Personalize It: Program Design in Resistance Training

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Learning Objectives

From this article, the reader should understand the following concepts in relation to designing resistance training programs:

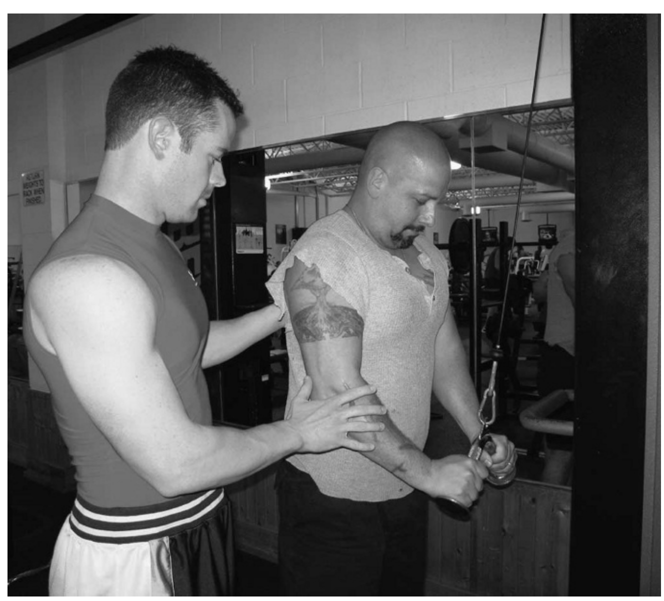
1. *The dynamic program design and progress in optimizing resistance training programs*
2. *Principles of individualization, overload, variation, and periodization*
3. *Basic components of designing resistance training programs: a needs analysis, workout design, and changes with chronic programming*
4. *How to use the acute program variables in designing and modifying resistance training programs*
5. *Differentiation between linear periodized programs and a nonlinear periodized programs*

Key words: *Resistance Training, Strength Training, Weight Training, Program Design, Acute Program Variables.*

Resistance training has become an important part of every health/fitness program. It can have dramatic positive effects on the target tissue (most notably muscle and bone) and can have dramatic health/fitness implications (1). Following resistance training, improvements in physiological function and physical capabilities have been observed in groups of individuals ranging from patient populations (*e.g.*, cardiac, cancer, arthritis, diabetes) to elite athletes. Thus, resistance training is a key part of every total health/fitness program.

Optimal program development occurs when a program is individualized and matched with an individual's specific needs and goals. In part, the popularity of personal trainers attests to this important aspect of resistance training. Each program also must be individually monitored to enhance effectiveness and provide for optimal safety (2). Needs change overtime; therefore, the goals of the resistance training program also will change as fitness improves. It is important to remember that resistance training program design is a dynamic process and requires changes to maintain effectiveness or adjust to new goals for an individual. Any program can become ineffective if continued improvements are desired due to an individual's genetic potential being met or if a program does not challenge the individual with greater demands over the training period.

Physiological adaptations occur as the body is challenged to adapt. This is fundamental to the concept of progressive resistance training. In order to continue to produce further strength gains and/or physiological adaptations, a more demanding exercise stimulus (*i.e.*, exercise protocol) must be used by modifying the acute program variables in resistance training (*i.e.*, intensity, volume, etc.). Oftentimes, individuals drop out after only two or three months of membership in a fitness center or when using a personal trainer. This can be due to a lack of progress in their training goals or boredom with the program. Again, it is important to understand that the effectiveness of a training program is based on many different factors, most importantly, an individual's genetic potential, age, and how trained s/he is in a particular fitness component.



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Resistance training can produce dramatic results in the first two or three months, after which progress typically slows as the large initial gains in such variables as strength have occurred because of neural adaptations. Thus, the pattern of change for each of the trainable goals in a fitness program will track at different rates of gain depending upon the exercise protocol used. The greatest gains in strength can be observed early in training (*i.e.*, first several weeks) or more specifically in beginning a resistance training program when the individual is in an untrained state (3). In this period, the opportunity for improvement is the greatest. However, one major mistake in exercise prescription that should be avoided at this point is trying to do "too much, too soon," which can lead to excessive soreness, acute overtraining, or injury. Care is needed to develop the individual's neuromuscular fitness base before progressing to more demanding workouts. A base resistance training program of two to three nonconsecutive days per week for six to eight weeks with light resistance (12 to 15 repetition maximum [RM]) and low volume (one set) is a good way for beginners to start a program before moving to multiple set programs.

