CHAPTER 16

Resistance Training Programs

OBJECTIVES

- Define resis ance training principles
- Review how and why resistance training should be performed
- Provide direction to the Personal Trainer on how to design, evaluate, and implement resistance training programs
- Provide the fundamental tools to evaluate clients' resistance training needs and progress

Resistance training, also known as strength training or weight training, is now a standard part of a comprehensive personal training program. The benefits of resistance training are numerous and include increases in strength, muscle mass, and bone density, to mention a few. All of these aspects are important to maintain good health in both men and women, and almost every population, from adolescents to senior citizens, can benefit f om resistance training.

THE SCIENCE BEHIND RESISTANCE TRAINING

At the end of the second World War, Captain Thomas Delorme, MD, experimented with the use of progressive resistance exercise as a rehabilitation modality for injured soldiers (3). A few years later, DeLorme and A. L. Watkins published the fi st paper in a scientific jou nal on the topic of long-term resistance training (4). After the initial work by DeLorme and Watkins, the science of resistance training lay somewhat dormant until the 1980s. Two notable former weightlifters, Dr. Patrick O'Shea from Oregon State University and Dr. Richard Berger from Temple University, became scientists, and their pioneering work in the 1960s and 1970s fueled the e ventual explosion in scientific ork on this topic (34,35). Prior to that, the most influential pe sonalities in resistance training during the last century were Mr. Bob Hoffman of York Barbell Club, who pioneered the interest in Olympic-style weightlifting and weight training with free weights through his publications and sales of barbells and dumbbells, and Mr. Joe Weider and his brother Ben, who promoted bodybuilding. Since the 1980s, published research on resistance training has grown exponentially in both scientifi manuscripts and books on the topic. A resistance training program can affect almost every system in the body and is used in a wide v ariety of populations, from young children preparing for sports to offsetting the effects of ag ing. With an explosion of information from books, magazines, and the Internet, a demanding challenge has been placed on the Personal Trainer to study and carefully evaluate information and its scientific rationale as resistance training mythology and marketing ploys remain very common in the field tod y. Once information has passed a critical evaluation, it is necessary to understand how it can be used in the implementation of a r esistance training program that ultimately affects the health, fitness and performance of a client.

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In the later 1980s, the focus of much of the research changed from enhancement of athletic performance to improvement of health and fitness among both men and omen in the general population and among special populations (6). Research on resistance training now appears in a wide range of specialized medical and physiological scientific jou nals such as the American College of Sports Medicine's *Medicine & Science in Sports & Exercise* and the National Strength and Conditioning Association's *Journal of Strength and Conditioning Research*. There are literally thousands of scientific a ticles examining different aspects of resistance training. This has led to a large and still growing knowledge base of physiological adaptations and mechanisms, gender differences, biomechanical influences and specificity considerations needed to unde stand resistance training exercise prescription. As a result, resistance training programs protocols can be guided by scientific acts and not by purely anecdotal evidence or marketing "mythology" as was the case during much of the last century. Today, resistance training is being utilized in a variety of rehabilitation disciplines from orthopedic to cardiac and obesity management based on the work of many contemporary clinicians including Dr. Kerry Stewart (at Johns Hopkins) and Dr. Barry Franklin (at William Beaumont Hospital).

GENERAL RESISTANCE TRAINING PRINCIPLES

The terms resistance exercise and resistance training are often used interchangeably; however, there is an important distinction between the two terms. *Resistance exercise* refers to a single exercise

FIGURE 16.1. Exercise prescription in resistance training is an individualized process that requires a series of steps from a needs analysis and goal-setting to evaluations and making changes in the workouts over time.

Resistance exercise refers to a single exercise session, whereas resistance training refers to the combination of many consecutive resistance exercise sessions over time.

session, whereas *resistance training* refers to the combination of many consecutive resistance exercise sessions over time. Thus, a resistance exercise protocol is an exercise prescription for a single session (also called a "workout") and a resistance training program is an overall program guiding the specific e ercise parameters chosen for each exercise protocol.

Designing a resistance training program is a very individualized process, and the needs and goals of the client are paramount to the selection of program characteristics (Fig. 16.1). Even though an individual may be training to maximize muscle hypertrophy, the client will also develop some muscular strength and endurance. The general principles of any effective resistance training program are as follows:

1. *Specificity of training*: Only the muscles that are trained will adapt and change in response to a resistance training program. For this reason, resistance programs must target all muscles for which a training effect is desired.
2. *SAID (Specific Adaptations to Imposed Demands) Principle*: SAID relates to the fact that the adaptation will be specific to the demands that the characte istics of the workout place upon the individual. If a high number of repetitions are used, the muscles will increase their ability to perform a high number of repetitions (muscular endurance).
3. *Progressive overload*: As the body adapts to a given stimulus, an increase in the stimulus is required for further adaptations and improvements. Thus, if the load or volume is not increased over time, progress will be limited.
4. *Variation in training*: No one program should be used without chang ing the exercise stimulus over time. Periodized training is the major concept related to the optimal training and recovery programming.
5. *Prioritization of training*: It is difficult to train for all aspects of uscular fitness Thus, within a periodized training program, one needs to focus or pr ioritize the training goals for each training cycle. This technique is often used in athletics paralleling competitive season schedules.

PROGRAM DESIGN PROCESS

The key to improved program design is the identification of specific ariables, which need to be controlled to better predict the training outcomes. The most challenging aspect of resistance training exercise prescription is making decisions r elated to the development and changes of an indi vidual's training goals and program design. One is faced with making appropriate changes in the resistance training program over time. This means that sound "clinical decisions" must be made on the basis of factual understanding of resistance training, the needs of the sport or activity, individual training responses, and testing data. Therefore, planning and changing the exercise prescription are vital for the success of any resistance training program.

An understanding of resistance training exercise prescription allows better quantification of th exercise stimulus. Planning ranges from the development of a single exercise session to the variation of the training program over time. The ability to quantify the workout and evaluate the progress made toward a specific training goal is the basic hallmark of the ersonal Trainer who is capable of designing safe and effective programs that lead to optimal physical development.

Training Potential

The gains made in any variable related to muscular performance will ultimately be linked to an individual's genetic potential. If an individual starts to train in a relatively deconditioned state, the initial gains are great because of the large adaptational potential that is available. As training proceeds, gains decrease as an individual approaches his or her genetic potential. At this point, some goals are maintained, whereas other target goals for the resistance training program must be adjusted to prevent the client from losing interest and quitting because of a lack of progress or boredom. Appreciation of this concept is important in understanding the adaptations and changes that occur over time. Furthermore, one can see how almost any program might work for an untrained individual in the early phases of training.

Initial Assessments

When working with a new client, the Personal Trainer should always devote adequate time to evaluate the client's prior resistance exercise experience before beginning any exercise sessions. The initial assessment should include a needs analysis focusing on learning about the client's personal goals and needs, the intended time frame for achieving these goals, targeted areas or muscle groups, health issues (e.g., cardiovascular disease, asthma, diabetes, osteoporosis, osteoarthritis, immune system disorders, neurologic disorders, other), musculoskeletal limitations, recent surgeries, chronic injuries, sites of pain, etc. Furthermore, Personal Trainers should try to understand why these goals are important to the clients as well as the level of support the clients feel they are receiving from their loved ones (see Chapter 10 for additional discussion of social support). Also, Personal Trainers should try to elucidate experiences with resistance training to uncover challenges, barriers, and strategies for motivation that their clients may face. The needs analysis will help the Personal Trainer determine which muscle groups, energy systems, and muscle actions need to be trained and how these and the other acute program variables should be manipulated to meet the specific needs of the training program. Furthermore, the Personal Trainer will be able to develop strategies to help the client overcome potential barriers to resistance training.

Before developing a resistance training program, Personal Trainers should take the time to conduct a baseline fitness assessment, consisting of anthropometric measurements (height, weight, circumferences, skinfolds, etc.), resting hemodynamics (heart rate, blood pressure), body composition, and tests of muscular strength and endurance (see Chapter 14 for more information on evaluations). Initial determination of the level of the different fitness ariables can help in the development of an effective training program. Examples of tests of muscular strength include 1 repetition maximum (1RM) testing on a variety of exercises, especially those exercises that involve the major muscle groups such as bench press and squat, but only if tolerable to the client (19). Muscular endurance testing might include 1-minute timed tests of curl-ups, push-ups to fatigue, or maximal amount of repetitions that can be performed at a given percentage of the 1RM load.

Follow-Up Assessments

It is exciting and motivating for clients to see improvements toward reaching their goals. To see these improvements, it is important that Personal Trainers keep records of their clients' progression. Individualized training logs are a useful tool for monitoring progress. These logs should record specifi exercises, resistance or load, number of sets, and number of repetitions (consider discussing using an RPE scale or a 0–10 scale rating effort on each exercise). Kept over time, these logs provide the Personal Trainer with a means to examine and evaluate progress and the effectiveness or to identify areas of weakness of the program. Another very important benefit of the training l g is that it allows the Personal Trainer to assign the appropriate resistance to be used during an exercise on the basis of the resistance and performance of previous exercise sessions.

Formal reassessment of a client's progress should occur periodically for encouragement, but not so often that there has not been adequate time for noticeable changes to develop. These follow-up assessments should include the same measures as administered at the baseline assessment, including anthropometric measurements and tests of muscular strength, power, and endurance.

Based on these assessments, the concepts of progression, variation, and overload can be applied to the resistance training program to achieve optimal physiological adaptations and to accommodate changing fitness l vels and goals of clients. These assessments will give the Personal Trainer a basis for modifying the acute program variables, including choice of exercise, order of exercises, intensity, number of sets, set structure, rest periods, load or resistance, and repetition speed. Variation can be incorporated by altering joint angles and positioning, primary exercises versus assistance exercises, or multijoint exercises versus single-joint exercises to stress the muscles and joints specified y the client's needs analysis. Progressive overload can be accomplished by increasing the intensity and/or volume by increasing the resistance, number of sets, number of repetitions, or number of exercises or by decreasing or increasing the rest intervals.

Individualization

Clients are not replicas of each other. Therefore, skilled and effective Personal Trainers do not give standard programs to multiple clients. Similar training programs provided to different clients will result in varied training responses. Therefore, the exercises that are given to one client may need to be modified to better suit the anatomical characte istics, needs, and abilities of another client. Additionally, the Personal Trainer must make modifications in esponse to the training adaptations of the specific client Adjustments to programs should focus on optimizing the individual's physiological adaptations.

Client Feedback

When designing a resistance training program that meets and/or surpasses the needs and expectations of the client, it is critical that the Personal Trainer pay special attention to feedback from the client. This feedback can be openly expressed, clients may request favorite exercises or muscle groups they hope to focus on during the training session, or they may complain of pain or fatigue and require program and exercise modifications It is important for the Personal Trainer to be alert to this feedback and encourage further feedback to ensure that the program and strategy meet the expectations of the client. This can be accomplished by asking the client for feedback, for example, "How do you think the workout went?" "Did you feel that you worked out hard enough?" "Was the exercise protocol too hard? Just right?" Furthermore, Personal Trainers must learn to recognize physical signs of dizziness and lightheadedness as well as complexion changes, profuse sweating, facial expressions, and muscle exhaustion. Working a client to the point of v omiting or passing out will not lea ve a good impression with clients or any spectators who are present when medical attention arrives.

