstrated by the downward phase of the biceps curl. This is often referred to as the *negative portion of the repetition*. Even though the fibers are lengthening, they're also in a state of contraction, permitting the weight to return to the starting position in a controlled manner.

3. *Isometric muscle action.* This type of muscle action occurs when the muscle contracts without moving, generating force while its length remains static (see figure 1.1*c*). Isometric muscle actions are demonstrated in an attempt to lift an immovable object or an object that is too heavy to move. The muscle fibers contract in an attempt to move the weight, but the muscle does not shorten in overall length because the object is too heavy to move.

Among strength training scientists there is much debate about the importance of each of these types of muscle actions regarding increases in strength and muscle mass. Studies have been conducted in an effort to determine whether one type of muscle action is most important for enhancing muscle strength and mass. Because it is possible to produce greater force during eccentric and isometric muscle actions as compared to concentric muscle actions, it has been hypothesized that these muscle actions may be more important than concentric muscle actions for inducing changes in muscle strength and size.

Researchers have found that training with isometric muscle actions can increase muscle strength and size (Fleck and Schutt 1985). However, the

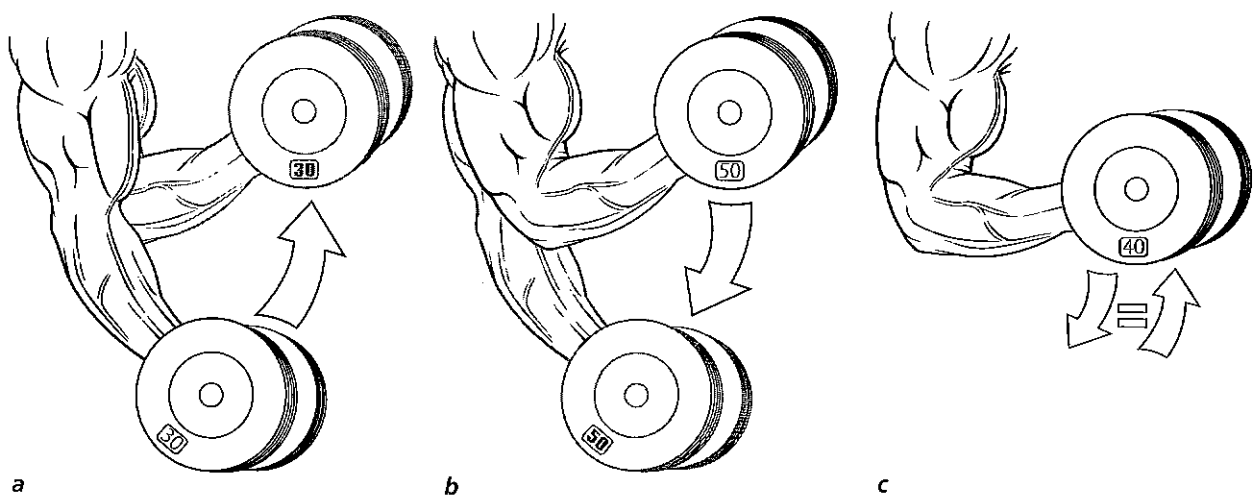


Figure 1.1 Major types of muscle actions: (a) concentric, (b) eccentric, and (c) isometric.

strength gains from isometric training are realized only during the specific joint angles at which the muscles were trained. In other words, if someone trains isometrically on the bench press at the point halfway between the start and finish, that person will gain muscle strength only at that specific point in the exercise. This would not equate to greater overall strength in the bench press unless a variety of joint angles between the start and finish were also trained isometrically. Therefore, while isometric training can be beneficial, concentric and eccentric muscle actions should also be included for better overall muscle adaptations. For a sample training program that uses isometric muscle actions, see Static Strength Training on page 170 in chapter 9.

Because it is possible to overload a muscle more during eccentric muscle contractions, these contractions cause more muscle damage. It has been hypothesized that this greater overload can induce greater gains in strength. Indeed, research has shown that eccentric-only training does induce significant strength gains; however, this training appears to offer no greater strength benefit than concentric-only training. Therefore, to maximize muscle adaptations, strength training programs need to incorporate both concentric and eccentric muscle actions. For sample training programs that incorporate eccentric training, see Negative Repetitions on page 89 in chapter 6 and Negative-Rep Strength Training on page 177 in chapter 9.

The use of concentric, eccentric, and isometric muscle actions in strength training will yield somewhat different adaptations. Although isometric muscle actions can improve strength and muscle size to some degree, they provide mainly static strength. This does not necessarily carry over to dynamic strength used for most sports. Therefore, most strength training programs should focus on concentric and eccentric muscle actions. Greater improvements in strength and muscle mass can be achieved when repetitions include both concentric and eccentric muscle actions.