It is important to keep a few basic principles of resistance training in mind as one starts to design a program. Exercise specificity is vital in program design, as the carryover to any physiological function (*e.g.*, muscular hypertrophy, enhanced bone density) or performance function (*e.g.*, balance, strength) will be related to the specific characteristics of the exercise stimuli and the nature of the motor unit recruitment. Often called the SAID principle (*i.e.*, **S**pecific **A**daptations **I**mposed **D**emands), it reflects the biological specificity of adaptations to the "fingerprint" of the exercise stimuli created by the workout. Progressive overload (also called progressive resistance training), a concept given scientific and medical credibility by Dr. Thomas Delorme in the 1940s, requires greater demands to be placed on the body with subsequent exercise protocols over time (4). An important corollary to this principle is variation in training which provides planned periods of rest and variation in the exercise stress (1, 5). Program periodization models have been used to address this need for program variation and rest/recovery periods in long-term training (*i.e.*, months and years) (6).

The exercise prescription process in resistance training has been well documented with the basic components consisting of a needs analysis, workout design, and changes with chronic programming (1). It is important that the exercise professional is careful to monitor each aspect of the program, most importantly, an individual's toleration of the workout protocols from a musculoskeletal and psychological perspective.

A Needs Analysis

A needs analysis helps focus on the context for choices made in the design of a workout. A needs analysis should be undertaken for each new cycle of resistance training. Typically, workout cycles can last from 8 to 12 weeks and are designed to meet specific training goals. When training goals are changed (*e.g.*, a maintenance program for one variable is now indicated), the workout design must reflect these changing goals. A needs analysis along with a properly developed testing program will allow one to determine if training goals have been met. Although beyond the scope of this article, a properly designed testing program also will help determine program design for the next training cycle by providing a profile of health and fitness parameters. Program development in resistance training is an ongoing process reflective of appropriate progression and/or maintenance of health/fitness parameters (3).

The following areas are typically addressed in a needs analysis (1):

1. *Biomechanical analysis of the movements needed in the program.* This will implicate the type of muscle actions, angles of the exercise movements, and velocities of muscle actions used in the development of the workout.
2. *Metabolic demands of the workout.* Resistance training can stimulate a continuum of metabolic demands. With the manipulation of the acute program variables, one can create very different metabolic profiles from energy demands. Thus, what are the types of metabolic demands to be trained for? In sport, this is much more simplistic as each sport has a prominent energy profile. However, this can be used in the general population as well to reflect recreational demands (*e.g.*, down hill skiing), job demands (*e.g.*, fire fighter), or health demands (*e.g.*, type 1 diabetes).
3. *Injury prevention and reduction.* What are the primary risks of injuries from the job, sport, or recreational activity? Resistance training can enhance the tensile strength of many tissues in the body (*e.g.*, muscle and connective) and allow toleration to the mechanical forces of injury and this may reduce the number of injuries in the process. Making sure that the body is trained to prevent such injuries or reduce their severity is a vital part of any resistance training program.

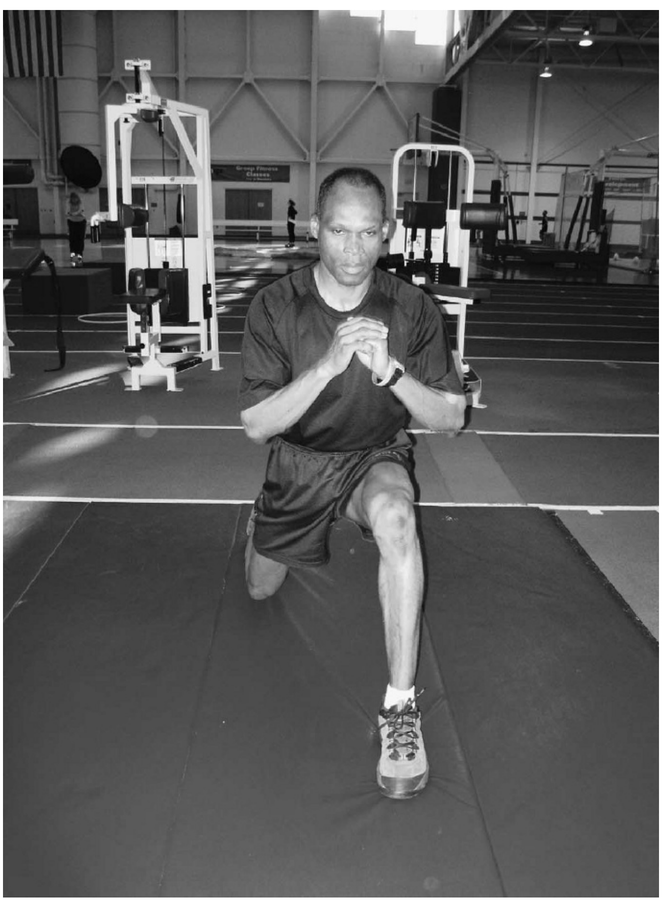
The development of a workout is a function of the choices made in each of the domains of the acute program variables.