Of special concern for Personal Trainers is the careful and proper progression in the resistance training program, especially in beginners or those coming off injury or disease. Too much exercise,

BOX 16.1 Likert-Type Chart to Determine Muscle Soreness

0	
1	Minor soreness
2	
3	Moderate soreness
4	
5	Extreme soreness
6	

too heavy of exercise, and/or accentuated eccentric exercise can lead to an excessive amount of muscle tissue damage and breakdown. This can result in "rhabdomyolysis" a clinical pathology that promotes the rapid breakdown of muscle tissue resulting in high amounts of breakdown products (e.g., myoglobin, myosin protein) entering into the blood stream that are harmful to kidneys and can cause kidney failure and sometimes death. With exercise, symptoms of delayed onset muscle soreness is a first sign that the individual has done too much too soon. Swelling, pain, and soreness are classical signs of muscle tissue damage, but if an improper workout was used, the damage has already been done. Therefore it is the careful progression to the heavier loads with prudent volume changes over time and the assessment of recovery from each workout that is key not to overshoot an individual's toleration of a resistance stress in a workout. A simple Likert-type (Box 16.1) chart can be used to gauge the level of soreness for the client. Individuals having over a score of 3 should have the resistance intensity and/or volume reduced dramatically and rest allowed in a periodized training program. Again, some muscle soreness is normal but extreme soreness is a sign of physiological overshoot.

"Rhabdomyolysis" is a clinical pathology that promotes the rapid breakdown of muscle tissue resulting in high amounts of breakdown products (e.g., myoglobin, myosin protein) entering into the blood stream that are harmful to kidneys and can cause kidney failure and sometimes death.

Careful attention to hydration levels in a workout with scheduled drinking is vital so as not to augment muscular damage and limit force production capabilities. Medical screening and being aware of medications (e.g., statins, diuretics) the client is taking are also vital to preventing or augmenting muscle tissue damage. There are many nonrelated causes of rhabdomyolysis from disease, infections, metabolic disorders, and drug and alcohol abuse, and even some statins used for the control of cholesterol levels have been linked to muscle tissue damage in some individuals. The main goal of any treatment is to deal with the shock and protect kidney function. Acute renal failure typically develops in 1 or 2 days after tissue trauma and thus it is so important to properly assess workouts and prevent extreme muscle injury from occurring. Within the context of resistance training, the resistance load and the volume of training need to be carefully progressed and monitored to limit muscle tissue damage and develop a physiological toleration to heavier resistance and volumes of exercise stress. Again, paying attention to the basic principle of progression and not doing too much too soon are important to an effective and safe exercise prescription.

Personal Trainers should always explain the muscle group(s) that the exercise is intended to target, and clients should be taught how to differentiate between muscle fatigue and soreness and unintentional pain or injuries. That way, if any pain is felt in any joint or nonsynergistic or stabilizer muscle, the exercise may not be a good match for the client, but it should be kept in mind that new exercises often feel uncomfortable or awkward. Exercises should be stopped immediately if the client complains of pain or the Personal Trainer suspects the client is in pain. The last thing a Personal Trainer wants to do is induce or aggravate an injury.

Feedback from the client can also come from paying close attention to the technique of the client during an exercise. Deterioration in technique often results from fatigue or insufficient flexibility the range of motion (ROM) involved in the exercise. Proper technique should always be a priority. When the technique is compromised during an exercise, the exercise should be either stopped or modified to eestablish correct technique to avoid injury.

Setting and Evaluating Goals

Personal Trainers encounter an assortment of clients with a plethora of goals including weight loss, weight gain, building strength, building muscle, shaping/toning, improving overall health, improving speed, agility, power, balance, coordination, decreasing blood pressure or cholesterol level, managing diabetes and other chronic diseases, injury rehabilitation, or sport-specific training Often the desired goals of clients are unrealistic. When improvements do not meet expectations, motivation can be lost, frustration may set in, and nonadherence to the program can occur. Therefore, it is crucial that the Personal Trainer help the client understand what realistic and obtainable goals are, considering the individual's training history and status, fitness l vel, and genetic potential. The expectations of the client must be realistic and measurable (see Chapter 8), considering the physiological time course of neural and muscle protein adaptations as well as weight loss. Goal-setting and time frame should also be considered, as well as the individual's age, physical maturity, training history, and psychological and physical tolerance. It is important to set measurable goals (such as increase in 1RM or fat mass loss). Progression toward the goals must be gradual to minimize the risk of injury. Resistance training program design and modifications should con sider these individualized goals.

Common program goals in resistance training are related to improvements in function, such as increased muscular strength, power, and local muscular endurance or decreased body fat (Fig. 16.2). Other functional gains such as increased coordination, agility, balance, and speed are also common goals of a program. It is becoming clear that such factors as balance may have implications for injury prevention by limiting falls in older individuals. Physiological changes related to increased body mass through muscle hypertrophy and improvement of other physiological functions such as improved blood pressure, decreased body fat, and increased metabolic rate to help burn calories are also goals that may be achieved with resistance training.

For the most part, training goals or objectives should be measurable variables (e.g., 1RM strength, vertical jump height) so that one can objectively judge whether or not gains were made or goals were achieved. Examination and evaluation of a workout log is invaluable in assessing the effects of

FIGURE 16.2. Setting goals and evaluating progress in a resistance training program are vital to realistic progress and gains.

various resistance training programs. Formal strength tests to determine functional changes in strength can be done on a variety of equipment, including isokinetic dynamometers, free weights, and machines. Using the results of these objective tests can help in modifying the exercise program to reach previous training goals or to develop new goals.

Athletic performance and health are not always the same thing.

It should be noted here that athletic performance and health are not always the same thing. Many elite athletes do things in their training program that far exceed what is recommended for good health (e.g., lifting 7 days a week or running 140 miles in a week or training 4–6 hours a day). Thus, goals in resistance training have to be put in the context of the needed or desired outcome for each individual. Factors such as age, physical maturity, training history, and psychological and physical toleration need to be considered in any goal development process and individual program design. Decisions on the use of the available training time must be made to affect the training goals, which directly influence perfo mance in the sport or activity. This is what makes an optimal program design.

Maintenance of Training Goals

A concept called "capping" may need to be applied to various training situations in which small gains will require very large amounts of time to achieve, and yet in the long run, these small gains are not necessary for success. This may be related to a performance (e.g., bench press 1RM strength) or some form of physical development (e.g., calf size). This is a tough decision that comes only after an adequate period of training time and observation of what the realistic potential for further change is for a particular variable. At some point, one must make a value judgment on how to best spend training time. By not adding any further training time to develop a particular muscle characteristic (e.g., strength, size, power), one decides to go into a maintenance training program. Thus, more training time is available to address other training goals. Ultimately, this decision may result in greater total development of the individual.

Decisions such as capping are part of the many types of clinical decisions that must be made when monitoring the progress of resistance training programs. Are the training goals realistic in relation to the sport or health enhancement for which the client is being trained? Is the attainment of a particular training goal vital to the program's success? These are difficult questions that need t be continually asked in the goal development phase of each training cycle for any program.

Unrealistic Goals

Careful attention must be paid to the magnitude of the performance goal and the amount of training time needed to achieve it. Although scientific studies m y last up to 6 months, most real-life training programs are developed as a part of a lifestyle for an individual's sports career or whole life. Goals change and resistance training programs must change to reflect these changing needs.

Too often, goals are open-ended and unrealistic. For most men, the 23-in biceps, the 36-in thighs, the 20-in neck, the 400-lb bench press, and the 50-in chest are unrealistic goals. This is because of genetic limitations most persons have for such extreme muscle size and performance. Women also can have unrealistic goals. Usually this is in an opposite direction from men, in that goals many times include desire for drastic decreases in limb size and body shape . Again, based on genetics, such changes may not be possible in many women because of a naturally larger anatomical structure. Many women mistakenly believe that large gains in strength, muscle definition and body fat loss can be achieved through the use of very light resistance training programs (e.g., 2- to 5-lb hand-held weights) that attempt to "spot build" a particular body part or muscle. Although one may be able to "spot hypertrophy" a particular body part, it is not done with light resistance.

In addition, the "fear of getting big" has produced unrealistic fears about lifting heavy weights, and thus many women do not gain the full benefits of esistance training. Ultimately, for both men

Ultimately, for both men and women, it is a question of whether the resistance training program used can stimulate the desired changes in their body.

and women, it is a question of whether the resistance training program used can stimulate the desired changes in their body. The desired changes must be carefully and honestly examined.

Unrealistic expectations of equipment and programs also exist when they are not evaluated on the basis of sound scientific principles. In today's "high tech" and "big hype" in marketing products, Internet information, programs, and equipment, unrealistic training expectations can be developed for the average person. In addition, movie actors, models, and elite athletes can also project a desired body image and/or performance level, but for most people such upper levels of physical development and performance are unrealistic. Proper goal development is accomplished by starting out small and making progress and then evaluating where the individual is and what is possible. Most people make mistakes in goal development by wanting too much too soon, with too little effort expended. Making progress in a resistance training program is related to a long-term commitment to a total training program.

In addition to resistance exercise, appropriate cardiovascular conditioning and proper nutrition and lifestyle behaviors can help support training objectives and physical development. Careful evaluation of training goals, objectives, and the equipment needed to achieve these goals and objectives can eliminate wasted time, money, and effort.

RESISTANCE TRAINING MODALITIES

There are many different training tools (e.g., free weights, machines, medicine balls) that can be used in a resistance training programs. All of these tools can be placed into specific categories of training. From the following, it is clear that each category has certain inherent strengths and weaknesses, and therefore, the modality chosen should depend on the needs, goals, experiences, and limitations of the client.

Variable-Resistance Devices

Variable resistance equipment operates through a lever arm, cam, or pulley arrangement. Its purpose is to alter the resistance throughout the exercise's ROM in an attempt to match the increases and decreases in strength (strength curve). Proponents of variable-resistance machines believe that by increasing and decreasing the resistance to match the exercise's strength curve, the muscle is forced to contract maximally throughout the ROM, resulting in maximal gains in strength.