Another type of muscle action that should be considered here is called *voluntary maximal muscle action*. This type of muscle action does not refer to the actual movement of the muscle but to the intensity of the resistance. When a muscle undergoes a voluntary maximal muscle action, it is moving against as much resistance as its current fatigue level will allow. Regardless of how many

repetitions are performed in a set—whether it be 1 or 10—it is the last repetition, when momentary concentric muscle failure is reached, that is considered the voluntary maximal muscle action. In other words, not another single repetition can be performed. This is also referred to as the *repetition maximum (RM)* and is usually represented with a number preceding the RM. For example, 1RM would represent the amount of weight that induces a voluntary maximal muscle action with one repetition. A 10RM is the amount of weight that induces a voluntary maximal muscle action on the 10th repetition.

## PRINCIPLES OF STRENGTH TRAINING

Countless principles of strength training are being employed today. But the validity of many of these principles is questionable, because few strength training professionals agree on the majority of them. However, there are a few principles that are revered by all strength training professionals: the principle of specificity, the principle of progressive overload, the principle of individuality, the principle of variation, the principle of maintenance, and the principle of reversibility. So important are these principles that few would argue against their being considered laws of strength training.

**principle of specificity**—One of the seminal principles in designing strength training programs. It is often referred to as SAID, which stands for “specific adaptation to imposed demands.” In its most basic definition, it means to train in a specific manner to produce a specific outcome. For instance, if the immediate goal is to increase 1RM strength, then training with the appropriate range of repetition, proper rest periods, and apposite frequency to optimize strength gains is a necessity. Or if the goal is to increase athletic performance in a specific sport, the exercises should mimic the types of movements performed in the sport, and they should be performed at a similar speed as those movements. This principle is one of the most important in strength training because if it is not being met, all other principles are negated.

**principle of progressive overload**—The practice of continually increasing the intensity of the work-

out as the muscle becomes accustomed to that intensity level. This can be done by increasing the weight lifted, the number of repetitions performed, or the total number of sets; or it can be done by decreasing the rest between sets. Continually increasing the stress placed on the muscle allows the muscle to increase its strength and prevents stagnation. This is one of the most critical principles of strength training as well as one of the earliest developed. This principle was established just after World War II by the research of DeLorme and Watkins (1945, 1948). Without providing the muscles with progressive overload, continual adaptations in muscle strength and size would cease. For example, at the start of a strength training program, performing three sets of 10 reps on the bench press with 135 pounds may be a challenge. After several weeks of training, performing three sets of 10 reps on the bench press with 135 pounds will become easy. At this stage, training adaptations will cease unless the weight is increased above 135 pounds, the reps are increased above 10 reps, the sets are increased to more than three, or the rest between sets is decreased.

***principle of individuality***—The theory that any training program must consider the specific needs or goals and abilities of the person for whom it is designed. For example, a beginning bodybuilder with the goal of adding muscle mass would have a much different training program than an advanced bodybuilder with the same goal. The difference in their training programs is based not on their desired training outcomes but on their training experiences. The advanced trainer would require more volume and high-intensity training techniques to reach the same goal as the beginner. On the other hand, an advanced lifter who has the goal of gaining muscle mass would train much differently than an advanced lifter with the goal of gaining muscle strength. Here the difference in their training programs is based on their different goals. In general, the advanced lifter with the goal of gaining more muscle strength would train with fewer reps, heavier weight, and lower volume than the advanced lifter with the muscle mass goal.

***principle of variation***—The simple fact that no matter how effective a program is, it will be effective only for a short period. Once a person

has experienced the specific adaptations that a particular training program is designed to provide, a new stimulus must be imposed on the muscles or continued progress will be stagnated. This is the foundation of periodization (discussed in chapter 3) and is the reason that training cycles must be employed.

***principle of maintenance***—As a person reaches his or her goals, it takes less work to maintain that level of strength or muscle mass. If he or she is happy with that level, the frequency of training can be reduced. This is typically a good time to involve more cross-training so that other fitness components can be developed.

***principle of reversibility***—The fact that once the strength training program is discontinued or not maintained at the minimal level of frequency and intensity, the strength or hypertrophy adaptations that were made with that program will not only stop forward progression but will also revert back to the starting level.

## SUMMARY

To properly apply any discipline, you must first familiarize yourself with the principles of the discipline. Without a clear understanding of the foundation of strength training, the application of it will be lacking. Just as an athlete who doesn't understand the basics of his sport will do poorly in that sport, not understanding the basics of strength training will severely limit your potential. Regardless of whether your goal is to increase muscle mass or muscle strength, having this knowledge will have a positive effect on your ability to reach your goal.