Setting Program Goals

To create an effective resistance training program, it is helpful to set specific program goals. 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. As resistance training is only one component of a total health/fitness program, it must be progressive and integrated with cardiovascular, flexibility, and nutritional programs. Such integration can be even more dramatic for advanced athletes as many more conditioning activities are involved (*e.g.*, speed and agility) and as programs are sports-specific.

Resistance training affects almost every physiological function and has the ability to enhance physical development and performance at all ages. Although the magnitude of changes in strength, power, and gains in lean tissue mass may differ across all ages and gender, relative improvements are typically observed (1). Many common program goals in resistance training are related to improvements in muscular strength, power, and local muscular endurance or in other physiological training adaptations (*e.g.*, increase in lean tissue mass). Other functional improvements, such as an increase in coordination, agility, balance, and speed, also can be the goals of a resistance training program for older individuals to help improve balance and locomotion capabilities. In addition, it is becoming clear that fitness attributes such as balance also have important implications for injury prevention (*e.g.*, limiting falls in older individuals). Physiological changes related to increased lean body mass through muscle hypertrophy or improvement of other physiological functions such as blood pressure, decreased body fat, and increased metabolic rate also are the goals of resistance training.



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Generally, training goals should be testable variables (*e.g.*, 1 RM strength, vertical jump height), so they can be objectively judged as to whether or not gains are made and if the exercise prescription is effective. Examination of a workout log can be an invaluable first-line tool in evaluating the effects and progress of resistance training programs. Using the results of other specific tests (*e.g.*, skinfolds for body composition estimates) also can help in modifying the exercise program or referring the individual to other professionals for help (*e.g.*, registered dietician) if improvements are not being made in the desired direction. In addition, notes related to the toleration of the workout and comments as to any symptoms or noticeable changes (*e.g.*, muscle soreness, joint soreness, feeling more energy, etc.) can be notated in a workout log.

Acute Program Variables

More than 20 years ago, the development of the governing dynamics for the choices made in the design of a workout was presented (7). The choices made within each of these variable domains dictate the specific "fingerprint" of the exercise stimuli created by the resistance training workout. An almost unlimited number of workouts can be developed using different combinations within each of these variable domains. These workout possibilities become a powerful tool for exercise prescription in addressing the needs of each individual.

The choices made are a function of the strength and conditioning professional's training, knowledge, and skill in matching the goals and needs of the individual with the type of workout stimuli that will effectively allow progression to the planned goals over a training cycle (1). The exercise professional must have the interpersonal skills and knowledge-based background to meet the needs of the individual on a number of different levels from the psychological to the physiological domains. Thus, there are many individual exercise prescription judgments that must be made on a daily basis in the implementation and progression of a resistance training program.

The acute program variables are related to five different domains in which choices need to be made. They are:

1. *Choice of Exercise.* A host of decisions have to be made involving this variable domain. It is important that exercises are chosen for both the upper and lower body, exercises for the torso (*i.e.*, abdominals and lower back) to help with reducing the likelihood of injury and lower back pain and making sure that exercises are included that activate the muscles around each joint to provide symmetrical muscular development. A few of the many choices follow:

   What type of muscle action? Should an isometric, concentric, or eccentric or a combination of these muscle actions be used? Popular conditioning programs have used only concentric muscle actions; to get the same effect as a typical concentric/eccentric repetition, the repetitions may have to be doubled. Work by Gary Dudley's, Ph.D., FACSM, research group at Kennedy Space Center in the early 1990s showed that concentric/eccentric repetition was the most efficient type of repetition in producing gains and resisting detraining even at the muscle fiber level (8, 9).

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   What Type of Equipment? Will the equipment be "fixed form" or "free form" (does the equipment set the degrees of freedom for the movement path or is it balanced and maintained by the exerciser)? Fixed form is typical of many weight training machines in order to isolate the exercise stimulus. Free form occurs when the exercise movement is controlled by the exerciser as typically seen with the use of free weights. Each type of equipment has its advantages and both are typically used. Free form exercise has been shown to help develop balance and enhance the control of the resistance mass with greater use of stabilizing and assisting muscles. Stable and unstable surfaces also have been used. Stable surfaces allow higher force production during exercise compared to unstable surfaces and hence may be more optimal when strength development is an important training goal (10). However, exercises performed on unstable surfaces, such as balance disks or Swiss balls, may have a place in the fitness program, particularly if balance and coordination are a training goal.

   Multiple or Isolated Joint Exercises? Multijoint (structural) exercises help the individual better address coordinated functional demands of several joints when performing whole body movements. Such movements are important in the performance of everyday activities (*e.g.*, shoveling snow) and athletic movements (*e.g.*, jumping for a rebound in basketball). Isolated exercises (*e.g.*, knee extensions, arm curls) are used in injury rehabilitation and to develop maximal hypertrophy in bodybuilding-type protocols. Most resistance training programs will have a combination of multiple and isolated joint exercises and both bilateral (using both right and left sides of the body simultaneously) and unilateral (isolating either the right or left side of the body) movements.

