



Progression and Resistance Training

Progression in a resistance training program has both anecdotal and scientific support and can provide the variation needed to keep the workouts fun as well as effective over the long haul. In 1998, the American College of Sports Medicine published a position stand entitled "The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults." In this document, an initial starting point consisting of performance of 1 set per exercise (8-10 exercises) for 8-12 repetitions (10-15 for older adults) 2-3 days per week was recommended. This initial recommendation has been shown to be effective for progression during the first few months of training, but then benefits can plateau during subsequent months when variation in the program design is minimal. To move beyond the plateaus in strength fitness further progression in program stress is needed. There are numerous ways to progress as long as one adheres to basic tenets regarding the proper manipulation of the acute program variables. How much one can progress depends on the individual's genetic makeup, program design and implementation, and training status or level of fitness (i.e., slower rates of improvement are observed as one advances). In this paper, we will discuss the critical elements to progression during resistance training and the current recommendations for manipulating the acute program variables. It is important to note that the amount of progression sought is individual-specific, as moderate improvements have been shown to elicit significant health benefits. Once the desired fitness level is achieved, maintenance programs can be used to maintain that current level of fitness.

Introduction

The popularity of resistance training has increased in recent times. Not only is resistance training used to increase muscular strength, power, endurance, and hypertrophy in athletes, but the adaptations to resistance training have been shown to benefit the general population as well as clinical (i.e., those individuals with cardiovascular ailments, neuromuscular disease, etc.) populations (Kraemer et al., 2002) (see Table 1). Both scientific and anecdotal evidence points to the concept that progression is needed in order to create a more effective stimulus to promote higher levels of fitness. In fact, a threshold of activity/effort is necessary beyond the initial few months (which is characterized by enhanced motor coordination and technique) in order for the body to produce further substantial improvements in fitness. This threshold continually changes as one's conditioning level improves and is specific to the targeted goals of the exercise program. It is also bounded by each individual's genetic ceiling for improvement. Resistance training at or beyond this threshold level leads to *progression*.

The 1998 American College of Sports Medicine position stand has been shown to be effective for progression during the first few months of training (Silvester et

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TABLE 1
GENERAL BENEFITS OF
RESISTANCE TRAINING

- Increased muscular strength
- Increased muscular power
- Increased muscular endurance
- Increased muscle size
- Reduced body fat
- Increased balance, coordination, and flexibility
- Enhanced speed and jumping ability
- Enhanced motor performance and ability to perform activities of everyday living
- Increased bone mineral density
- Increased basal metabolic rate
- Lower blood pressure
- Reduced cardiovascular demands to exercise
- Greater insulin sensitivity and glucose tolerance
- Improved blood lipid profiles
- Reduced risk for injury and disease (i.e., osteoporosis, sarcopenia, low back pain, etc.)
- Enhanced well-being and self-esteem

al., 1982; Starkey et al., 1996), but then benefits tended to plateau during subsequent months when variation in the program design was minimal (Marx et al., 2001). However, the question then arose, “what type of programs would be recommended for those individuals who desire a higher level of fitness?” Because it is important to make exercise a lifetime commitment, recommendations based on scientific research were needed to provide specific directives for those who desire to make further goal-specific improvements via resistance training. In response to this need, the American College of Sports Medicine later published a position stand providing basic recommendations for progression during resistance training (2002). In this document, recommendations were given to novice, intermediate, and advanced individuals who sought to improve muscle strength, power, endurance, hypertrophy, and motor performance. The general conclusion was that there were numerous ways to progress as long as one adhered to basic tenets regarding the proper manipulation of the acute program variables. How much one can progress depends on the individual’s

genetic makeup, program design and implementation, and training status or level of fitness (i.e., slower rates of improvement are observed as one advances) (Kraemer & Ratamess, 2004). In this paper, we will discuss the critical elements to progression during resistance training and the current recommendations for manipulating the acute program variables. It is important to note that the amount of progression sought is individual-specific, as moderate improvements have been shown to elicit significant health benefits (Feigenbaum & Pollock, 1999). Once the desired fitness level is achieved, programs can be used to maintain that current level of fitness.