First you must understand the different types of strength that you can train for: absolute, maximal, relative, speed, starting, acceleration, and endurance. Being familiar with the different muscle actions is essential to understanding the components of any repetition you perform. You will learn the concepts to follow in order for adaptations to take place. This basic information is just the starting point. This knowledge base will continue to grow with information contained in the following chapters of part I. Once you are armed with this seminal information, applying the training techniques and programs in the later sections will be easier and the results will be more substantial.



# Training Variables

**T**he average strength training program will last several weeks to several months before a new training phase is implemented. Considering this time frame, a single workout may seem inconsequential to the overall program. Yet the design of each single workout is just as important as the overall program. This is because each workout adds up sequentially to create the long-term training program that will provide the adaptations that the program imparts. This chapter discusses the principles involved in designing a single strength training workout.

Every workout is composed of at least five specific program variables that you can manipulate in order to alter the workout: choice of exercises, order of exercises, number of sets, resistance, and rest taken between sets. You must carefully choose these variables to get a workout that is appropriate for your level of fitness and that initiates the desired adaptations.

Although strength athletes such as Olympic weightlifters, powerlifters, and bodybuilders have manipulated these variables for many years, William J. Kraemer, PhD, is credited with scientifically determining and recording what he has termed the five specific clusters of acute program variables (see table 2.1). The systematic alteration of these acute variables results in the periodized training program.

## CHOICE OF EXERCISES

While all acute variables of a program are critical to a person's progress, choice of exercise is arguably one of the most critical. The reasoning behind this is that if you are not training the appropriate muscle groups, then all other variables are somewhat meaningless. Simply put, muscles that are not trained will not benefit from the program. Therefore, choosing the proper exercises for each

workout is the first step in creating an effective strength program.

For those interested in gaining muscle strength, all exercises in a workout can be categorized as either a primary exercise or an assistance exercise. Refer to table 2.2 for a list of common primary and assistance exercises. Primary exercises are those that are most specific to the goals of the individual. These exercises must involve the muscle groups in which the person is most interested in gaining strength. For competitive athletes, the primary exercises not only should target the same muscle groups that are used in competition but should also include some exercises that mimic the movements performed in their sports. For example, the primary exercises for an Olympic weightlifter are the clean and jerk and the snatch; for a powerlifter they are the bench press, squat, and deadlift; for an offensive lineman they are the squat and incline bench press.

Primary exercises usually are multijoint movements such as the bench press, squat, and deadlift. These exercises require the coordinated use of multiple muscle groups. Because several large muscle groups are used in performing these exercises, they tend to be the ones in which the most weight can be lifted. For instance, the world records in the deadlift and the squat are well over 900 and 1,100 pounds (408 and 499 kilograms), respectively. The world record in the barbell biceps curl (although this is not a lift that is sanctioned by any powerlifting federation), a single-joint exercise (typically referred to as an assistance exercise), is not much more than 400 pounds (181 kilograms). Because the primary exercises call for great strength and coordination, they should be performed early in the workout when the muscle groups are the least fatigued.

Assistance exercises typically are single-joint exercises such as the biceps curl, triceps extension, and deltoid lateral raise. These exercises



**Table 2.1 Program Design Details**

Variable	Specifics
Choice of exercises	Primary exercises Assistance exercises Multijoint exercises Single-joint exercises Exercise equipment
Order of exercises	Primary exercises followed by assistance exercises Larger muscle groups followed by smaller muscle groups Lagging muscle groups trained first Straight sets for each exercise Supersets
Number of sets	Volume effects Single sets Multiple sets Number of sets performed per exercise Number of sets performed per muscle group Number of sets performed per workout
Resistance (intensity)	Percentage of 1RM RM target zone OMNI-resistance exercise scale
Rest period between sets	Dependent on resistance used Dependent on muscle adaptation desired Dependent on metabolic pathway being trained Dependent on training technique

Adapted, by permission, from S.J. Fleck and W.J. Kraemer, 2004, *Designing resistance training programs*, 3rd ed. (Champaign, IL: Human Kinetics), 158.

**Table 2.2 Primary and Assistance Exercises**

Primary exercises	Assistance exercises
Power clean	Knee extension
Deadlift	Leg curl
Squat	Chest fly
Leg press	Deltoid lateral raise
Bench press	Biceps curl
Military press	Triceps extension
Barbell row	Wrist curl
Pull-up	Calf raise
	Abdominal crunch

involve only a single muscle group. Because only one muscle group is working to lift the weight, these exercises usually involve much lighter weight than primary exercises do. For powerlifters and other strength athletes, assistance exercises are usually done toward the end of the workout after the major muscle groups are fairly fatigued from

performing the primary exercises. An exception to the rule that all assistance exercises are single-joint exercises is core training. Training the core (the deep muscles in the abdominal cavity and lower back) involves complicated movement patterns that involve multiple joints and force the core musculature to work at stabilizing the body.