   What Velocity of Movement? The choices of this variable relate to what is needed on the force-time curve (*i.e.*, concentrically, as the speed of an exercise increases, the force declines) with the training program. If very rapid force development is needed at the early phase of a force-time curve for a particular movement, then explosive exercise movements are needed with limited deceleration during the range of motion (*e.g.*, medicine ball exercises or exercises in which no deceleration of the limb is warranted such as in a high pull). These types of programs are typical for more advanced protocols for athletes, yet power development in the elderly has become an important performance factor.

   This domain of choices again references the choice of equipment and exercises. Although not common in fitness programs, Olympic weightlifting style exercises

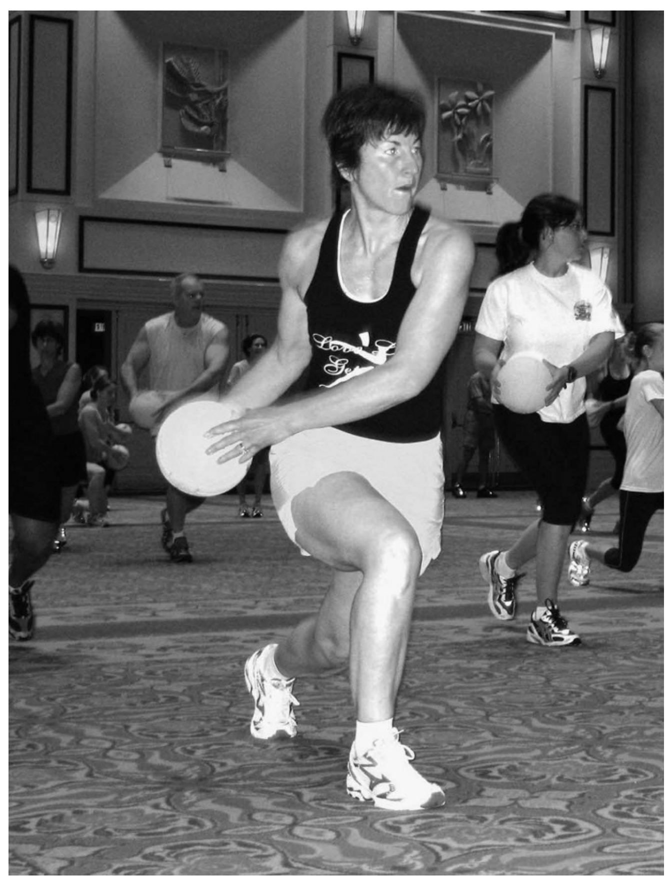
(*e.g.*, hang cleans, high pulls, etc.) using free weights are power-type exercises with rapid accelerations and power development, with little deceleration occurring in the joint. Exercises such as bench throws using a Smith Machine and medicine ball exercises also allow the mass to be released and reduce the amount of deceleration during the exercise movement allowing greater power development. For example, it has been shown that the concept of "speed reps" with a light weight that cannot be released (*i.e.*, hanging on to the bar in a bench press) is detrimental to producing rapid force and power production because of the high deceleration component needed to protect the joints from the accelerating mass (11). With the development of new equipment technologies (*e.g.*, pneumatic machines), high-velocity movement is now possible for single and multiple joint exercises without any deceleration effects. Rapid force production requires high-power output exercises using the proper equipment and/or exercise movements.

For the most part, the intention of most resistance exercises is to control the resistance through the full range of motion both concentrically and eccentrically as has been stipulated by the American College of Sports Medicine. To emphasize this, various counting schemes have been introduced in the literature from 2 seconds up and 4 seconds down to 3 seconds up and 3 seconds down, etc. Most research studies have used volitional velocities of movement, asking the subjects to control the resistance in both parts of the repetition but allowing the resistance and the type of exercise as the primary determinants of how fast the weight can move; such studies keep in mind the problem with the "speed reps" using conventional equipment discussed above. Thus, intentional or unintentional movement speeds have been used in resistance exercise protocols.

In unintentional velocities, it is generally observed that as the concentric resistance increases when conventional resistance modalities are used, the speed of the exercise will go toward 0 velocity or an isometric muscle action (typical of sticking points in a range of motion). The concentric 1 RM is positioned right under the isometric 0 velocity on the force-velocity curve as movements with maximal resistances are very slow. Therefore, unintentional velocities are affected by the resistance used and the strength curve (*i.e.*, force changes over the range of motion) of an exercise. If the use of intentional movement speeds (*i.e.*, counting protocols) reduces the amount of resistance that can be used for the desired number of repetitions (RM zone), the number of motor units activated may be compromised and it becomes analogous for the most part as lifting a lighter weight. Thus, velocity of the repetition should be related to the exercise being performed, the desired resistance used, and the equipment capabilities for handling velocity changes with different resistance loads.