There are three major types of strength curves: ascending, descending, and bell-shaped (Fig. 16.3). In an exercise with an ascending strength curve, it is possible to lift more weight if only the top ½

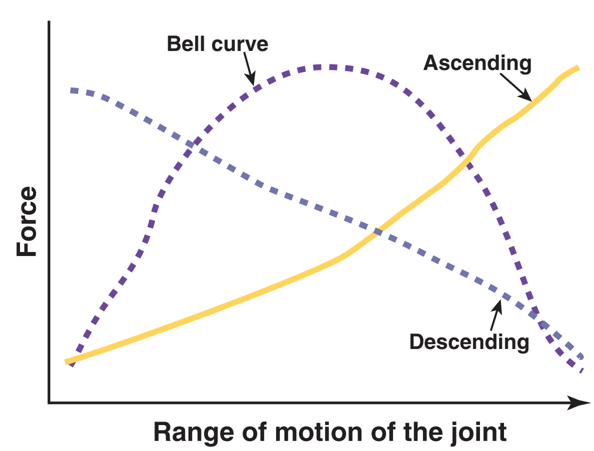


FIGURE 16.3. Three basic strength curves exist for every exercise, with hybrids of them for certain movements.

or ¼ of a repetition is performed than if the complete ROM of a repetition is performed. For example, an exercise with an ascending strength curve is the squat exercise. If an exercise has a descending strength curve, it is possible to lift more weight if only the bottom half of a repetition is performed. Such an exercise is upright rowing. A bell-shaped curve is an exercise in which it is possible to lift more resistance, if only the middle portion of the ROM is performed and not the beginning or end portions of the range of the motion. Elbow flexion has a bell-shaped st ength curve. Because there are three major types of strength curves, variable-resistance machines have to be able to vary the resistance in three major patterns to match the strength curves of all exercises. To date, this has not been accomplished. Additionally, because of variations in limb length, point of attachment of a muscle's tendon to the bones, and body size, it is hard to conceive of one mechanical arrangement that would match the strength curve of all individuals for a particular exercise.

Biomechanical research indicates that one cam type of variable-resistance equipment does not match the strength curves of the elbow curl, fl , knee extension, knee flexion and pullover exercises (8,28). A second type of cam-type equipment has been reported to match the strength curves of females fairly well (12). However, for females, the cam resulted in too much resistance near the end of the knee extension exercise. The cam also provided too much resistance during the fi st half and too little during the second half of the elbow flexion and extension e ercises. The knee flexion ma chine matched the female's strength curve well throughout the ROM.

Elastic resistance bands have become popular within the fitness orld because they are relatively easy to work with and less intimidating to clients. Although very effective as a training modality if the resistance can be heavy enough (20), care must be taken when using elastic bands with certain types of exercises that do not match the ascending strength curve. A possible major drawback to elastic bands is that the resistance increases constantly as the band is stretched, a resistance pattern that only matches an ascending strength curve; thus, at the beginning of a muscle flexion the resistance is low, and at the end of the flexion the resistance is very high. This means that only the part of the muscle involved in the latter part of the flexion m y be optimally stimulated if the setup is not correct. Thus, proper starting fit and st etch is essential for the training outcome . Also, because of the physics of elastic bands, the resistance during the extension phase will be lower than that during the flexion phas , again reducing the training stimulus. In addition, elastic bands give minimal feedback that may be important to some clients.

Dynamic Constant External Resistance Devices

Isotonic is traditionally defined as a uscular contraction in which the muscle exerts a constant tension. The execution of free-weight exercises and exercises on various weight training machines, though usually considered isotonic, is not by nature isotonic. The force exerted by a muscle in the performance of such exercises is not constant but varies with the mechanical advantage of the joint involved in the movement and the length of the muscle at a particular point in the movement. A more workable definition of isotonic is a esistance training exercise in which the external resistance or weight does not change and both a lifting (concentr ic) phase and a lowering (eccentric) phase occur during each repetition. Thus, free-weight exercises and exercise machines that do not vary the resistance are isotonic in nature. Because there is confusion concerning the term isotonic, the term dynamic constant external resistance training has been adopted.

The types of devices used for dynamic constant external resistance include dumbbells, barbells, kettle bells, weight machines, and medicine balls; these are generally devices that do not use pulleys or levers. The major disadvantage to this type of device is that it does not stimulate the neuromuscular systems involved maximally throughout the entire ROM. The changes in the musculoskeletal leverage occurring during a movement also change the force requirement and thus the exercise stimulus. However, these types of devices require that muscles other than the primary movers of an exercise are recruited to act as stabilizers, and this increases the total amount of physiological work the body must do to perform the exercise, as well as produce exercise stimuli to the stabilizing muscles that are very important in a real-world setting or for athletic performance. We also call these types of modalities "free form" exercises, as they operate in multiple dimensions of space. Other benefits t most constant external resistance devices include little or no limitation in the ROM allowed and easy adaptation of the exercise to accommodate individual differences such as the clients' body size or physical capabilities. Equipment fit is also not a limiting factor for large and small body sizes and limb lengths.

Static Resistance Devices

Specialized static or isometric contraction devices, in which a person pulls or pushes against an immovable resistance, are rarely used. Pushing an overloaded barbell against the safety racks, or using a wall or partner for an isometric contraction, is occasionally used for an individual to overcome a sticking point, and this form of resistance exercise is called "functional isometrics." Isometrics or static resistance training refers to a muscular action in which no change in the length of the muscle takes place. This type of resistance training is normally performed against an immovable object such as a wall, a barbell, or a weight machine loaded beyond the maximal concentric strength of an individual.

Isometrics can also be performed by having a weak muscle group contract against a strong muscle group. For example, trying to bend the left elbow by contracting the left elbow flexo s maximally while resisting the movement by pushing down on the left hand with the right hand with just enough force to prevent any movement at the left elbow. If the left elbow flexo s are weaker than the right elbow extensors, the left elbow flexo s would be performing an isometric action at 100% of a maximal voluntary contraction.

Review of subsequent studies demonstrated that isometric training leads to static strength gains but that the gains are substantially less than 5% per week (7). Increases in strength resulting from isometric training are related to the number of muscle actions performed, the duration of the muscle actions, whether the muscle action is maximal or submaximal, the angle at which the exercise is performed, and the frequency of training. Most studies involving isometric training manipulate several of these factors simultaneously. It is difficult therefore, to evaluate the importance of any one factor. Enough research has been conducted, however, to allow some recommendations concerning isometric training. Isometric exercises are thought to strengthen muscle fibe s within 15° of the position being held isometrically and therefore clients should perform multiple positions with isometric contraction to ensure full ROM strengthening. Also, isometric training is good for individuals with joint disorders in which pain is elicited by motion (i.e., rheumatoid arthritis).

Other Resistance Devices

Isokinetic devices allow one to maintain a maximum resistance throughout the whole ROM by controlling the speed of the movement. These devices use friction, compressed air, or pneumatics, which often allow for both the concentric and the eccentric component of a repetition, or hydraulics for the concentric component of a repetition. Isokinetic exercises, although popular in the rehabilitation setting, have never caught on as a typical modality used in a weight room. The initial excitement for this training modality was related to the ability to train at fast velocities similar to the high-speed movements seen in sport and real life. Isokinetic refers to a muscular action performed at constant angular limb velocity. Unlike other types of resistance training, there is no set resistance to meet; rather, the velocity of movement is controlled. The resistance offered by the isokinetic machine cannot be accelerated; any force applied against the equipment results in an equal reaction force. The reaction force mirrors the force applied to the equipment by the user throughout the range of movement of an exercise, making it theoretically possible for the muscle(s) to exert a continual, maximal force through the movement's full ROM.

Pneumatic resistance (compressed air) exercise has become relatively popular as it allows both the concentric and eccentric portions of a repetition and can be adjusted during a repetition or a set of exercises with hand-held buttons. This type of device has been popular for working with older populations. In addition, with no deceleration, it can be used effectively to train power with joint exercises not possible with conventional machines. Power is important for older adults to maintain function as well as for athletes. Because of the fixed nature of the configuration for most pneumatic machines, they are unable to address key factors such as balance and control in a multidimensional environment.

Hydraulics equipment has also become more popular with many fitness clubs promoting it as a safe and nonintimidating form of resistance exercise. Although this modality has no deceleration in its repetition range and has been used as a type of power training modality, it also has no eccentric component, which limits its efficiency as twice the number of repetitions may be required to get the same effect as a typical concentric–eccentric repetition (5). The eccentric phase is important to protect the body from injury and also enhance the ability to recover from injury. Furthermore, concentric-only training appears to be less resistant to detraining.

MACHINES VERSUS FREE-WEIGHT EXERCISES

A topic of great debate, especially in the health and fitness world, is the use of free weights versus machine resistance exercises. The two different exercise modalities were covered during the sections on constant external resistance and variable-resistance devices, respectively. Below is a comparison of the two modalities.

A topic of great debate, especially in the health and fitness world, is the use of free weights versus machine resistance exercises.

1. Machines are not always designed to fit the proportions of all individuals. Clients who are obese, have special physical considerations or disabilities, and are shorter, taller, or wider than the norm may not be able to fit comfortably in the machines and use them with ease. Free-weight exercises can easily be adapted to fit most clients' physical size or special requirements.
2. Machines use a fixed ROM; thus, the individual must conform to the movement limitations of the machine. Often, these movements do not mimic functional or athletic movements. Free weights allow full ROM, and the transfer to the real-world movements is greater than that for machines.
3. Most machines isolate a muscle or muscle group, thus negating the need for other muscles to act as assistant movers and stabilizers. Free-weight exercises almost always involve assisting and stabilizing muscles. On the other hand, if the goal is to isolate a specific muscle or muscle group, as in some rehabilitation settings or because of physical disabilities, machine exercises can be used.
4. Although it is never advisable to perform resistance exercise alone, machines do allow greater independence, as the need for a spotter or helper is usually diminished once the client has learned the technique of the exercise. However, there is a misconception of extra safety that may lead to a lack of attention being paid to the exercise. It is still possible to be injured when using machines.
5. Machine exercises may be more useful than free-weight exercises in some special populations. One reason for this is that machines are often perceived to be less intimidating to a beginner. As the resistance training skill and experience level increases, free-weight exercise can gradually be introduced if desired. However, it is important to inform clients of the benefits that free weights have compared with machines (e.g., increased musculoskeletal loading that reduces the risk of developing osteoporosis, improved balance).
6. Certain free-weight exercises (e.g., Olympic-style lifts) and hydraulic and pneumatic machines allow training of power, as no joint deceleration occurs.
7. Rotational resistance accommodates certain body movements (e.g., shoulder adduction) that would be difficult to work through a full ROM with free weights.

From the comparison above, it should be clear that variable resistive devices (machines) in general are at a comparative disadvantage to constant resistance devices (free weights), but machine exercises can still be useful in resistance training when used appropriately. Actually, a safe and optimally effective resistance training program involves a combination of both free-weight and machine exercises, taking into consideration many aspects of the client's needs and the advantages of the different modalities. They can also be used differently to add variation to the training program and as an effective tool in your fitness "tool box" of resistance training devices. To summarize, in general, machines and other variable-resistance devices should be used only as an adjunct to training of mid-level and advanced clients and athletes. For the general population, a combination of free weights and equipment devices is generally most effective.

> ***A combination of free weights and equipment devices is generally most effective.***

THE NEEDS ANALYSIS

Before designing a training program, a needs analysis (see Chapter 12) of the client should be performed to design the most effective program (6). Once the needs and goals of the client have been established, the following areas should also be carefully considered so the resistance training program can address questions that will come up when designing the workout using the acute program variables. It is important to keep in mind the general principles of resistance training covered in the beginning of this chapter as one continues with the development of the exercise.

A needs analysis for strength training consists of answering some initial questions that affect the program design components (14). It is important to take time to examine such questions. The major questions asked in a needs analysis are as follows:

1. What muscle groups need to be trained?
2. What are the basic energy sources (e.g., anaerobic, aerobic) that need to be trained?
3. What type of muscle action (e.g., isometric, eccentric actions) should be used?
4. What are the primary sites of injury for the particular sport or prior injury history of the individual?