For those interested in building muscle size, all exercises also can be divided into multijoint and single-joint exercises. However, the terms used in bodybuilding circles are *multijoint* and *isolation exercises*. *Isolation* implies that the single-joint movement is isolating the major muscle group and forcing it to perform all the work in that exercise without the help from other muscle groups. An example of this is the leg extension. While most major muscle groups have both multijoint and isolation exercises that target them, the biceps, forearms, hamstrings, calves, and abdominals are muscle groups that are trained usually with just isolation exercises. For a list of multijoint and isolation exercises for most major muscle groups, refer to table 2.3.

**Table 2.3 Multijoint and Isolation Exercises**

Muscle group	Multijoint exercises	Isolation exercises
Chest	Bench press Dumbbell bench press	Dumbbell fly Cable crossover
Shoulders	Barbell overhead press Upright row	Lateral raise Front raise
Triceps	Close-grip bench press Dips	Triceps pressdown Lying triceps extension
Biceps		Barbell curl Seated incline curl
Forearms		Wrist curl Reverse wrist curl
Quadriceps	Squat Leg press	Leg extension
Hamstrings		Leg curl Romanian deadlift
Calves		Standing calf raise Seated calf raise
Abdominals		Crunch Reverse crunch

Exercise equipment is another factor to consider when choosing exercises for an individual workout. While free weights are used in the majority of the primary exercises, other equipment has its benefits depending on the overall goals of the person. For example, to mimic movements that occur in a more horizontal plane while an athlete is in an upright position (such as swinging a baseball bat), free weights are a poor choice because they offer resistance only in a vertical plane. Here, the use of a cable apparatus or resistance tubing would be a better exercise choice. Choosing appropriate strength training equipment is discussed in more detail in chapter 4.

## ORDER OF EXERCISES

How the specific exercises that make up a single workout are ordered will determine not only the effectiveness of the workout but also the particular adaptations that the program imparts. Therefore, the order in which exercises are performed must correspond with the specific training goals.

In training for strength, the primary exercises are performed first in the workout relative to assistance exercises. The logic behind this is the fact that

primary exercises typically involve numerous large muscle groups working together to lift relatively heavy weight. Therefore, these exercises must be done early enough in the program that fatigue is not an issue. Performing single-joint exercises first will compromise the amount of weight a person can lift on the primary exercises and may even make the person more susceptible to injury, because form tends to suffer when muscles are fatigued.

If building muscle size is the primary goal, then multijoint exercises should be performed first with isolation exercises performed later in the workout. The multijoint exercises help to build muscle size because it is possible to train with heavier weight on them. An exception to this rule involves a common bodybuilding technique known as preexhaust. This technique involves the use of single-joint exercises before multijoint exercises in an effort to exhaust a particular muscle group so that it becomes the weak link in the multijoint exercise. This concept is discussed in detail in chapter 6.

If multiple muscle groups are trained in a workout, such as in whole-body workouts, and only one exercise per major muscle group is performed, then ordering exercises involves determining the most critical muscle groups based on the goals of the

person. Typically, larger-sized muscle groups (such as the legs and back) are trained before smaller muscle groups (such as the shoulders and biceps) for the same reason mentioned previously: Larger muscle groups need to be trained before fatigue is an issue.

## NUMBER OF SETS

A set is a grouping of repetitions that is followed by a rest interval. The number of sets performed in a workout is one of the factors affecting the total volume (sets  $\times$  repetitions  $\times$  resistance) of exercise. Therefore, it must be consistent not only with the individual's strength goals but also with his or her current level of fitness.

Generally speaking, it is accepted that multiple sets are more beneficial for developing strength and muscle mass. In fact, this stance is supported in guidelines set by the National Strength and Conditioning Association (Pearson, Faigenbaum, Conley, and Kraemer 2000) and the American College of Sports Medicine (Kraemer et al. 2002). Single sets are effective for building strength for beginning weightlifters or for maintaining strength during periods when it is necessary or desired to reduce the volume performed. Beginners starting with a single-set program should progressively increase the number of sets to make continued adaptations in strength.