2. *Order of the Exercises.* For many years, the *order* of exercise in a resistance training workout was not considered. Limited research has demonstrated that it does, in fact, play a role in the development of the exercise stimuli (1). It has been theorized that by exercising the larger muscle groups first, a superior training stimulus is presented to all of the muscles involved because of less fatigue and the ability to lift more weight. This, in turn, helps to create a more optimal exercise stimulus for strength and power development. Typically, large muscle groups are targeted first in the workout.

   Another consideration in the exercise order is placing exercises which are being taught or practiced (especially complex movements) in the beginning of the exercise order. Power exercises (*e.g.*, medicine ball plyometrics or more advanced exercises like high pulls with a barbell or Smith machine) should be performed in the beginning of the workout to enhance the power output produced. Fatigue can hinder the development



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of maximal power or the quality of this type of workout protocol (*e.g.*, including plyometrics) unless the purpose of the placement is to improve power output under conditions of fatigue for such athletes as wrestlers (1). If an individual is learning how to perform advanced exercises (*e.g.*, hang cleans), this exercise should be placed in the beginning of the workout so learning and concentrating on proper lifting techniques will not be inhibited by the distraction of prior fatigue.

The sequencing of exercises also involves the order used in circuit weight training protocols. The question when to follow a leg exercise with another leg exercise or to proceed to another muscle group has to be addressed in the training protocol design. Arm-to-leg exercise orders allow for some recovery of the arm muscles while the leg muscles are being exercised. This is the most common order used in designing circuit weight training programs. Beginning lifters are less tolerant of arm-to-arm and leg-to-leg exercise orders for exercises using a particular muscle group because of the fatigue process (12).

For resistance training, it is recommended that basic large muscle group exercises such as the squat, leg press, and bench press be performed in the beginning of the workout. Advanced training protocols for enhanced speed and power involve the performance of total-body explosive lifts such as the power clean and jump squats, and these exercises also should be placed in the beginning of a workout protocol. Since all exercises cannot be placed at the beginning of a workout, different workouts with different featured exercises need to be developed, especially for advanced trainees. Typical bodybuilding protocols involve the performance of many different exercises to isolate and develop a specific muscle or body part where order may be related to priority of the muscular development of each body part.

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Exercise order needs to correspond with specific training goals, exercises used, and the desired loading for a particular workout protocol. A few general methods for sequencing exercises for both multiple or single muscle group training sessions are as follows:

- large muscles before smaller ones
- rotation of push/pull exercises for total body sessions
- rotation of upper/lower body exercises for total body sessions
- multijoint exercises performed before single-joint exercises
- weak-point exercises performed before stronger-point exercises
- Olympic lifts before basic strength and single-joint exercises
- most intense to least intense (particularly when performing several exercises consecutively for the same muscle group)

One final consideration for exercise order is the fitness level of the individual. Workouts should never be designed to be too stressful for an individual, especially a beginning or older exerciser; therefore, order of exercise is an important choice that needs to be considered when designing a workout protocol. For the beginner, it is especially important so that s/he can complete the workout protocol with the desired intensity, total work, and proper form without undue fatigue.

3. *Number of Sets.* It should be noted that not all exercises in a training session need to be performed for the same number of sets (1). This variable is a "volume" variable as set × reps × intensity is a typical way to calculate the volume of a workout. Each muscle group may not need the same volume of exercise to achieve the desired goal in a training cycle. "Total work" remains an important variable dictated in part by the number of sets used for an exercise (13). The need for variation in the number of sets is further supported as one moves toward the concept of a periodized training program in which volume plays an important role to allow for rest and recovery. Decisions as to the volume of exercise are related to the need for program variation (*e.g.*, periodization models) mediating overload, unloading, rest, and recovery.
4. *Rest Between Sets and Exercises.* The amount of rest between sets and exercises dictates how much recovery has occurred before the next effort and the overall physiological stress of the workout (1). Shorter rest protocols (*e.g.*, two minutes or less) are used when trying to develop local muscular endurance or stimulate greater caloric consumption. Longer rest periods (*e.g.*, four

minutes or longer) are used when trying to produce greater amounts of force or power. The amount of rest dictates how demanding the workout is based on lactate concentrations indicating a greater reliance on glycolysis. In addition, continued higher rates of ATP hydrolysis and proton production can be associated with reductions in pH and disruption of the normal acid-base status. Perceptually, psychologically, and symptomatically, short rest workouts can be more demanding than the same workouts using longer rest periods (14, 15). Very careful progression is needed when short rest period programs are used, especially if moderately heavy weights (*i.e.*, 8–10 RM loads) are used with shorter rest period lengths so as not to exacerbate symptoms of dizziness, nausea, and lightheadedness that can be observed with such protocols (14). Such symptoms are not expected and may require medical attention. If they do occur, the workout should be stopped, proper care and evaluation rendered, and program design reevaluated and altered to a less stressful workout. Rest period lengths should be longer as the resistance used or the power output needed increases towards maximal levels. In general, rest period lengths can be classified as short: less than two minutes, moderate: two to four minutes, or long: greater than four minutes.