Biomechanical Analysis to Determine Which Muscles Need to be Trained

The fi st question requires an examination of the muscles and the specific joint angles designated t be trained. For any activity, including a sport, this involves a basic analysis of the mo vements performed and the most common sites of injury. With the proper equipment and a background in basic biomechanics, a more definit ve approach to this question is possib le. With the use of a slo w-motion videotape, the coach can better evaluate specific aspects of m vements and can conduct a qualitative analysis of the muscles, angles, velocities, and forces involved. The decisions made at this stage help define one of the acute p ogram variables—choice of exercise.

Specificity is a major tenet of esistance training and is based in the concept that the exercises and resistances used should result in training adaptations that will transfer to better performance in sport or daily activity. Resistance training is used because it is often difficult if not impossible, to overload sports or other physical movements without risk of injury or dramatically altering sport skill technique. Specificity assumes that uscles must be trained similarly to the sport or activity in terms of:

- The joint around which movement occurs
- The joint ROM
- The pattern of resistance throughout the ROM (ascending, descending, or bell-shaped)
- The pattern of limb velocity throughout the ROM
- Types of muscle contraction (e.g., concentric, eccentric, or isometric)

Resistance training for any sport or activity of daily living should include full R OM exercises around all the major body joints. However, training designed for specific spo ts or activity movements should also be included in the workout to maximize the contribution of strength training to performance. The best way to select such exercises is to biomechanically analyze, in quantitative terms, the sport or physical activity and match it to exercises according to the above variables. Few such analyses of sports or activities have been done to date. Yet biomechanical principles can be used in a qualitative manner to intelligently select exercises. Ideally, this analysis is followed up with appropriate resistance exercises in the weight room that train the specific muscles and joint angles involved. For general fitness and muscular development, the major muscle groups of the shoulders, chest, back, and legs should be focused on and trained.

Biomechanical principles can be used in a qualitative manner to intelligently select exercises.

Each exercise and resistance used in a program will have various amounts of transfer to another activity or sport. When training for improved health and well-being, such a concept of transfer is related more to its effects on medical variables (e.g., bone mineral density) than to physical performance. The concept of "transfer specificity" is unclear to many Personal Trainers and healthcare/fitness professionals. Every training activity has a percentage of carryover to other activities. Except for practicing the specific task (e.g., lifting groceries or shoveling snow) or sport (e.g., running, basketball) itself, no conditioning activity has 100% carryover. However, some activities have a higher percentage of carryover than others because of similarities in neuromuscular recruitment patterns, energy systems, and biomechanical characteristics. Most of the time, one cannot use the sport or activity to gain the needed "overload" on the neuromuscular system, and this is why resistance training is used in the conditioning process. The optimal training program maximizes carryover to the sport or activity.

Determining the Energy Sources Used in the Activity

Performance of every sport or activity uses a percentage of all three energy sources. The energy sources (see Chapter 5) to be trained have a major impact on the program design. Resistance training usually stresses the anaerobic energy sources (adenosine triphosphate–creatine phosphate [ATP–CP] energy source and glycolytic energy source) more than aerobic metabolism (9). It is very difficult for individuals who have gained initial cardiovascular fitness to improve maximal oxygen consumption values using conventional resistance training alone (23). However, resistance training can be used to improve endurance performance by improving running efficiency and economy (13).

Selecting a Resistance Modality

Decisions regarding the use of isometric, dynamic concentric, dynamic eccentric, and isokinetic modalities of exercise are important in the preliminary stages of planning a resistance training program for sport, fitness or rehabilitation. The basic biomechanical analysis is used to decide which muscles to train and to identify the type of muscle action involved in the activity. Most resistance training programs use several types of muscle actions. As discussed previously in this chapter, it is important to understand that not all equipment uses concentric and eccentric muscle actions and that this can reduce the training effectiveness (e.g., hydraulics) (5).

Injury Prevention Exercises

It is also important to determine the primary sites of injury in the sport or recreational activity performed along with the prior injury profile of the individual. The prescription of resistance training exercises will be directed at enhancing the strength and function of tissue so that it better resists injury, recovers faster when injured, and reduces the extent of damage related to an injury. The term prehabilitation (the opposite of rehabilitation) has become popular. This term refers to preventing initial injury by training the joints and muscles that are most susceptible to injury in an activity. The prevention of reinjury is also an important goal of a resistance training program. Thus, understanding the sport's or activity's typical injury profile (.g., knees in downhill skiing or elbows and shoulders for baseball pitchers) and the individual's prior history of injury can help in properly designing a resistance training program.

THE ACUTE PROGRAM VARIABLES

Developed more than 20 years ago, the paradigm of acute program variables allows one to defin every workout (15). Every resistance exercise protocol or workout is derived from the fi e acute program variables. In turn, the choices made for each of these variables define the e ercise stimuli and ultimately, with repeated exposure, the training adaptations. Essentially, the choices made for the specific combination of acute p ogram variables create an exercise stimulus "finge print" that is specific and unique to that orkout protocol. Thus, by making specific choices for the acute p ogram variables that are related to the needs and goals of the client, the Personal Trainer is able to create many different types of workouts (6). The classical acute program variables are choice of exercises, order of exercises, resistance and repetitions used, number of sets for each exercise, and duration of rest period between sets and exercises.

> ***The classical acute program variables are choice of exercises, order of exercises, resistance and repetitions used, number of sets for each exercise, and duration of rest period between sets and exercises.***

Choice of Exercises

The choice of exercise will be related to the biomechanical characteristics of the goals targeted for improvement. The number of possible joint angles and exercises is almost as limitless as the body's functional movements. As muscle tissue that is not activated will not benefit f om resistance training, the exercises should be selected so they stress the muscles, joints, and joint angles specified y the client's needs analysis. To aid the Personal Trainer in making the correct choices, exercises can be divided into several different categories based on their function and/or muscle involvement.

Exercises can be designated as primary exercises or assistance exercises. Primary exercises train the prime movers in a particular movement and are typically major muscle group exercises (e.g., leg press, bench press, hang pulls). Assistance exercises are exercises that train predominantly a single muscle group (e.g., triceps press, biceps curls) that aids (synergists or stabilizers) in the movement produced by the prime movers.

Exercises can also be classified as ultijoint or single-joint exercises. Multijoint exercises require the coordinated action of two or more muscle groups and joints. Power cleans, power snatches, dead lifts, and squats are good examples of whole-body m ultijoint exercises. The bench press, which involves movement of both the elbow and shoulder joints, is also a multijoint, multimuscle group exercise, although it involves only movement in the upper body. Some examples of other multiple-joint exercises are the lat pull-down, military press, and squat.

Exercises that attempt to isolate a particular muscle group's movement of a single joint are known as single-joint and/or single-muscle group exercises. Biceps curls, knee extensions, and knee curls are examples of isolated single-joint, single-muscle group exercises. Many assistance exercises may be classified as single- uscle group or single-joint exercises.

Multijoint exercises require neural coordination among muscles and thus promote coordinated multijoint and multimuscle group movements. It has recently been shown that multijoint exercises require a longer initial learning or neural phase than single-joint exercises (2); however, it is important to include multiple-joint exercises in a resistance training program, especially when whole-body strength movements are required for a particular activity. Most sports and functional activities in everyday life (e.g., climbing stairs) depend on structural multijoint movements, and for most sports, whole-body strength/power movements are the basis for success. Running, climbing stairs, jumping, as well as activities such as tackling in American football, a takedown in wrestling, or hitting a baseball, all depend on whole-body strength/power movements. Thus, incorporating multijoint exercises in a resistance training program is important for both athletes and nonathletes.

In addition, it is important to consider the inclusion of both bilateral (both limbs) and unilateral (single limb) exercises in a program to make sure that proper balance is seen in the development of the body. Unilateral exercises (e.g., dumbbell biceps curl) play an important role in helping maintain equal strength in both limbs. Bilateral differences in muscle force production can be developed with one limb working harder on every repetition than the other, leading to an obvious force production deficit and imbalances bet een limbs.

Many multijoint exercises, especially those with an explosive component, involve the need for advanced lifting techniques (e.g., power cleans, power snatches). These exercises require additional technique coaching beyond just the simple movement patterns. An important advantage to multijoint exercises is that they are time efficient because several different muscle groups are activated at the same time. Therefore they can be especially useful for an individual or a team with a limited amount of time for each training session. In addition, the other benefits of ultijoint exercises include enhanced hormonal response and greater metabolic demands. Multijoint exercises also outweigh single-joint exercises. Most workouts should revolve around these types of exercises.

Order of Exercises

The order in which the chosen exercises are performed is an important acute program variable that affects the quality and focus of the workout. It has been theorized that by exercising the larger muscle groups fi st, a superior training stimulus is presented to all of the muscles involved. This is believed to be mediated by stimulating a greater neural, metabolic, endocrine, and circulatory response, which potentially may augment the training with subsequent muscles or exercises trained later in the workout. This concept also applies to the sequencing of multijoint and single-joint exercises. The more complex multijoint technique-intensive exercises (e.g., power cleans, squats) should be performed initially followed by the less complex single-joint exercises (e.g., leg extension, biceps curls).

The sequencing rationale for this exercise order is that the exercises performed in the beginning of the workout require the greatest amount of muscle mass and energy for optimal performance. This has been observed by Simao et al. (31), who found that performing exercises of both the large and the small muscle groups at the end of an exercise sequence resulted in significantly f wer repetitions in the three sets of an exercise. This decrease in the number of repetitions performed was especially apparent in the third set, when an exercise was performed last in an exercise sequence (31). These sequencing strategies focus on attaining a greater training effect for the large muscle group exercises. If multijoint exercises are performed early in the workout, more resistance can be used because of a limited amount of fatigue in the smaller muscle groups that assist the prime movers during the multijoint exercises. Also, alternating upper and lower body exercises and/or pushing and pulling exercises allows more time for the assisting muscles to recover between exercises.

> ***If multijoint exercises are performed early in the workout, more resistance can be used because of a limited amount of fatigue in the smaller muscle groups that assist the prime movers during the multijoint exercises.***

As the order of exercise affects the outcome of a training program, it is important to have the exercise order correspond to the specific training goals In general, the sequence of exercises for both multiple and single muscle group exercise sessions should be as follows:

1. Large muscle group before small muscle group exercises
2. Multijoint before single-joint exercises
3. Alternating push/pull exercises for total body sessions

4. Alternating upper/lower body exercises for total body sessions
5. Explosive/power type lifts (e.g., Olympic lifts) and plyometric exercises before basic strength and single-joint exercises
6. Exercises for weak areas (priority) performed before exercises for strong areas of the client
7. Most intense to least intense (particularly when performing several exercises consecutively for the same muscle group)

Resistance and Repetitions Used

The amount of resistance used for a specific exercise is one of the key variables in any resistance training program. It is the major stimulus related to changes observed in measures of strength and local muscular endurance. When designing a resistance training program, the resistance for each exercise must be chosen carefully. The use of either RMs (the maximal load that can be lifted the specifie number of repetitions) or the absolute resistance, which allows only a specific umber of repetitions to be performed, is probably the easiest method for determining a resistance. Typically, a single training RM target (e.g., 10RM) or an RM target range (e.g., 3–5RM) is used. Throughout the training program, the absolute resistance is then adjusted to match the changes in strength so a true RM target or RM target range resistance continues to be used. Performing every set until failure occurs can be stressful on the joints, but it is important to ensure that the resistance used corresponds to the targeted number of repetitions. This is because performing 3–5 repetitions with a resistance that allows for only 3–5 repetitions or using a resistance that would allow 13 or 15 repetitions produces quite different training results.