Basic Components of Resistance Training Programs

Maximal benefits of resistance training may be gained via adherence to three basic principles:

- 1) progressive overload, 2) specificity, and 3) variation.

Progressive overload necessitates a gradual increase in the stress placed on the body during training. Without these additional demands, the human body has no reason to adapt any further than the current level of fitness.

Specificity refers to the body’s adaptations to training. The physiological adaptations to resistance training are specific to the muscle actions involved, velocity of movement, exercise range of motion, muscle groups trained, energy systems involved, and the intensity and volume of training (Kraemer & Ratamess, 2004). The most effective resistance training programs are designed individually to bring about specific adaptations.

Variation is the systematic alteration of the resistance training program over time to allow for the training stimulus to remain optimal. It has been shown that systematic program variation is very effective for long-term progression (Marx et al., 2001).

Progression and Resistance Training Program Design

The resistance training program is a composite of acute variables. These variables include: 1) muscle actions used, 2) resistance used, 3) volume (total number of sets and repetitions), 4) exercises selected and workout structure (e.g., the number of muscle groups trained), 5) the

sequence of exercise performance, 6) rest intervals between sets, 7) repetition velocity, and 8) training frequency. Altering one or several of these variables will affect the training stimuli, thus creating a favorable condition by which numerous ways exist to vary resistance training programs and maintain/increase participant motivation. Therefore, proper resistance exercise prescription involves manipulation of the variables to the specificity of the targeted goals.

Muscle Actions

The selection of muscle actions revolve around concentric (CON), eccentric (ECC), and isometric (ISOM) muscle actions. Most resistance training programs include mostly dynamic repetitions with both CON and ECC muscle actions, whereas ISOM muscle actions play a secondary role. Eccentric muscle actions result in larger forces generated and less motor unit activation per tension level (Komi et al., 1987), require less energy per tension level (Evans et al., 1983), are very conducive to muscle hypertrophy (Hather et al., 1991), and elicit greater muscle damage (Ebbeling & Clarkson, 1989) compared to CON actions. Muscular strength is enhanced to a greater extent when ECC actions are included (Dudley et al., 1991). It is recommended that both CON and ECC muscle actions be included in novice, intermediate, and advanced resistance training programs (ACSM, 2002). The use of ISOM actions is beneficial but adaptations to ISOM are mostly specific to joint angles trained so ISOM actions need to be performed throughout the range of joint motion.

Resistance

The amount of weight lifted is highly dependent on other variables such as exercise order, volume, frequency, muscle action, repetition speed, and rest interval length, and has a significant effect of both the acute response and chronic adaptation to resistance training. Individual training status and goals are primary considerations when considering the level of resistance. Light loads of approximately 45-50% of one repetition maximum (1 RM) or less can increase muscular strength in novices who are mostly improving motor coordination at that level (Anderson & Kearney, 1982). As one becomes progressively stronger, greater loading is needed to increase maximal strength (i.e., 80-85% of 1 RM for advanced training) (Häkkinen et al., 1985). These findings have also been recently supported by a meta-analysis, which demonstrated that 85% of 1 RM yielded the highest effect size for strength gains in athletes (Peterson et al., 2004). It is important to note, however, that there are few

data examining consistent resistance training with heavier loading. There appears to be specific motor unit recruitment patterns during the lifting of very heavy or maximal loads which may not be reproducible with light to moderate loading. In addition, muscle hypertrophy reduces the motor unit activity necessary to lift a desired load (Ploutz et al., 1994). In order to continually recruit these higher threshold motor units, progressively heavier loads are needed to advance at a faster rate.