5. *Intensity of the Exercise.* The amount of resistance used for a specific exercise is probably one of the most studied, if not one of the most important, variables in any resistance training program. Intensity is the major stimulus related to changes observed in measures of strength, muscle size, and local muscular endurance. Ultimately, the amount of resistance used is related to the amount of muscle that is recruited by different motor units to perform specific exercise for a given number of repetitions. The resistance used specifies the type, number, and size of the motor units involved and therefore stimulated by the resistance exercise protocol.

   When designing a resistance training program, a resistance for each exercise must be chosen. Options for the typical loading schemes used for various resistance training exercises are either RM (or the specific resistance which only allows a specific number of repetitions to be performed), an RM training zone (a range such as 3 to 5 RM) which allows one to target a training zone, or the percentage of some RM value (typically the 1% RM), which are the major types of prescription approaches for dynamic concentric exercises. Of note is the fact that a given percentage of 1 RM does not result in the same RM for all muscle groups (*e.g.*, one can do more repetitions in a leg press with 80% of the 1 RM compared to a smaller muscle group exercise like the arm curl) (16, 17). Furthermore, it requires more frequent testing of 1 RM, especially in beginners, to keep the exercise stimulus effective. Using an RM zone (*i.e.*, a three-rep range) rather than a single RM target was developed, in part, to reduce the number of sets where one had to go to failure. This reduces joint compressions, joint soreness, and the frequency of blood pressure elevations because of the breath-holding associated with the Valsalva maneuver, especially in older individuals or those individuals with cardiovascular anomalies (*e.g.*, high blood pressure, cardiac patients, etc.).

   Heavier resistance (*e.g.*, 6 RM and lower or 85% of 1 RM and higher) typically promotes the increase of maximal dynamic strength. Power can be developed with the use of light to moderate resistances (30% to 65% of 1 RM) performed at high velocities of movement with the appropriate exercises (*e.g.*, pulls and cleans) limiting deceleration effects in the exercise choice. Lighter loads (*e.g.*, 20 RM and higher) have only had small effects on maximal strength in previously untrained individuals. However, higher numbers of repetitions have shown to be very effective for increasing local muscular endurance (1). It now appears that using a variety of intensities over a training cycle may be more conducive to increasing muscular fitness components as opposed to performing all exercises with the same relative intensities. This has led to an increasing interest by both practitioners and scientists alike for periodization models in resistance training (*e.g.*, linear and nonlinear periodization) in which greater load and volume variations along with recovery days are integrated into the program to optimize the training adaptations and recovery.

Models of Resistance Training Variation and Chronic Programming

Linear Periodization

A host of models have been used to address the need for program variation. Most notably has been the concept of periodization of training (6). In a periodized plan, variations

Table 1. A Typical Linear Periodized Program Using 4-Week Microcycles

Microcycle 1 1 to 3 sets of 12 to 15 RM	**Microcycle 2** 3 to 4 sets of 8 to 10 RM
Microcycle 3 3 to 4 sets of 4 to 6 RM	**Microcycle 4** 2 to 3 sets of 2 to 3 RM
Microcycle 5 (1 to 2 weeks) Active rest/rest or competition followed by active rest/rest microcycle	

are made over time with regard to the volume and intensity of training. The classic linear periodization model starts with lighter resistances and higher volumes and progresses over a training cycle to heavier resistance and lower volumes (1). This has been termed "classic periodization," as it was the general model developed for strength/power athletes and used to achieve a progressive overload over time (18). The model is conducive to beginners because the first cycles use relatively light loads with the volume of training the only variable that may need to be carefully monitored for total work toleration in the early phases of training. A program consists of 2- to 4-week microcycles (the smallest length of training), 3- to 6-month mesocycles (the larger cycle that is repeated), and the year-long macrocycle (total training cycle for the individual).

An example of a classic linear periodization scheme is shown in Table 1. The resistances and the volume used for each individual may vary based on the training level and toleration of the exercise protocol, but the basic concept or progression is relatively similar for each individual. Typically, the resistances for the major muscle groups are periodized with a lighter resistance used for smaller muscle groups (varied between 8 to 10 RM and 12 to 15 RM resistances for variation). The resistance used is based on the type of exercises prescribed through the program.