When designing a resistance training program, the resistance for each exercise must be chosen carefully.

Another method of determining resistances for an exercise involves using a percentage of the 1RM (e.g., 70% or 85% of the 1RM). If the client's 1RM for an exercise is 200 lb (90.9 kg), a 70% resistance would be 140 lb (63.6 kg). This method requires that the maximal strength in all exercises used in the training program must be evaluated regularly. In some exercises, percent 1RM needs to be used, as going to failure or near-failure is not optimal (e.g., power cleans, Olympic-style lifts). Without regular 1RM testing (e.g., each week), the percentage of 1RM actually used during training, especially at the beginning of a program, will decrease, and the training intensity will be reduced. From a practical perspective, the use of percentages of 1RM as the resistance for many exercises may not be administratively effective because of the amount of testing time required. In addition, for beginners, the reliability of a 1RM test can be poor. It is therefore recommended that the RM target or RM target range be used, as it gives the Personal Trainer the ability to alter the resistance in response to changes in the number of repetitions that can be performed at a given absolute resistance.

As is the case for the acute program variables, the loading intensity should depend on the goal and training status of the client. The intensity of the loading (as a percentage of 1RM) has an effect on the number of repetitions that can be performed, and vice versa. It is ultimately the number of repetitions that can be performed at a given intensity that will determine the effects of training on strength development (10,11). If a given absolute resistance allows a specific umber of repetitions (defined as the RM) then any reductions in the number of repetitions without an increase in the resistance will cause a change in the training stimulus. In this case, the change in the stimulus will lead to a change in the motor units recruited to perform the exercise and thus the neuromuscular adaptations. It is also important to understand that differences exist between free weights and machines for percentage of RM used. For example, in a squat exercise, one may be able to perform only 8–10 repetitions, whereas in the leg press, 15–20 repetitions are possible. Differences exist owing to the amount of balance and control that is needed in the exercise, with free weight exercises requiring more neural control and activation of assistance muscle. In addition, the size of the muscle groups used influences this effect as ell. With 80% (of 1RM) in an arm curl, a client may be able to do only 6–8 repetitions, so as the muscle group gets smaller, the response to a given percentage of the 1RM gets smaller.

Specific neu omuscular adaptations to resistance training depend in large part on the resistance used. These adaptations follow the SAID principle presented earlier in this chapter. Heavier resistances will produce lower numbers of repetitions (1–6) but will lead to greater improvements in maximal strength (1,32). Thus, if maximal strength is desired, heavier loads should be used. Alternately, if muscular endurance is the goal, a lower load should be used, which will in turn allow a greater number of repetitions (12–15 RM) to be returned (1,32).

Number of Sets for Each Exercise

The number of sets performed for each exercise is one variable in what is referred to as the volume of exercise equation (e.g., sets × reps × resistance) calculation.

First, the number of sets does not have to be the same for all exercises in a workout program. In reality, apart from training mythologies, the number of sets performed for each exercise is one variable in what is referred to as the *volume* of exercise equation (e.g., sets × reps × resistance) calculation. As such, one of the major roles of the number of sets performed is to regulate the volume performed during a particular exercise protocol or training program. In studies examining resistance-trained individuals, multiple-set programs have been found to be superior for strength, power, hypertrophy, and high-intensity endurance improvements (24,25). These findings have prompted the recommendation from the American College of Sports Medicine (1) for periodized multiple-set programs when long-term progression (not maintenance) is the goal. No study has shown single-set training to be superior to multiple-set training in either trained or untrained individuals. It appears that both single- and multiset programs can be effective in increasing strength in untrained clients during short-term training periods (i.e., 6–12 weeks). However, some short-term studies (1,32) and all long-term studies (1,32) support the contention that the greater training stimulus associated with the higher volume from multiple sets is needed to cr eate further improvement and progression in physical adaptation and performance. Yet variation in training stimuli, as is discussed in detail later, is also critical for continued improvement. This variation often includes a reduction in training volume during certain phases of the overall training program. The determining factor here is in the "periodization" of training volume rather than in the number of sets, which is only one of the components in the volume equation. Once initial fitness has been achieved, a multiple presentation of the exercise stimulus (three to six sets), with specific est periods between sets to allow the use of the desired resistance, is superior to a single presentation of the training stimulus. Some advocates of single-set programs believe that a muscle or muscle group can perform maximal exercise only for a single set; however, this has not been demonstrated. On the contrary, studies have found that with sufficien rest between sets, trained individuals can produce the same maximal effort during multiple sets (1).

Exercise volume is a vital concept in resistance training progression, especially for those who have already achieved a basic level of training or strength fitness As mentioned earlier, the principle of variation in training or more specifically "periodized training" involves the number of sets performed. As the use of a constant-volume program can lead to staleness and lack of adherence to training, variations in training volume (i.e., both low- and high-volume exercise protocols) are important during a long-term training program to provide adequate rest and recovery periods. This concept is addressed later in this chapter under "Periodization of Exercise." Multiple-set programs are superior for long-term progression, but one-set programs are effective for developing and maintaining a certain level of muscular strength and endurance. For some fitness enthusiasts this given level of muscular fitness m y be adequate. Also, one-set programs sometimes result in greater compliance by those who are limited in their time for exercise and also need to perform cardiovascular exercise, flexibility e ercise, etc. It may be better for this client to do one set than no sets at all.

Duration of Rest Period between Sets and Exercises

The rest periods play an important role in dictating the metabolic stress of the workout and influence the amount of resistance that can be used during each set or exercise. A major reason for this is that the primary energy system used during resistance exercise, the ATP–CP system, needs to be replenished, and this process takes time (see Chapter 5). Therefore, the duration of the rest period significantly influences the metabol, hormonal, and cardiovascular responses to a short-term bout of resistance exercise, as well as the performance of subsequent sets (21,22). For advanced training emphasizing absolute strength or power (few repetitions and maximal or near-maximal resistance), rest periods of at least 3–5 minutes are recommended for large muscle mass multijoint exercises (such as squat, power clean, or dead lift), whereas shorter rest may be sufficient for smaller uscle mass exercises or single-joint movements (1). For a novice-to-intermediate resistance exercise protocol, rest periods of 2–3 minutes may suffice for large uscle mass multijoint exercises, because the lower absolute resistance used at this training level seems to be less stressful to the neuromuscular system. Performance of maximal resistance exercises requires maximal energy substrate availability at the onset of the exercise and a minimum fatigue level and thus requires relatively long rest periods between sets and exercises.

> ***The duration of the rest period significantly influences the metabolic, hormonal, and cardiovascular responses to a short-term bout of resistance exercise, as well as the performance of subsequent sets (21,22).***

Resistance training that stresses both the glycolytic and ATP–CP energy systems appears to be superior in enhancing muscle hypertrophy (e.g., bodybuilding); thus, less rest between sets appears to be more effective in high levels of muscular definition If the goal is to optimize both strength and muscle mass, both long rest with heavy loading and short rest with moderate loading types of workout protocols should be used. However, it should be kept in mind that the short-rest resistance training programs can potentially cause greater psychological anxiety and fatigue because of the greater discomfort, muscle fatigue, and high metabolic demands of the program (33). Therefore, psychological ramifications of using short-rest workouts must be carefully considered and discussed with the client before the training program is designed. The increase in anxiety appears to be associated with the high metabolic demands found with short-rest exercise protocols (i.e., 1 minute or less). Despite the high psychological demands, the changes in mood states do not constitute abnormal psychological changes and may be a part of the normal arousal process before a demanding workout.

The key to rest-period lengths is the observation of symptoms of loss of force production in the beginning of the workout and clinical symptoms of nausea, dizziness, and fainting, which are direct signs of the inability to tolerate the workout. When such symptoms occur, the workout should be stopped and longer rest periods used in subsequent workouts. With aging, decreased ability to tolerate decreases in muscle and blood pH underscores the need for gradual progression when cutting rest period lengths between sets and exercises (22). Rest periods may be thought of as:

- Very short rest periods—1 minute or shorter
- Short rest periods—1–2 minutes
- Moderate rest periods—2–3 minutes
- Long rest periods—3–4 minutes
- Very long rest periods—5 minutes or longer

The more rest that is allowed between sets and exercises, the heavier the resistance. Also, more rest allows for a greater number of repetitions to be performed at a specific RM load (16,22). Improvements take place for a given rest period when the body's bicarbonate and phosphate, blood and muscle buffering systems, respectively, are improved by the gradual use of shorter rest period lengths (16,22).

VARIATION OF THE ACUTE PROGRAM VARIABLES

The acute program variables can be manipulated to develop different workouts for the single-exercise sessions used over time. Also, the number of sets, number of repetitions, relative resistance used, and rest periods do not have to be the same for each exercise in a session. They can all be varied either within an exercise or, more frequently, between different exercises in an exercise protocol. Variation must seek to address the needed change in the demands placed on the neuromuscular system over time, with planned rest a vital part of this principle. It is also important to understand that one can use light exercise to rest higher threshold motor units (i.e., motor neuron and associated muscle fibers). Understanding the "size principle" in this regard is important, as not all motor units are recruited with each resistance loading experience of a muscle, and therefore, different loadings can result in different amounts and types of muscle tissue being used. Heavier loads with adequate volume recruit more muscle tissue and are one reason why women need to have heavy loading cycles in their resistance training programs, regardless of fears related to excessive hypertrophy (6). The use of the size principle is vital for understanding variation in resistance training and ultimately periodized training.

Muscle Actions

Muscles can produce force while performing one of three different actions:

1. When sufficient force is produced to overcome the external load and shorten the muscle, the action is termed *concentric* muscle action or contraction.
2. If the muscle produces force but there is no change in length of the muscle, the action is termed *isometric.*
3. Production of force while the muscle is lengthening (i.e., resisting the movement) is termed *eccentric* muscle action.

In the past, the term *contraction* was used for each of the three muscle actions; however, this use is inappropriate, because only the concentric muscle actions actually involve a muscle contraction in which a classic muscle shortening occurs. An exercise can include one, all, or any combination of the three muscle actions; however, most exercises are performed using either isometric muscle action or both concentric and eccentric muscle actions. The force–velocity curve runs from high- to low-speed eccentric muscle actions to maximal isometric muscle action to slow- to high-velocity concentric muscle contractions, creating a descending hierarchy of force productions. However, the most effective training programs appear to use concentric–eccentric repetitions (5).

The most effective training programs appear to use concentric–eccentric repetitions (5).