There is an inverse relationship between the amount of weight lifted and the number of repetitions performed. Several studies have indicated that training with loads corresponding to 1-6 RM (i.e., the maximal amount of weight that can be lifted 1 to 6 times) were most conducive to increasing maximal dynamic strength (Campos et al., 2002; Weiss et al., 1999). This loading range appears most specific to increasing dynamic 1 RM strength. Although significant strength increases have been reported using loads corresponding to 7-12 RM (Staron et al., 1994), it is believed that this range may not be as specific to increasing maximal strength in advanced resistance-trained individuals compared to 1-6 RM (although it is very effective for strength training in novice and intermediate trainees). The 7-12 RM loading zone is commonly used in programs targeting muscular hypertrophy at all levels of training. Although heavy loading (1-6 RM) is effective for increasing muscle hypertrophy, it has been suggested that the 7-12 RM range may provide the best combination of load and volume in direct comparison (Kraemer & Ratamess, 2000). Loads lighter than this (13-15 RM and lighter) have only had small effects on maximal strength and hypertrophy (Campos et al., 2002), but have been very effective for enhancing local muscular endurance (Campos et al., 2002). Each “training zone” on this continuum has its advantages and, in order to avoid encountering training plateaus or overtraining, one should not devote 100% of the training time to one general RM zone. It appears that optimal strength, hypertrophy, and endurance training requires the systematic use of various loading strategies (ACSM, 2002). Therefore, the American College of Sports Medicine (2002) recommends 60-70% of 1 RM loading for novice, 70-80% of 1 RM for intermediate, and 70-100% of 1 RM (periodized) for advanced strength training.

Training Volume

Training volume consists of the total number of sets and repetitions performed during a training session. Altering training volume can be accomplished by changing the

number of exercises performed per session, the number of repetitions performed per set, or the number of sets per exercise. Volume and intensity are inversely related such that use of heavy loads results in lower volumes whereas use of light to moderate loads results in higher training volumes. Typically, high volume programs are synonymous with training for muscle hypertrophy and local muscular endurance whereas low volume programs are synonymous with strength and power training.

The vast majority of studies that examined volume and resistance training have investigated the number of sets performed per exercise. Most comparisons have been made between single- and multiple-set programs (Galvao & Taaffe, 2004; Wolfe et al., 2004). In novice individuals, similar results have been reported from single- and multiple-set (mostly 3 sets) programs (Messier & Dill, 1985; Starkey et al., 1996), whereas some studies have shown multiple sets superior (Berger, 1963; Borst et al., 2001; Sanborn et al., 2000). Thus, either may be used effectively during the initial phase of resistance training. However, periodized (i.e., varied), multiple-set programs have been shown to be superior as one progresses to intermediate and advanced stages of long-term training in all (Kraemer, 1997; Kraemer et al., 2000; Marx et al., 2001; Kramer et al., 1997; Rhea et al., 2002; Schlumberger et al., 2001) but one study (Hass et al., 2000). Interestingly, a recent study (using a randomized, cross-over design) in trained postmenopausal women showed that multiple-set training resulted in a 3.5 to 5.5% range of strength increase whereas single-set training resulted in a 1.1 to 2.0% reduction in strength (Kemmler et al., 2004). Within multiple-set training programs, two (Dudley & Djamil, 1985), three (Berger, 1962), four-five (Campos et al., 2002; Dudley et al., 1991), and six or more (Sale et al., 1990) sets per exercise have all produced significant increases in muscular strength in both trained and untrained individuals. Only a few studies have made direct comparisons and they reported similar strength gains in novice individuals between two and three sets (Capen, 1956), and two and four sets (Ostrowski et al., 1997), whereas three sets have been reported as superior to one and two (Berger, 1963). Therefore, it appears that similar improvements, at least in novice-trained individuals, may be gained within various multiple-set protocols. Less is known with intermediate and advanced training. Typically, 3-6 sets per exercise are common during resistance training, although more and less have been used successfully. It is important to note that each set will have a specific purpose and that each exercise may be performed with a different number of total sets. Performing each set to near or actual muscular

exhaustion (as well as the impact of rest interval length) may affect the total number of sets per exercise. We have recently shown that when 2-3 min rest intervals are used during 10-repetition sets of multiple-joint exercises (i.e., squats, bench press) with 70-75% of 1 RM, acute lifting performance tends to decrease beyond the third set (when 5 or 6 sets are performed) (Ratamess et al., in review). Based on the aforementioned data, the American College of Sports Medicine (2002) has made the following strength training recommendations: 1) Novice—1-3 sets per exercise x 8-12 repetitions per set; 2) Intermediate—multiple sets of 6-12 repetitions per set; and 3) Advanced—multiple sets of 1-12 repetitions per set (periodized).