It can be seen in Table 1 that there is some variation within each microcycle because of 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. After the microcycle 5 in a periodized program, one starts over with microcycle 1 and continues in this example for another 16 weeks, and this continues until the macrocycle is completed. Although the relative intensities would remain the same, the absolute intensities for that same RM zone would be higher, thus inherently increasing the volume of exercise over the macrocycle training period. 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, yet over the macrocycle, the volume of each mesocycle will be greater for each phase because of improvement in the amount of weight that can be lifted in a given set. With linear periodization, the goal is to enhance strength and power leading up to a peak by the end of the macrocycle. Changes in the acute program variables will take place to add variation in the exercise choices to complement muscular development from multiple perspectives. This approach has succeeded with both trained and untrained men and women when strength was a primary training goal (1, 13, 18).

Table 2. An Example of a Nonlinear Periodized Program

Monday 1 sets of 13 to 15 RM	**Wednesday** 2 sets of 8 to 10 RM
Friday 3 sets of 4 to 6 RM	**Monday** power/plyometric day
Wednesday 4 sets of 2 to 3 RM	**Friday** active rest day

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

Nonlinear Periodization

Another model that is becoming popular with many personal trainers and athletes in the academic setting is termed "nonlinear" periodization, in which a set period is used as the overall training cycle, typically 12 weeks with an active rest/rest phase of one to two weeks taken upon completion of the cycle. However, the planned workouts represent dramatically different intensities and volumes, therefore allowing much more dramatic variation in the protocols during a 1- or 2-week period. This allows for the boredom factor to be reduced and workouts to be chosen that are best suited for a given day's circumstances.

It can be observed in Table 2 that intensity spans over large resistance and volume range over the 14 days of training. Again, these are just examples, and resistances can be chosen to match the specific individual's needs and capabilities. But the concept of variation is key. Preliminary results indicate that this type of training variation appears to be as effective as linear programs. The power training day uses exercises that allow for loads from 30% to 45% of 1 RM (maximal mechanical power output) and limited deceleration effects to promote rate of force production and power development (19). Other modalities also can be used as mentioned before to promote effective rapid movements (*e.g.*, pneumatic machines). Plyometric exercises (*e.g.*, medicine ball exercises, drop jumps, bounding, cone jumping, hopping and skipping, repetitive vertical jumps, etc.) also can be used to enhance the speed and power capabilities of muscle (20). All of these types of exercises and modalities can be used on power days if power is a training goal.

Different from the linear periodization model, one trains the different components of muscle size, strength, local muscular endurance, and power as well as providing for rest/recovery in a training cycle. This approach may be more conducive to many individual's schedules especially when competitions, travel, or other schedule conflicts can make the traditional linear method difficult to adhere to. In the