When designing a workout, one should consider the number of sets performed per exercise, the number of sets per muscle group, and the total number of sets for the workout. The number of sets per exercise typically varies depending on the strength training program. Most programs designed for the intermediate to advanced weight trainer incorporate between three and six sets per exercise. This set range is considered optimal for increasing strength. How many sets one should perform per muscle group is a question that is most applicable to bodybuilding-type training, in which numerous exercises are performed for each muscle group. This is in opposition to strength training programs for conditioning athletes, which may typically involve only one exercise per major muscle group. The number of sets per muscle group may range from 3 to 24 but ultimately depends on the number of exercises performed for that muscle group, the number of muscle groups trained in that workout, the intensity used, and where the person is in his or her training cycle. The total number of

sets performed for a workout may vary from about 10 to 40, depending on the type of training and the number of sets per exercise. Care must be taken so that not too many total sets are performed, particularly when intensity is high, since these variables greatly influence total work. Performing too much total work over time stresses the body and can lead to overtraining. Although defining how much work is too much is a difficult task because many factors are involved, such as the person's training experience and genetics, general recommendations can be made. Typically doing more than 20 sets per muscle group for an extended period can lead to overtraining. In addition, doing more than 40 sets per workout, even when multiple muscle groups are trained in that workout, can lead to overtraining if done too frequently.

As for any other acute variables of training, the number of sets should be manipulated to prevent stagnation of training adaptations. The most important variable of training that influences the number of sets that should be performed is intensity (the amount of weight lifted). The greater the intensity, the greater the stress placed on the muscle, and thus the lower the number of sets that should be performed. Therefore, the total number of sets in a training cycle should vary inversely with training intensity. In fact, training with too many total sets can be detrimental to the adaptations of strength training and lead to overtraining.

## RESISTANCE

The term *intensity* refers to the amount of weight lifted (or resistance used) on a particular set. Alternatively, many bodybuilders use *intensity* to refer to the difficulty of a set or a workout, regardless of the amount of weight used. For example, a bodybuilder may perform a high-intensity set involving very light weight at extremely high repetitions until muscle failure is reached. The intensity of that set would be even higher if the spotter helped the bodybuilder get three extra forced reps at the end of that set. However, according to the formal definition of *intensity*, that set would be categorized as low intensity. Therefore, to avoid confusion, the term *resistance* will be used when referring to the amount of weight used.

The resistance used is one of the most important variables in a training program, ranking second only to exercise choice. The amount of resistance used for a set is inversely related to

the number of repetitions performed. That is, the heavier the weight, the fewer the repetitions that can be performed. One of the most common ways that resistance is measured is through the use of a percentage of the repetition maximum (RM). For example, an exercise can be prescribed at 80 percent of the individual's 1RM.

If, for instance, the person's 1RM on the bench press is 300 pounds (136 kilograms), then

$$300 \text{ pounds} \times .80 = 240 \text{ pounds}$$

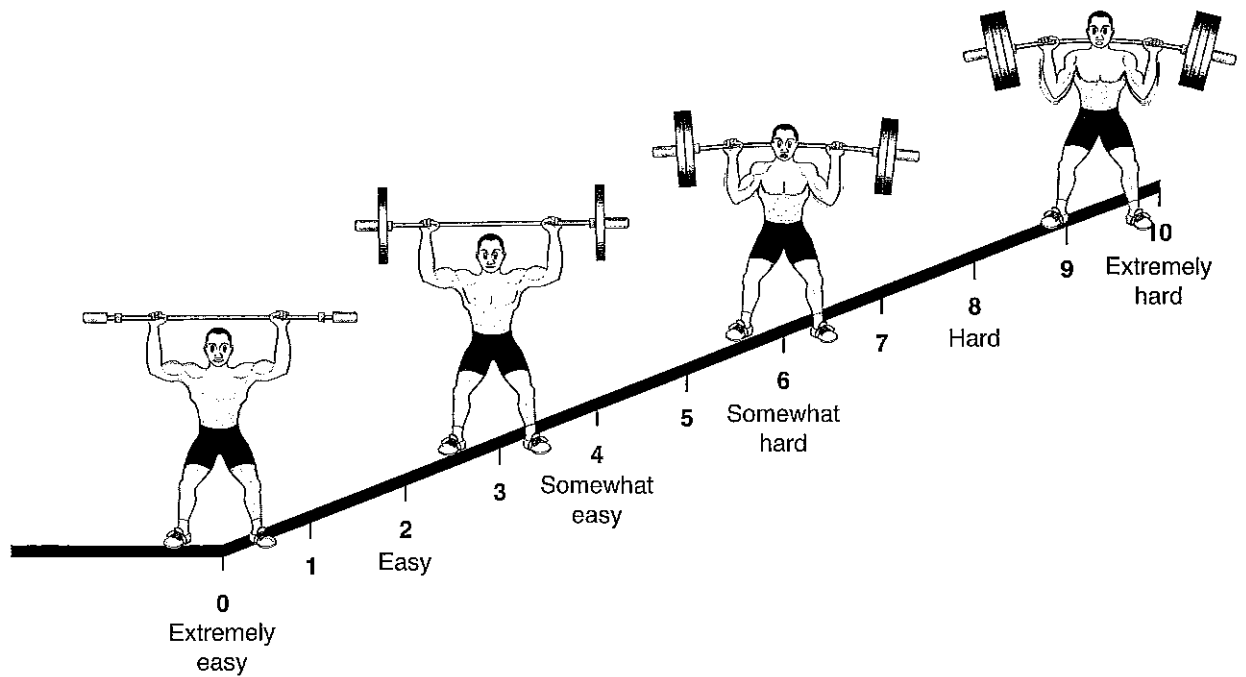
Using this method does require frequent 1RM testing to ensure that accurate training resistance is used. This method may be desirable for certain strength athletes because recurrent testing is a commonly used measure of an athlete's progress and a predictor of preparedness for competition. Olympic weightlifters should use this method regularly because of the skill component required for that type of lifting. Competitive weightlifters must use precisely measured resistance for their training phases. Powerlifters also commonly use this method because the defining moment in their sport is the amount of weight they can perform at 1RM on the bench press, squat, and deadlift. However, many top powerlifters train with percentages that are based on the 1RM they are predicting to lift in competition. The down side to prescribing exercise intensity with RM percentages is the fact that the amount of reps you can perform at a certain percentage of 1RM can vary depending on experience, the muscle group being trained, and the exercise equipment used.