True Repetition and Range of Movement

Muscle actions involving movement of a joint are termed *dynamic,* and thus exercises involving joint movements are called dynamic exercises. A full-range dynamic exercise repetition usually contains both a concentric phase and an eccentric phase. The order of the phases depends on the choice of exercise. A squat, for example, starts with the eccentric phase; a pull-up normally starts with the concentric phase. It is important to perform the exercise so that the joints involved move through a large full ROM. For single-joint exercises especially, it is important to move the joint through the full ROM. For example, in the arm curl, a full repetition should start with the elbow almost completely extended, progress until the elbow is maximally flexed, and finish with the elbow almost completely extended again. By using the whole ROM, the whole length of the muscle is stimulated, leading to adaptations throughout the whole muscle and not just in parts of it. However, ROM may need to be carefully monitored and restricted when working with clients who have orthopedic injuries or limitations.

PERIODIZATION OF EXERCISE

Periodization is a concept, and the exact design or workouts used are the program and its application (26). Understanding some of the basic concepts about periodization is important to create workouts and the actual periodized program using the acute program variables. Periodization refers to systematic variation in the prescribed volume and intensity during different phases of a resistance training program. A traditional linear periodization program contains four phases:

> ***Periodization refers to systematic variation in the prescribed volume and intensity during different phases of a resistance training program.***

1. Hypertrophy, consisting of high volume and short rest periods
2. Strength/power, consisting of reduced volume but increased load and rest periods
3. Peaking, consisting of low volume but high load and longer rest periods
4. Recovery, consisting of low volume and load

There is no set formula for how a program should be periodized, as it depends on the specifi goals and needs of the clients (29). Table 16.1 presents an example of a traditional four-phase periodized training program aimed at producing maximal power and strength.

The reason for incorporating periodization into the training program is that by systematically varying some of the acute program variables, the muscles are exposed to different stimuli to which they must adapt differently, leading to greater increases in muscle quality, characteristics, and performance. In addition, rest is encouraged at different points in the training program, which allows for recovery and the prevention of both short- and long-term overtraining. Another important benefit to periodization is that it can reduce the potential boredom found with repeating the same resistance exercise program over and over again. This may well affect adherence to a fitness p ogram. Many different models for periodization have been developed; thus, the model to be used should be selected on the basis of the needs and desires of the client.

The popular terms micro-, meso-, and macrocycle refer to different phases of periodization. The largest time frame for a training cycle is the *macrocycle.* In the example used in this chapter, a macrocycle refers to a year, and all phases are included in this cycle. A *mesocycle* refers to the next smaller group of training cycles that make up the macrocycle, usually four to six in a year. Finally, the *microcycle* is the smallest component, which usually ranges in time from 1 to 4 weeks dedicated to one type of workout variable in that phase (e.g., high-volume, low-intensity, power). Anecdotally, it has been found that more mesocycles are more beneficial to the verall training effect, and this leads to the concept that higher degrees of variation in the training stimulus are more effective in producing overall adaptations in the body. In part, this leads to many different variations in the classic periodization model, including nonlinear periodization.

TABLE 16.1 TRADITIONAL AMERICAN-STYLE PERIODIZATION SCHEDULE

Goal	Hypertrophy	Maximal Strength/Power	Peak	Recovery
Reps	High Moder	ate-low	Low	Moderate
Sets	High	Moderate	Low	Moderate
Rest	Short	Moderate	Long	Moderate
Load	Low	Moderate	Very high	Low
Volume	High-moderate	Moderate	Low	Low

The use of periodized resistance training has been shown to be superior to constant training methods. Periodized training involves the planned variation in the intensity of exercises and in the volume of a workout. Typically, one periodizes large muscle group exercises. However, variation schemes can be created for smaller muscle groups. One must consider the type of periodized program to use. In general, there are two basic types that have been developed, linear and nonlinear periodized protocols for maximal strength development.

Linear Periodization

Classic periodization methods use a progressive increase in the intensity with small variations in each 1- to 4-week microcycle.

Classic periodization methods use a progressive increase in the intensity with small variations in each 1- to 4-week microcycle. An example of a classic four-cycle linear periodized program (4 weeks for each cycle) is presented in Table 16.2.

One can see that there is some variation within each microcycle due to the repetition range of each cycle. Still, the general trend for the 16-week program is a steady linear increase in the intensity of the training program. Microcycle 5 is a 2-week active rest period in which no lifting is done or at best very light, low-volume training is used prior to the next mesocycle. Because of the straight-line increase in the intensity of the program, it has been termed "linear" periodized training. Because most training programs from which periodization evolved were of the single-peaking nature (e.g., track and field weightlifting), consecutive buildup to the peak was used in this so-called classic method. Now, many more models that are hybrids of this classical model exist.

The volume of the training program will also vary with the classic program, starting with a higher initial volume, and as the intensity of the program increases, the volume gradually decreases. The drop-off between the intensity and volume of exercise can decrease as the training status of the individual advances. In other words, advanced athletes can tolerate higher volumes of exercise during the heavy and very heavy microcycles.

It is important to point out here that one must be very careful not to progress too quickly to train with high volumes and heavy weights. Pushing too hard has the potential for a serious overtraining syndrome. Overtraining can compromise progress for weeks or even months. Although it takes a great deal of excessive work to produce such a long-term overtraining effect, highly motivated individuals can easily make mistakes out of sheer desire to make gains and see rapid progress in their training. So it is important to monitor the stress of the workouts and the total conditioning program. Exercises within a program can interact to compromise each other.

The purpose of the high-volume exercise in the early microcycles is that it has been thought to promote the muscle hypertrophy needed to eventually enhance strength in the later phases of training. Thus, the late cycles of training are linked to the early cycles of training, and they enhance each other as strength gains are related to size changes in the muscle. Programs that attempt to gain strength without the needed muscle tissue are limited in their potential.

The increases in the intensity of the periodized program then start to develop the needed nervous system adaptations for enhanced motor unit recruitment. This happens as the program progresses and heavier resistances are used. Heavier weights demand higher threshold motor units to become involved in the force production process. The subsequent increase in muscle protein from the early

TABLE 16.2 AN EXAMPLE OF A CLASSIC LINEAR PERIODIZED PROGRAM USING 4-WEEK MICROCYCLES

Microcycle 1	Microcycle 2	Microcycle 3	Microcycle 4	Microcycle 5 (2 Weeks)
3–5 sets of 12–15RM	4–5 sets of 8–10RM	3–4 sets of 4–6RM	3–5 sets of 1–3RM	Active rest/Recovery

cycle training enhances force production from the motor units. Here again one sees integration of the different parts of the 16-week training program.

The completion of all of the cycles in this 16-week program would be one mesocycle, and a year training program (macrocycle) is made up of several mesocycles. Again, shorter mesocycles have been used to better delineate the different trainable features of muscle. Each mesocycle attempts to progress the body's musculature upward toward one's theoretical genetic maximum for a given variable. Thus, the theoretical basis for a linear method of periodization consists of developing the body with a sequential loading from light to heavy and from high volume to low volume, thereby addressing the goals of the program for that training cycle while providing active rest at the completion of the mesocycle. This is repeated again and again with each mesocycle, and progress is made in the training program over an entire macrocycle.

Nonlinear Periodized Programs

More recently, the concept of nonlinear periodized training programs has been developed to maintain variation in the training stimulus. However, nonlinear periodized training makes implementation of the program possible because of schedule, business, or competitive demands placed on the individual. The nonlinear program allows variation in the intensity and volume within each week over the course of the training program (e.g., 12 weeks). Active rest is then taken after the 12-week mesocycle. The change in the intensity and volume of training will vary within the cycle, which could be 7–14 days. An example of a nonlinear periodized training program over a 12-week mesocycle is shown in Table 16.3.

The nonlinear program allows variation in the intensity and volume within each week over the course of the training program (e.g., 12 weeks).

The variation in training is much greater within the 7-day period. One can easily see that intensity spans a wide range. This is but just one set of workout options for intensity and volume, and many others can be created. This span in training variation appears to be as effective as linear programs. One can also add a "power" training day in which loads may be from 30% to 45% of 1RM and exercises must not have a high deceleration component, so the choice of exercise and/or equipment used is vital (e.g., Olympic lifts or pneumatic resistance) so that no deceleration exists with the movement of the joint(s), or one can have a plyometric training day of different exercises and intensities (e.g., jumps, bounds, medicine ball exercises).

Unlike the linear programs, one trains the different components of muscle size, strength, and power within the same week. Unlike the linear methods, nonlinear programs attempt to train different features of muscle within the same week (e.g., hypertrophy and power and strength). Thus, one is working at two different physiological adaptations together within the same 7- to 10-day period of the 12-week mesocycle. Such a periodization model may be more conducive to many individuals' schedules, especially when travel, school, competitions, or other schedule conflicts ca make adherence to the traditional linear method difficult

In this program, one just rotates through the different protocols. The workout rotates different workouts with the different training sessions. If one misses the Monday workout, the rotation order is just pushed forward, meaning that one just performs the rotated workout scheduled. For example, if the light 12–15RM workout was scheduled for Monday and you miss it, you just perform it

TABLE 16.3 AN EXAMPLE OF NONLINEAR PERIODIZED TRAINING PROTOCOL

Monday	Wednesday	Friday	Monday
1 set 12–15RM	3 sets of 8–10RM	4 sets of 4–6RM	Power day 6 sets of 3 at 30%–45% of 1 RM in using power exercises (e.g., hang pulls etc.) /plyometrics

This protocol uses a 4-day rotation with 1-day rest between workouts.

on the next training day and continue with the rotation sequence. In this way, no workout stimulus is missed in the training program. One can also say that a mesocycle will be completed when a certain number of workouts are completed (e.g., 48) and not use training weeks to set the program duration.

One of the new advances in periodization is called "unplanned nonlinear periodization." The name is somewhat of a misnomer, as an overall plan is developed for a 12-week mesocycle, but the actual day that a given workout will be performed is based on the readiness to train. In other words, in unplanned nonlinear periodization, a workout plan is set for the mesocycle but deciding what workout is to be done on what day is left to the Personal Trainer, who will base it on the client's fatigue level, psychological state, or fitness to use only the most optimal workout that can be performed on a given day. In this model, the training session category (e.g., light, moderate, power, or heavy) is prescribed on the basis of the physiological ability or state of the client at the time of the session. Thus, if the client is very fatigued before a particular exercise session, some workouts would not be prescribed (e.g., a power training or plyometrics training day or a high-volume, low-rest training day would not be a good choice because prior fatigue would dramatically reduce the workout quality). After a workout is done, it is checked off in the major planning matrix for the 12-week mesocycle.

In any periodization model, it is the primary exercises that are typically periodized, but one can also use a two-cycle periodization program to vary the small muscle group exercises. For example, in the "triceps pushdown" one could rotate between the moderate (8–10RM) and the heavy (4–6RM) cycle intensities. This would provide not only the hypertrophy needed for such isolated muscles of a joint but also the strength needed to support heavier workouts of the large muscle groups.

In summary, two different approaches can be used to periodize a resistance training program, specificall , linear and nonlinear program workout schedules. The programs appear to accomplish the same effect and appear superior to constant-intensity training programs. This seems to be accomplished by training either the hypertrophy component fi st and then the neural strength component second in the linear method and both components within a 7- to 14-day time period, depending on the number of workout types one uses in the nonlinear method. The key to workout success is variation, and different approaches can be used over the year to accomplish this training need.