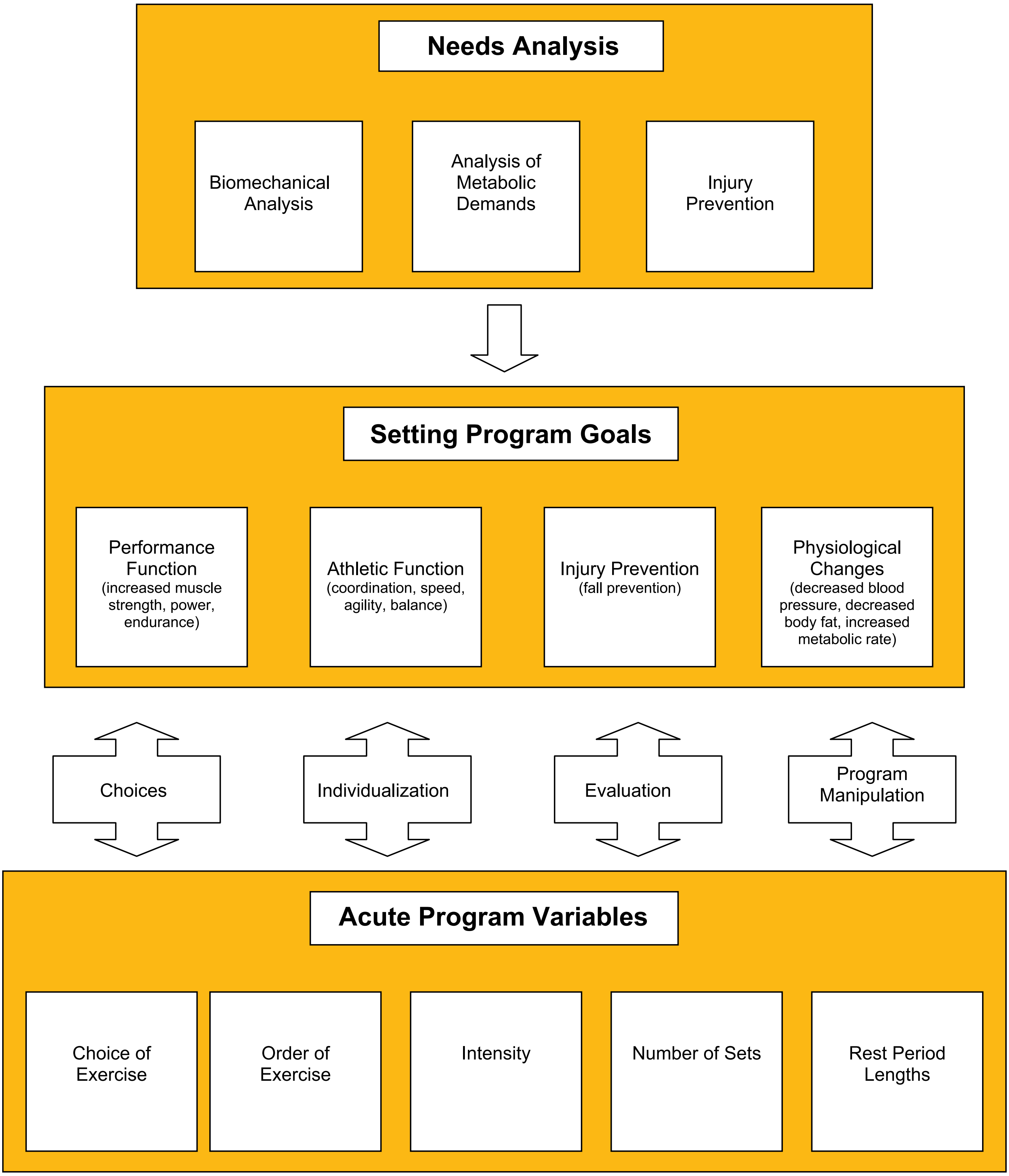

Figure 1. A model for designing a resistance training exercise prescription.

"nonlinear" periodization program, the workout rotates through the different protocols. The workout rotates the different training sessions over the 14-day cycle, and one can choose the protocol on a given day so that it matches the vigor and training potential of the individual for that day. Missing workouts are treated as rest days. A mesocycle will

Table 3. Example of Three Workouts in a Weekly Schedule Using a Nonlinear Periodization Schedule for Advanced Beginners After a Base Program of Training

Exercises

Monday (Heavy)	Wednesday (Moderate)	Friday (Light)
squats/leg press	lunges	squats/leg press
bench press	incline bench press	bench press
stiff leg deadlift*	leg curls	stiff leg deadlift
seated rows	bent over rows	seated rows
front lat pull down	close grip lat pull down	front lat pull down
sit ups†	Swiss ball twisting sit ups†	hanging knee ups†
dumbbell shoulder press	barbell upright rows barbell	shoulder press
dumbbell arm curls	EZ bar arm curls	preacher bench arm curls

Resistance and Set Ranges

- Monday—4 to 6 RM zone, 2 to 3 sets
- Wednesday—8 to 10 RM zone, 2 to 4 sets
- Friday—13 to 15 RM zone, 1 to 3 sets

Rest Period Lengths Between Sets and Exercises

- Monday—3 to 4 minutes for heavy loadings
- Wednesday—2 to 3 minutes for moderate loadings
- Friday—1 to 2 minutes for light loadings

*Use the 8- to 10-RM resistance for this exercise. †For abdominal exercises, use sets of 20 repetitions.

be completed when a certain number of workouts are completed (*e.g.*, 48) instead of using training weeks to set the program length. Figure 1 overviews the exercise prescription process in resistance training leading up to the development of workouts for a periodized resistance training program.

A weekly sample program is presented in Table 3 and is just one of many different programs that could be developed using the basic principles outlined in this article. Resistance training programs should be developed to meet the needs of the individual and their goals. Using a strong theoretical basis for such programs along with a testing program that can monitor the trainable variables will ultimately help optimize exercise prescription and program development. Many factors go into the progression of a training program, and changes must be made according to individual's responses, improvements, symptoms, and adaptations.

Summary

The design of a resistance training program is both a science and an art. Professional understanding of the process and the many program options available for a specific individual are vital to the development of an optimal program. The exercise prescription process all starts with the individual. Personal history, preliminary assessments, and education, followed by a needs analysis, lead to the choices in the acute program variables which, in turn, will dictate the exercise stimuli for the planned workouts over a given training cycle. The process continues with reassessment and evaluations made as training progresses in order to reach and maintain desired training goals. Resistance training can be an important and effective component of any health and fitness program if it is optimized for each individual with proper program design processes and exercise prescriptions.

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Recommended Reading

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Condensed Version and Bottom Line

Resistance training program design is a dynamic process that should focus on individualization, overload, variation, recovery, and periodization to optimize program development. Program development should begin with a comprehensive needs analysis and follow-up with frequent evaluations to modify the acute program variables to maximize the effectiveness of the program.