For bodybuilders and other fitness enthusiasts, frequent testing of 1RM is not convenient or often feasible. It would be too time consuming because of the larger number of exercises they typically use. In addition, many of the exercises they perform are not conducive to 1RM testing. Although charts are devised for estimating 1RM based on the number of reps that can be completed at a certain weight, these are far from accurate. For serious weight trainers, an RM target zone is the easiest way to monitor training resistance. This is depicted as 10RM or 5RM and refers to a resistance that limits them to that number of repetitions. As their strength increases, they simply move to a heavier weight but shoot for the same RM goal. This allows them to continually stay in the repetition range they are shooting for without the need to test their 1RM. Worth mentioning here is that many strength coaches and strength training scientists

suggest that repetitions (resistance) should be kept in a fairly small range for any given workout. They believe that muscle can be trained for only one goal in any acute situation. Yet bodybuilders often train with a wide range of repetitions in a single workout. For example, they may do one set of an exercise with a very heavy weight for 5 to 7 reps and follow it with another set with light weight for reps in the 15 to 20 range.

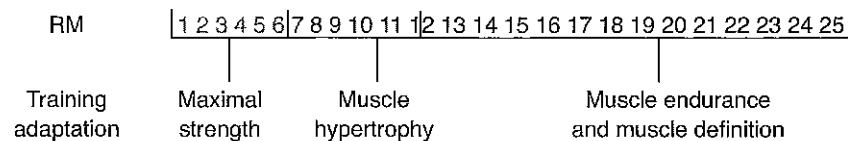
A more recently developed method of prescribing and monitoring resistance involves the use of the OMNI-resistance exercise scale (Robertson et al. 2003; Robertson 2004). This is a 10-point subjective scale (see figure 2.1) that is a modified version of the rating of perceived exertion (RPE) scale that was originally described by Borg (1982) and used mostly for monitoring aerobic exercise. Each value from 1 to 10 on the OMNI represents approximately a 10 percent increase in repetition maximum. For example, the use of 100 percent of a person's 1RM elicits a rating of 10 on the OMNI-resistance exercise scale, while the use of 50 percent of the person's 1RM corresponds to a rating of 5 on the scale. The OMNI-resistance exercise scale is not a precise quantitative scale but more a qualitative scale that determines how hard the weight feels to the lifter. For this reason, it is best used by trainers who are prescribing strength training to inexperienced lifters.

Today, thanks to the many years of trial and error by athletes and the numerous research studies to confirm the original inclinations, it is now well established that using certain resistance intensities provides corresponding results. This information can be used in designing a repetition maximum continuum as seen in figure 2.2. This figure is a modification of the continuum devised by Fleck and Kraemer (2004) that is recognized as the most acceptable by exercise scientists and strength coaches. The continuum in figure 2.2 ranges in maximal repetitions from 1 to 25, as does the original, but adds the adaptation of muscle hypertrophy. On the lower end of the continuum, strength gains are more pronounced, particularly when using maximal repetitions in the range of 1 to 6, or about 80 to 100 percent of 1RM (O'Shea 1966; Weiss, Coney, and Clark 1999). Enhanced muscle hypertrophy is most notable when training with repetition maximums in the 8 to 12 range, which corresponds to about 70 to 80 percent 1RM (Kraemer, Fleck, and Evans 1996). And muscular endurance benefits occur with repetition



**Figure 2.1** OMNI-resistance exercise scale.

Reprinted, by permission, from R.J. Robertson, 2004, *Perceived exertion for practitioners* (Champaign, IL: Human Kinetics), 49.