PROGRESSION FROM BEGINNER TO ADVANCED

The level of fitness and esistance training experience of the client is maybe the most important factor to be considered when designing a resistance training program. Resistance exercise can place a large stress on the body, and certain exercises require a high level of technique to avoid injury.

> ***Resistance exercise can place a large stress on the body, and certain exercises require a high level of technique to avoid injury.***

The most important aspect for beginners is resistance exercise techniques. At the beginning of the training program, correct technique of the exercises involved should be stressed, and the resistance and volume should be kept low. From a strictly short-term performance-enhancement point of view, a single set per exercise may be enough for beginners to achieve the stimulus needed from an exercise.

Although multiple sets may not lead to greater improvements in performance for beginners in the short term, there may still be benefits to using ultiple sets from the onset of the training program (25,30). One reason for this is that more repetitions can lead to faster improvements in the technique of the exercises involved in the training program, especially for multijoint exercises. The squat exercise is an example of an exercise that requires a great deal of technique to be performed correctly. In addition, some studies have found that multiple sets even for beginners create larger improvements than single sets, whereas no study has found that single sets are superior (30).

As the client progresses past the initial few months of training, multisets should be used for each exercise session. As the skill and experience level of the client improves, more technical exercises can be taught. Advanced resistance training can include highly technical exercises such as the clean or the snatch, as well as advanced modalities such as plyometric exercises. The progression will differ among individuals, and the Personal Trainer must evaluate each client extensively and continuously before including more advanced exercises, to ensure that the exercises match the client's skill and experience level.

CLIENTS

Client Interactions

As a Personal Trainer working with clients, it is important to encourage and motivate them as well as to provide innovative, optimal, individualized resistance training programs. Many clients hire Personal Trainers because they feel they need constant guidance. In addition, it provides them with a support system. Most importantly, they are hiring professionals with training and knowledge in conditioning science. They are also hiring professionals to help them perform exercises properly and who understand exercise prescription to allow them to achieve their personal goals and objectives. For some clients, it is an important part of their sports conditioning program. Ultimately, the Personal Trainer must form a special relationship with each and every client that is based on professionalism, trust, and openness (Fig. 16.4).

Clients should feel that their Personal Trainer genuinely cares about them and is personally vested in helping them achieve their goals. Clients expect their Personal Trainer to be a source of knowledge and an educator. Clients expect their Personal Trainer to be able to explain things or answer the question "Why?" Thus, clients appreciate having their Personal Trainer explain why they are doing this exercise or this combination of sets and reps in their program. Personal training has been found to be superior to unsupervised training, even for people who understand resistance training (27).

Personal Trainers should convey the specific benefits of resistance training, including increases in strength, muscle mass, and bone mass, particularly to clients who may be skeptical about why resistance training is important.

Additionally, Personal Trainers should convey the specific benefits of resistance training, including increases in strength, muscle mass, and bone mass, particularly to clients who may be skeptical about why resistance training is important. Many uneducated clients may have false impressions of the outcome from resistance training. In particular, some women often perform programs that are not optimal, excluding a heavy loading workout or cycles because of the "fear of getting big muscles." This misunderstanding of resistance training effects has held many women in particular, back in achieving optimal gains in muscle tissue mass and bone mineral density, which are challenged to a greater extent in women as they age.

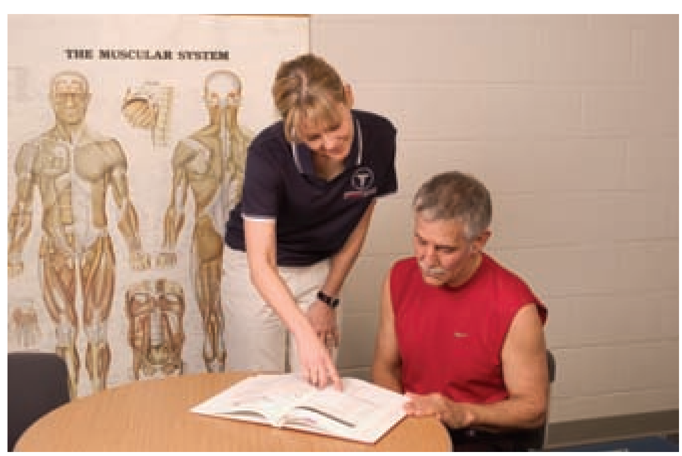


FIGURE 16.4. Having education and being a credible source of knowledge as a fitness xpert is part of what Personal Trainers must provide to their clients. This takes continual study and preparation to stay current and up-to-date on basic topics and hot topics of the day.

Clients consider Personal Trainers experts and will often want to hear their opinion on fads facing the fitness indust y. Often clients' knowledge of resistance training comes from infomercials and magazine marketing products, which frequently mislead clients by encouraging the sales of the various products. It is important for Personal Trainers to stay educated and ideally current with the scientific literatu e and know how to do research on topics of interest to their clients. Clients will also ask questions the Personal Trainer cannot answer (nobody knows everything). In these cases, it is best for the Personal Trainer to admit that he or she does not know the answer but will find it f om experts in the field thus showing a broader network of people who can act as resources. This is always a better strategy than con veying potentially incorrect information. Furthermore, Personal Trainers are often required to obtain continuing education credits to maintain their certifications therefore, staying current is critical to success.

SPOTTING IN RESISTANCE EXERCISE

In comparison with other components of a complete fitness p ogram (such as cardiovascular conditioning), resistance training often requires more physical interaction between the client and the Personal Trainer to ensure proper positioning, fit and setup of a machin , and techniques in both machine and free-weight exercises. It is important for the Personal Trainer to explain to clients the spotting procedures in resistance training and the level of physical interaction required between the client and the Personal Trainer. Always ask your clients before physically touching them, to ensure that they are comfortable with it. For example, when performing elbow extension exercises, it is sometimes helpful for the Personal Trainer to place his or her hands on the client's elbows as a reminder to keep the elbow from pointing outward. In these cases, explain to the client, "I am going to put my hands on your elbows to remind you to keep them from pointing outward. Is this okay with you?" In most cases, clients will have no problem with this physical contact, but it is always better to ask than to assume.

> ***Ask your clients before physically touching them, to ensure that they are comfortable with it.***

Know Proper Spotting Technique

Good spotting technique is vital for a safe resistance training program. It is important for the Personal Trainer to understand proper technique for every exercise and how to position clients for the exercise, whether it is in a machine that may not fit all people or with f ee weights to get the proper anatomical positioning throughout the exercises. Most important is to understand how to spot each and every exercise in a program. A checklist for the Personal Trainer is:

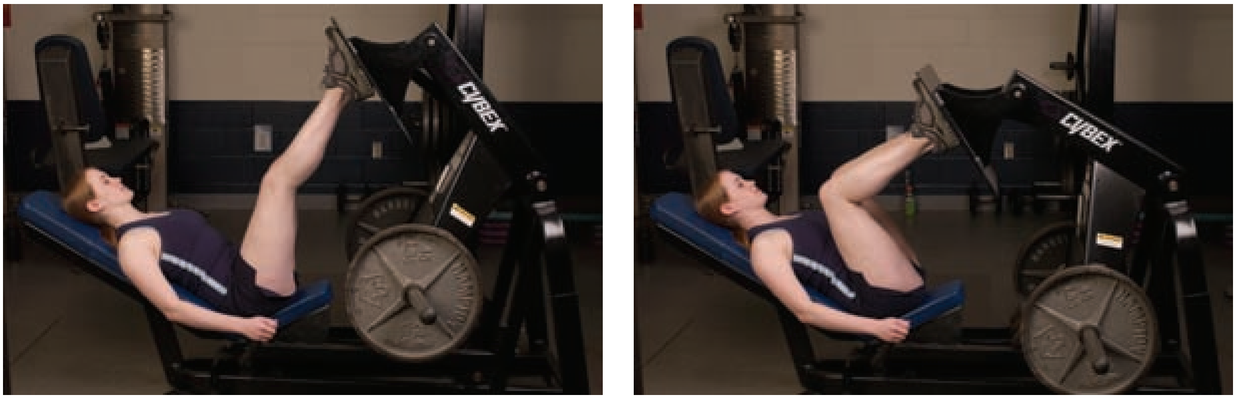
1. Know proper exercise technique
2. Know proper spotting technique
3. Be sure you are strong enough to assist the lifter with the resistance being used or get help
4. Know how many repetitions the lifter intends to do
5. Be attentive to the lifter at all times
6. Stop lifters if exercise technique is incorrect or they break form
7. Know the plan of action if a serious injury occurs

The goal of correct spotting is to prevent injury. A lifter should always have an exercise spotted, and the Personal Trainer must mediate this process, alone or with additional help.

RESISTANCE EXERCISES

A large number of resistance exercises can be used in a program. It is beyond the scope of this chapter to go through each and every exercise. The reader is referred to a comprehensive list of more than 125 exercise descriptions of both machine and free-weight exercises along with spotting techniques by Kraemer and Fleck (18). Each program should be designed on the basis of the pr inciples outlined in this chapter. Periodization is very important and many Personal Trainers are now using nonlinear methods to k eep the clients inter ested and the pr ograms effective (17). Free weights and machines can be used for each ex ercise as well as bilateral and unilateral ex ercises. See Figure 16.5 A–O for examples.

FIGURE 16.5. A. Back squat (thighs). Place the barbell on the back of the shoulder s and grasp the barbell at the sides, with feet shoulder-width apart, toes slightly out. Dismount bar fr om rack. Descend until thighs ar e just past parallel to the floo and then extend the knees and hips until legs ar e straight, returning you to the st arting position. Repeat for the appropriate number of repetitions. Keep the head forward with the chin level, back straight, and feet flat on the flo ; keep equal distribution of weight throughout forefoot and heel and either squat within the power r ack or have spotter(s). **B.** Supine leg press (thighs). Lie flat on the sled with shoulde s against the pad. Place the f eet on the platform, making sure that they are securely on the base plat e. Extend the hips and knees. Fle x the hips and knees until the knees ar e just short of complete fl x-ion and return to the starting position to complete the repetition. Keep the feet flat on the plat orm and do not lock the knees. A full ROM should be used; keep the knees in the same dir ection as the feet.