The number of sets performed per workout has not been extensively studied. In a recent meta-analysis examining 37 studies, Peterson et al. (2004) reported that 8 sets per workout (per muscles trained) yielded the largest effect size for strength development in athletes. However, few data directly compare resistance training programs of varying total sets, thus leaving numerous possibilities for the strength and conditioning professional when designing programs.

Exercise Selection

Two general types of free weight or machine exercises may be selected in resistance training: single- and multiple-joint. *Single-joint exercises* stress one joint or major muscle group whereas *multiple-joint exercises* stress more than one joint or major muscle group. Although both are effective for increasing muscular strength, multiple-joint exercises (e.g. bench press, squat) have generally been regarded as most effective for increasing muscular strength because they enable a greater magnitude of resistance to be used (Kraemer & Ratamess, 2000). Exercises stressing multiple or large muscle groups have shown the greatest acute metabolic and anabolic (e.g., testosterone, growth hormone family) hormonal responses (Ballor et al., 1987; Kraemer & Ratamess, 2005) which may play a role in muscle size and strength increases. The American College of Sports Medicine (2002) recommends that novice, intermediate, and advanced resistance training programs incorporate single- and multiple-joint exercises with emphasis on multiple-joint exercises for advanced training.

Exercise Order and Structure

The sequencing of exercises significantly affects the acute expression of muscular strength. In addition, sequencing depends on program structure. There are three basic workout structures: 1) *total body workouts* (e.g.,

TABLE 2
GENERAL SEQUENCING STRATEGIES
FOR STRENGTH TRAINING

Total Body Workout:

1. Large before small muscle group exercises
2. Multiple-joint before single-joint exercises
3. Rotation of upper and lower body exercises or opposing (agonist-antagonist relationship) exercises

Upper and Lower Body Split Workout:

1. Large before small muscle group exercises
2. Multiple-joint before single-joint exercises
3. Rotation of opposing exercises (agonist-antagonist relationship)

Muscle Group Split Routines:

1. Multiple-joint before single-joint exercises
2. Higher intensity before lower intensity exercises

performance of multiple exercises stressing all major muscle groups per session), 2) *upper/lower body split workouts* (e.g., performance of upper body exercises only during one workout and lower body exercises only during the next workout), and 3) *muscle group split routines* (e.g., performance of exercises for specific muscle groups during a workout). All three structures are effective for improving muscular strength and it appears that individual goals, time/frequency, and personal preferences will determine which one(s) will be used. One study has shown similar improvements in previously untrained women between total body and upper/lower body split workouts (Calder et al., 1994). Once the structure has been developed, the sequencing of exercise will ensue. For strength training, minimizing fatigue and maximizing energy are critical for optimal acute performance — especially for the multiple-joint exercises. Studies have shown that placing an exercise early vs. later in the workout will affect acute lifting performance (Sforzo et al., 1996). Thus, exercise sequencing strategies are described in Table 2 (Kraemer & Ratamess, 2004).

Rest Intervals

Rest interval length depends on training intensity, goals, fitness level, and targeted energy system, and affects acute

performance and training adaptations. Acute force production may be compromised with short (i.e., 1 min) rest periods (Kraemer, 1997; Ratamess et al., in review). Kraemer (1997) showed that all participants completed 3 sets of 10 repetitions with 10 RM loads when 3-min rest periods were used. However only 10, 8, and 7 repetitions were completed, respectively, with 1-min rest intervals in the study. We have recently developed a continuum for rest interval length for the bench press in which 3-5 min rest intervals were most effective for maintaining acute lifting performance, but 30 sec to 2 min of rest produced significant reductions in set performance (Ratamess et al., in review). Longitudinal studies have shown greater strength increases with long vs. short rest periods between sets (Robinson et al., 1995; Pincivero et al., 1997). These studies show the importance of recovery for optimal strength training. Rest intervals will vary based on the goals of that particular exercise, i.e., not every exercise will use the same rest interval. Muscle strength may be increased using short rest periods but at a slower rate, thus demonstrating the need to establish goals (i.e., the magnitude of

strength improvement sought) prior to selecting a rest interval. The American College of Sports Medicine (2002) recommends 1-2 min rest intervals for novice training, 2-3 min rest intervals for core exercise and 1-2 min rest intervals for others for intermediate training, and at least 3 min rest intervals for core exercises and 1-2 min rest intervals for others for advanced strength training.