**Figure 2.2** Continuum of repetition maximums.

Modified from S.J. Fleck and W.J. Kraemer, 2004, *Designing resistance training programs*, 3rd ed. (Champaign, IL: Human Kinetics), 167.

maximums of 12 and above, or 70 percent of 1RM and below, are used (Stone and Coulter 1994). These varied muscle adaptations underscore the importance of periodization for producing the most desirable changes in a muscle, whether the person's goal is increasing muscle endurance or increasing maximal strength. This is because each adaptation is related to the others. For example, increasing both maximal strength and muscle endurance beneficially affects muscle hypertrophy. So while the person should spend the majority of training time using the repetition range that best fits his or her major goals, the periodic cycling of other intensities will enhance this goal.

One major assumption that the continuum of repetition maximums makes is that all repetitions

are performed at a moderate speed. Yet the speed of a rep can be increased or decreased, particularly at light to moderate loads. And this change in speed will dramatically alter the muscle adaptations. In general, fast repetition speeds with very light weight are best for building speed strength, or power, when few repetitions are performed. In contrast, slow to moderate repetitions with a submaximal weight are better for producing adaptations in muscle endurance and hypertrophy as the time the muscle is under tension is increased. As an example, using a weight that is about 30 to 45 percent of 1RM to do three reps as fast as possible builds speed strength (power) and has little effect if any on muscle hypertrophy or endurance.

## REST PERIOD BETWEEN SETS

How long a weightlifter should rest between sets is dependent on numerous factors. These include the resistance being used, the goals of the lifter, and the metabolic pathways that need to be trained. The general consensus is that the lower the reps being performed (that is, the higher the resistance intensity), the longer the rest periods that should be taken. And so as the periodized routine alters resistance intensity, so too do the rest periods change accordingly.

If a person is training for maximal strength or power, he or she should take long rest periods between sets. This is because lifting heavy weight for low reps requires energy derived from anaerobic metabolism, called the ATP-PC (adenosine triphosphate-phosphocreatine) system. This metabolic pathway provides the immediate energy required for lifting heavy weight or performing explosive movements for a short period. This system requires more than 3 minutes of rest for the majority of recovery to occur. Therefore, the recommendation is to rest at least 3 to more than 5 minutes when training for maximal strength or power. The general guidelines are as follows: resistance at less than 5RM requires over 5 minutes of rest, 5-7RM requires 3-5 minutes, 8-10RM requires 2-3 minutes, 11-13RM requires 1-2 minutes, and over 13RM requires about 1 minute (Kraemer 2003). This level of rest ensures that fatigue will be minimal at the start of a new set, and in turn, strength can be near maximal. Similarly, if a strength athlete or other athlete performs short bouts of high-intensity exercise with long rest periods between, the athlete should rest at least three minutes between sets.

When training for muscle hypertrophy (which is best attained with reps in the range of 8 to 12), shorter rest periods appear to be the most beneficial. Resting less than three minutes between sets stresses the anaerobic energy systems, and this is often recommended for bodybuilding training. This is because fatigue is believed to play some role in the pathways leading to muscle growth. One possibility involves lactate, which dramatically increases as reps increase and rest between sets decreases. There is a strong relationship

between lactate and levels of growth hormone after a bout of weightlifting. Increased levels of growth hormone are associated with a higher anabolic response.

For athletes interested in improving muscle endurance, low intensity (less than 60 percent 1RM), high repetitions of 15 and beyond, and short rest periods (under one minute) seem to be the best plan. This plan allows them to train to the point of fatigue and beyond, which enhances the body's ability to use lactate as an energy source and even improves aerobic capacity to some degree. Because fatigue is associated with muscle hypertrophy, many bodybuilders also frequently use this style of training.

Some styles of training use such minute rest periods between sets that they are classified in gym circles as using "no rest" between sets. This means that you would take no deliberate rest but instead immediately move to the next exercise. Such training methods include circuit training and the various forms of superset training, which includes compound sets, triple sets, and giant sets (see chapter 6 for more detailed explanations of these methods). With each of these methods, a certain number of sets of different exercises are done back to back with no rest between exercise sets. Only after you complete the prescribed number of exercises (which can vary from 2 to as many as 12) would you take a rest period. Then you would repeat the cycle anywhere from one to five times depending on the program.