C

Start Finish

D

Start Finish

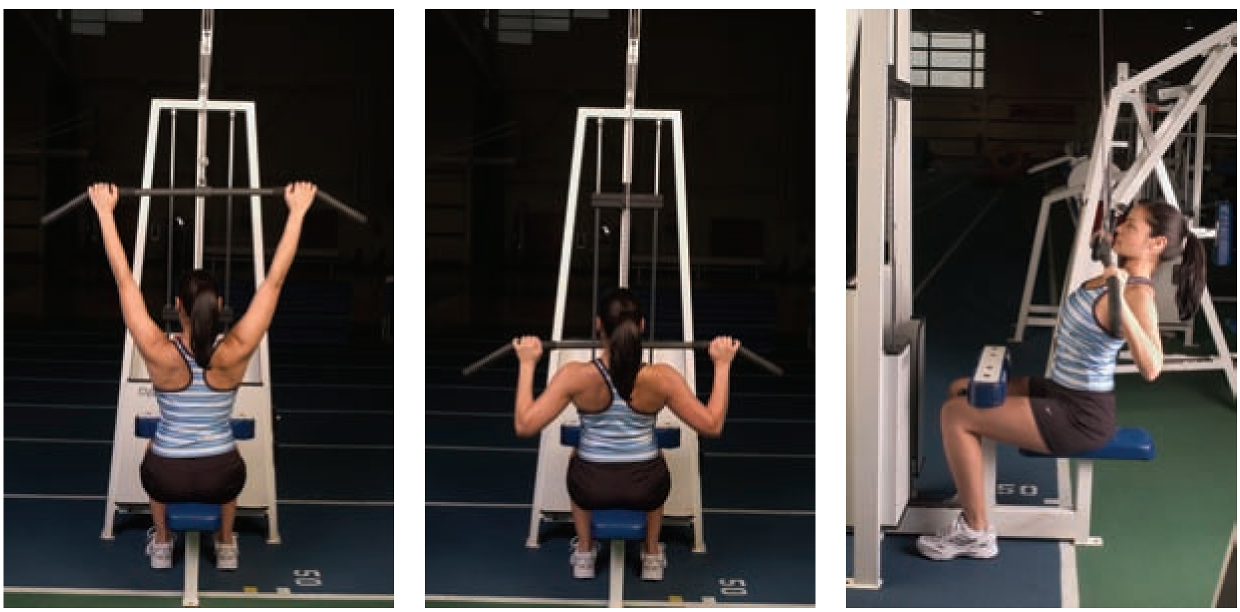
FIGURE 16.5. (*Continued*) **C.** 45° leg press (thighs). Lie down on the machine with the back on the padded supports. Place the feet on the platform. Grasp the handles on the side and release the weight. Lower the weight by fl xing the hips and knees until the hips are completely fl xed and then extend the knees to complete the repetition. Make sure that the feet are flat o the platform and the knees track over the feet. **D.** Lunge (thighs, unilateral). Standing straight up with feet shoulder-width apart, stand holding the dumbbells at the sides. Lunge forward with one leg at a time, keeping the hips in the middle of the two legs, with the trailing knee just above the ground. Return to the standing position to complete the repetition and then repeat with the opposite leg. Keep the back straight and chin level with the ground.

FIGURE 16.5. (*Continued*) **E.** Leg extensions (thighs, bilateral or unilateral). Sit on the machine with the back straight against the back pad or seat and grasp the handles on the side of the machine. Place the legs under the padded lever, making sure that they are positioned just above the ankles. Most machines will allow adjusting the length of the lever. Lift the lever until the legs are almost straight and return to the starting position to complete the repetition. It is important not to "rip" the plates off the stack, as this can add stress to the knees. This exercise can be done with a single leg (unilateral) or with both legs (bilateral). Make sure that the knees are aligned with the machine's center of rotation. **F.** Leg curls (hamstrings, bilateral or unilateral). Lying face down, grab the support handles in the front of the machine with the heels just beyond the edge of the lever pads. Lift the lever arm by fl xing the knees until they are straight. Return to the starting position to complete the repetition. Keep the body on the bench and focus on moving only the legs. Many machines are angled so that the user is in a better position for the exercise movement, to reduce stress on the lower back. Other forms of leg curls are standing and seated forms. This exercise can be done with a single leg (unilateral) or with both legs (bilateral). **G.** Vertical machine bench press (chest-triceps, bilateral). Sit on the seat, making sure that the line of the grips is just below the chest. The bar line should be an inch above the chest. Grasp the handles with an overhand grip and make sure that the feet are flat o the ground. Push the lever arm straight out until the elbows are straight. Return to the starting position to complete one repetition.

FIGURE 16.5. (*Continued*) **H.** Smith supine bench press (chest–triceps, bilateral). Lie flat on the bench with the u per chest under the bar, as shown in the bar position figu e above. Place the feet flat on the floor unless the bench is too high, in whi case put them flat on the bench. Keep the shoulde s and hips on the bench at all times during the lift. Grasp the bar with elbows at 45° angles. Disengage the bar hooks from the Smith machine. Lower the weight to the chest and then press the bar up until arms are extended to complete the repetition. When completed, rehook the bar to the machine. **I.** Free weight supine bench press (chest–triceps, bilateral). Lie flat on the bench with the u per chest under the bar, as shown in the bar position figu e above. Place the feet flat on the floor unless the bench is too high, in which case put them flat on the bench. Keep shoulders and hips on the bench at all times during the lift. Grasp the bar with elbows at 45° angles. Lower the weight to the chest and then press the bar up until the arms are extended to complete the repetition. When completed, rerack the bar with a spotter's help. **J.** Dumbbell bench press (chest–upper arms–triceps, unilateral). Start in a seated position on the bench with a dumbbell in each hand resting on the lower thigh. Lift the weights to the shoulder and lie back on the bench or have the spotter give you the dumbbells once you are in a position. Position the dumbbells to the side of the upper chest. Press the dumbbells up until the arms are extended and then return to complete a repetition. When completed, return to the seated position with the dumbbells on your thighs or have the spotter take the dumbbells. If heavy weights are used, two spotters may be necessary.

K

Start | Finish | Arm Position



L

Start | Finish | Bar Position

FIGURE 16.5. (*Continued*) **K.** Machine seated rows (upper back, bilateral). Take a seated position with the chest against the pad. Grasp the lever vertical handles with a vertical or horizontal overhand grip. Pull the lever back until the elbows are in line with the upper body and return to complete the repetition. Check the seat height so that the chest is directly in front of the lever handles, and check whether the client is pulling in a straight line parallel to the ground. The client can use an overhand grip as a variation to the movement, using the other horizontal handles. **L.** Front lat pull-down (upper back, bilateral). Use a locked grip (thumb around the bar) and grasp the cable bar with a wide grip. Sit with thighs under machine support. Proceed to pull down the bar to the upper chest. Return to the starting position to complete the repetition.

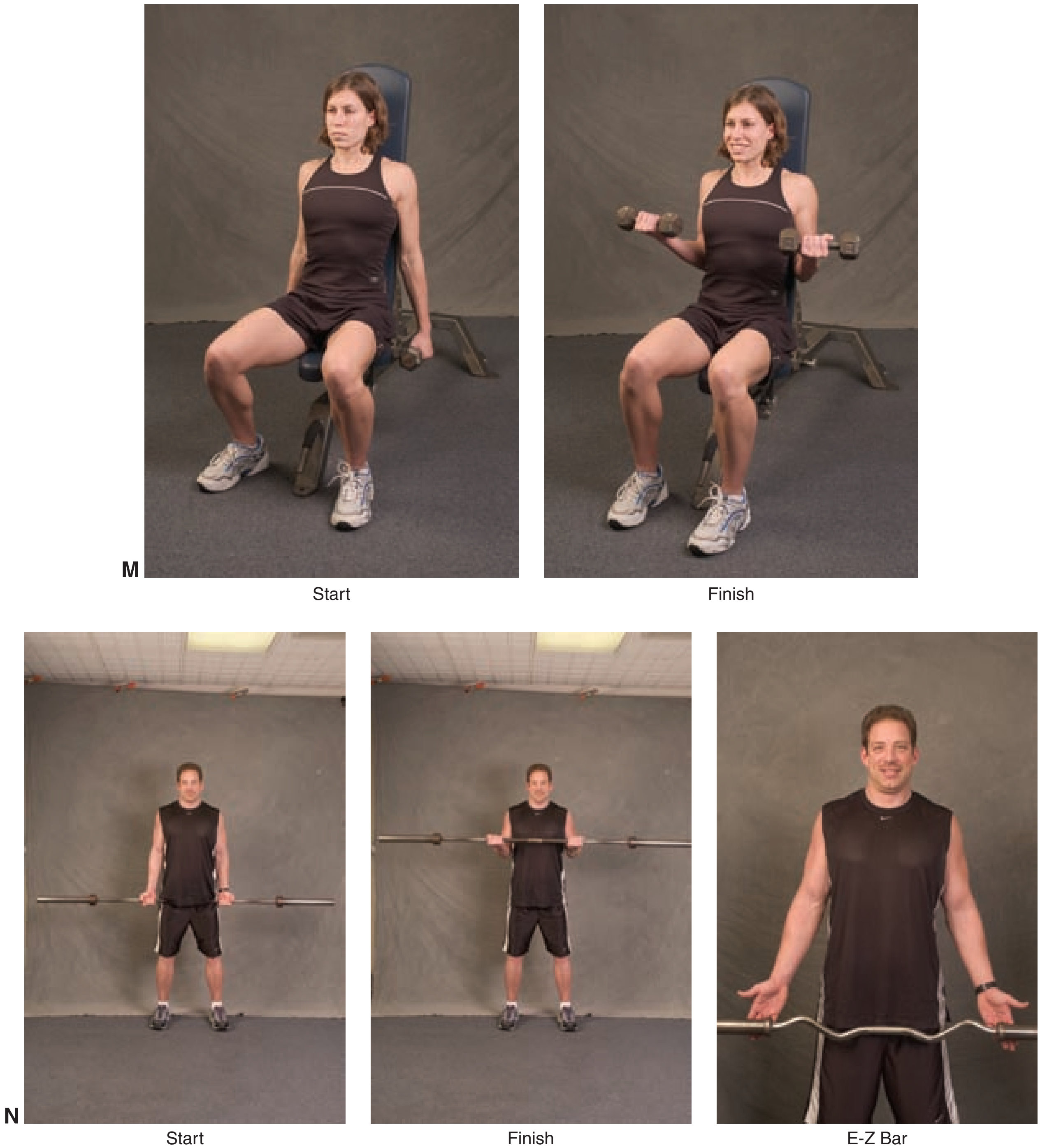


FIGURE 16.5. (*Continued*) **M.** Dumbbell arm curls (upper arm–biceps, unilateral). Take a seated position with two dumbbells held at the sides, with the palms facing in and the arms hanging straight down. Raise the dumbbells and rotate the forearm so that the palms face the shoulder. Lower to the original position to complete one repetition. One can also alternate one arm at a time. **N.** Barbell arm curls (upper arm–biceps, bilateral). In the standing position with the feet shoulder-width apart, grasp the straight barbell with an underhand grip and palms facing up. Raise the bar until the forearms are vertical and then lower the bar to the starting position to complete a repetition. One can also perform this exercise with an E-Z bar with the palms facing inward.

O

Start Finish

FIGURE 16.5. (*Continued*) **O.** Triceps push down (upper arm-triceps, bilateral). Stand in front of the lat pull station or high pulley station and take an overhand grasp on the bar with your elbows at the sides. Start at chest level and extend the arms down until straight and return to the starting position to complete the repetition. Position the hands above the bar prior to the push-down phase of the repetition.

SUMMARY

Development of a resistance training program is a systematic process in which science and art come together to allow the Personal Trainer to specifically address a client's needs or neuromuscular fitness. A sequence of events in the xercise prescription process consists of getting a client's medical clearance, personal training history, goal generation, a needs analysis, and a general preparation phase of initial training and testing before putting together workouts based on the acute program variables that will be used in a resistance training program. This program is then updated and revised with the same process over time. Education, client interactions, and motivation are vital components of successful resistance training programs that meet each client's goals and objectives.

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