Repetition Velocity

The velocity at which dynamic repetitions are performed affects the responses to resistance exercise. When discussing repetition velocity, it is important to note that velocity applies mostly to submaximal loading. Heavy loading requires maximal effort in order to lift weight. For *dynamic constant external resistance* (also called isotonic) training, significant reductions in force production are observed when the intent is to lift the weight slowly. There are two types of slow-velocity contractions, unintentional and intentional. *Unintentional* slow velocities are used during high-intensity repetitions in which either the loading and/or fatigue facilitate the velocity of movement (i.e., the resultant velocity is slow despite maximal effort) (Mookerjee & Ratamess, 1999). *Intentional* slow-velocity repetitions are used with

submaximal loads where the individual has greater control of the velocity. Concentric force production is significantly lower for an intentionally slow lifting velocity (5-sec CON: 5-sec ECC) compared to a traditional (moderate) velocity with a corresponding lower neural activation (Keogh et al., 1999). These data demonstrate that motor unit activity may be limited when the individual intentionally slows contraction velocity. Lighter loads (e.g. ~30% reduction) are required for intentionally slow velocities (i.e., > 5-sec CON, > 5-sec ECC) of training (when a targeted number of repetitions are desired) and may not provide an optimal stimulus for 1 RM strength enhancement in resistance-trained individuals (Keeler et al., 2001). Compared to slow velocities, moderate (1-2-sec CON, 1-2-sec ECC) and fast (< 1-sec CON, 1-sec ECC) velocities have been shown to be more effective for enhanced muscular performance, e.g., number of repetitions performed, work and power output, volume (Morrissey et al., 1998), and for increasing the rate of strength gains (Hay et al., 1983). The American College of Sports Medicine (2002) recommends slow to moderate velocities for novice training (i.e., with light loads while correct technique is learned), moderate velocities for intermediate training, and unintentionally slow (with heavy weights) and moderate to fast (with moderate to moderately heavy weights) for optimal strength training.

Frequency

Frequency refers to the number of training sessions performed during a specific period of time (e.g., 1 week) and/or the number of times certain exercises or muscle groups are trained per week. It is dependent upon several factors such as volume and intensity, exercise selection, level of conditioning and/or training status, recovery ability, nutritional intake, and training goals. Numerous studies have successfully used frequencies of 2-3 alternating days per week in novices (Hickson et al.,

1994; Dudley et al., 1991). For increasing strength, a) 3 days per week was superior to 1 day per week (McLester et al., 2000) and 2 days per week (Graves et al., 1988); b) 4 days per week was superior to 3 days per week (Hunter, 1985); c) 2 days were superior to 1 day (Pollock et al., 1993); d) 3-5 days per week was superior to 1 and 2 days (Gillam, 1981); and e) 2 and 3 days per week were similar (Carroll et al., 1998). Progression does not necessitate a change in frequency for training each muscle group, but may be more dependent upon alterations in other acute variables such as exercise selection, volume, and intensity. Advanced training frequency varies considerably. It has been shown that football players training 4-5 days/week achieved better results than those who trained either 3 or 6 days/week (Hoffman et al., 1990). Other advanced athletes have used frequencies higher than this (i.e., 8-12 workouts per week or more). It is important to note that not all muscle groups are trained specifically per workout using a high frequency. Rather, each major muscle group may be trained 2-3 times per week despite the large number of workouts. The American College of Sports Medicine (2002) recommends 2-3 days per week for novice training, 2-4 days per week for intermediate training, and 4-6 days per week for advanced strength training.

Summary

Resistance training poses numerous health and fitness benefits to all individuals, providing that a threshold of activity/effort is reached. Progressive overload, specificity, and variation are critical elements to resistance training programs targeting progression. These elements may be attained by proper manipulation of the acute program variables in order to obtain specific, individualized goals. Specific recommendations have been set forth by the American College of Sports Medicine and were discussed in the present document.

The act of resistance training itself does not result in health-promoting benefits unless the training stimulus exceeds the individual's fitness threshold. Progression in program design entails gradual progressive overload, specificity, and variation in the training stimulus in order for the individual to improve one's level of fitness.

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