## ADDITIONAL FACTORS

Besides determining the best exercises to use, the correct order of those exercises, the proper resistance to use, the optimal number of sets to do, and the right amount of rest to take between sets, other factors are to be considered. Some strength training experts believe that repetition speed—the length of time it takes to complete one rep—should also be manipulated. Typical rep speed in strength training lasts about three to five seconds. This is considered a controlled pace and is the pace taught by most strength coaches and personal trainers. However, some programs rely on the manipulation of rep speed. Speeding up the time it takes to complete a rep—in the range of two seconds or less—has been shown to be

an effective way to increase muscle power. See Ballistic Strength Training on page 175 in chapter 9 for an explanation of how to train with fast reps. Some strength training experts also believe that slowing down a rep—in the range of 10 to 20 seconds—can also enhance muscle strength as well as size. Research in this area is lacking, but anecdotal reports are positive. See Slow-Repetition Training on page 89 in chapter 6 for an explanation of how to train using very slow reps.

Another factor you should also be concerned about is how frequently you train. The frequency at which muscle groups are trained can be more critical than any of the acute variables of training discussed previously. The reason has to do with recovery. It is generally accepted that you should wait until a muscle has recovered from a previous workout before training the muscle again. Muscle recovery, however, is an individual thing that is influenced by factors such as lifting experience, intensity of the workout, and total volume. In most instances it is best to get 2 to 7 days of rest for each muscle group. This will be determined by how you split your training. *Training splits* refer to how you break down training days. For example, do you

train your whole body during every workout, or do you train only one or two muscle groups each workout? For obvious reasons, the more workouts it takes you to train all the major muscle groups of the body, the more rest you will take between workouts for the same muscle group. Training splits and training frequency are discussed in more detail in chapters 5 and 8.

## SUMMARY

The design of every workout is a critical component of the design of the strength training program. Regardless of your goal, you must carefully select appropriate acute variables to optimize the adaptations that occur in every workout. In designing the most effective training programs to reach your goals, you must carefully consider the choice of exercises and the order, intensity used, number of sets performed, and rest periods between sets. In addition to these variables, you may want to consider the speed at which you perform your reps. Last but not least is the frequency at which you train muscle groups. This basic information in this chapter will make more sense after you read about training details in parts II and III.

## CHAPTER 3

# Training Cycles

The term *periodization* refers to the systematic manipulation of the acute variables of training (as discussed in chapter 2) over a period that may range from days to years. The original concept was developed in the former Eastern Bloc countries in the late 1950s to optimize athletes' adaptations to resistance training. More important, periodization revolves around the athlete's competitive calendar so that he or she is at a competitive peak for competition.

The basis of periodization is general adaptation syndrome (GAS), which describes three stages that an organism—such as an athlete—goes through when exposed to a novel stress (Selye 1936). As a new stress is placed on the body (for example, heavy training in the range of three to five reps), the muscle first goes through an alarm reaction. During this stage the athlete momentarily gets weaker. But with continued exposure to the stress (successive workouts), the body enters the stage of adaptation. In this stage the body supercompensates for the stress—such as increasing muscle strength—to better deal with the stress. If the body is continually exposed to the same stress for too long, it may enter the stage of exhaustion, where its adaptation to the stress may actually decline. This may mean that the strength gains the athlete made during the adaptation stage will cease, and stagnation may set in. It may even lead to an actual decline in strength. Although this theory is now considered a simplistic take on the body's response to stress, it does hold true and explains the reason periodization is so important for proper adaptation to strength training.

You must expose the muscle to any one training style for just long enough to reap the benefits but avoid a nosedive of those positive adaptations. At this stage a new training style should be introduced, and the cycle continues. A simplistic

take on periodization is the maxim of “everything works, but nothing works forever.” This is a major theme of this book and is the reason it offers so many training methods. Having a large arsenal of training methods (as provided in chapters 6 and 10) to use for short periods and continually cycling them in a systematic order will prevent stagnation and maximize training adaptations.

The three periodization schemes most commonly used by strength coaches, which are the three most extensively researched, are classic strength and power periodization, reverse linear periodization, and undulating periodization. Although there are many other more obscure periodization schemes out there, a discussion including these three will cover the premise behind periodization. Regardless of the exact plan, periodized strength training programs have been shown through research to be significantly more effective than nonperiodized programs for increasing strength, power, and athletic performance in both men and women (Kraemer et al. 2003; Marx et al. 2001; Rhea and Alderman 2004; Willoughby 1993).

## CLASSIC PERIODIZATION

The name implies that this system is the hallmark periodization scheme most associated with the term *periodization*. In its most general form, classic periodization divides a long-term training period called the *macrocycle* (which typically involves six months to one year but may be up to four years, such as with Olympic athletes) into smaller phases called *mesocycles* (usually lasting several weeks to months), which are also subdivided into weekly *microcycles*. The strength training progresses over the macrocycle from low resistance (intensity) to high intensity with total volume following the opposite progression, from high to low. A



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