Resistance Training Strategies for the Clinician: Focus on the Novice Exerciser

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INTRODUCTION

Important benefits of resistance training include increasing muscular strength, power, hypertrophy, local muscular endurance, speed, balance, and coordination (16). Resistance training is recommended by such organizations as the American College of Sports Medicine (ACSM) and the National Strength and Conditioning Association (NSCA) (2,3,4,20) for nearly all individuals, including adolescent, healthy adult, elderly, and clinical populations. Appropriate program design is critical to achieving successful training outcomes and entails goal setting, proper exercise instruction and evaluation, and, most importantly, the correct application of acute program variables consistent with program goals. This article discusses exercise programming variables associated with the design of a resistance training program for the novice exerciser. While the novice exerciser is much like many clinical populations with respect to the starting point prescribed for resistance training, the reader is referred to other sources for more detailed discussion of other factors to consider in program design as well as specific considerations for various clinical populations (27).

RESISTANCE TRAINING PROGRAM VARIABLES

Acute training variables to consider in the design of a resistance training session include exercise selection, intensity and training frequency, rest intervals between sets, repetition velocity, and the sequence of exercises. Designing a proper program involves the manipulation of each variable specific to the individual's goals and limitations. (See Table 1 for a summary of acute variables and recommendations.) Some common goals include increases in muscle size, strength, power, speed, local muscular endurance, balance and proprioception, coordination, flexibility, reductions in body fat, improvements in general health, and rehabilitation from injury.

Exercise Selection

Exercise selection refers to the types of exercises chosen for the resistance training program. The variety of exercises available for the exercise clinician is substantial, and a compendium of exercises and instructions has been previously published as well as specific exercises for selected clinical populations (27). Resistance training exercises are either single or multiple joint, with single joint exercises stressing one joint or major muscle group and multiple joint exercises stressing more than one joint or major muscle group. Both types of exercises are effective for increasing muscular strength. Single joint exercises, such as the triceps extension or the biceps curl, have been used to target specific muscle groups and are less complex and, for clinical populations,

TABLE 1. ACSM Recommendations for Resistance Training for Strength, Power, Hypertrophy, and Muscular Endurance.

Acute Variable	Recommendations			
Intensity (%1RM)	Strength 50 to 70% novice	Power 30 to 60%	Hypertrophy 70 to 80%	Muscular Endurance 30 to 80%
Rest Interval	2 to 3 min for multiple joint exercises 1 to 2 min for single joint exercises >3 min for advanced lifters			1 to 2 min for high-repetition sets <1 min for moderate-repetition sets
Frequency	2 to 3 d·wk^{-1} for novice lifters			3 to 4 d·wk^{-1} for intermediate to advanced lifters

1RM = 1 repetition maximum

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TABLE 2. Sample exercises that may improve strength and function for clinical populations.

Focus	Suggested Exercises
Exercise for full body warm-up and leg strengthening	For frail elderly: chair sit to stand using arms to stand For robust elderly: chair sit to stand with arms held across chest
Exercises for lower body for older adults with osteoporosis	For facility based training: leg press; knee extension and leg curl For home based training: half squats; sit-back squats; chair stands and stair climbing
Exercises for lower body for older adults with hip and knee osteoarthritis	For ascending and descending stairs ambulation and standing for extended periods: one-leg squats on stairs or standing hamstring curls
Exercises for lower body for the adult who is overweight or obese	For beginner: chair sit to stand using arms if necessary For intermediate: wall squat with stability ball For advanced: squats and holding dumbbells at sides of the body

easier to learn. Multiple joint exercises, including the bench press and the back squat, involve a higher degree of coordination and thus education and training for clinical and novice exercisers.

However, due to the larger muscle mass involvement and amount of weight used, multiple joint exercises have generally been regarded as the most effective exercises for increasing muscular strength and power (7,17). The primary consideration in selecting the exercises to include in a training program is the goals of the individual. For the clinical population, exercises should be selected to enhance activities of daily living (ADLs) and improve an individual's ability to interact with his or her home and work environment as well as increase his or her ability to maintain a healthy lifestyle. For example, "step-ups" with weights are a great exercise for an individual recovering from an uncomplicated myocardial infarction that may need to climb stairs to get to his or her house or apartment. (Refer to Table 2 for other exercise examples for clinical populations.)

Intensity

Intensity describes the amount of weight or load lifted and is typically expressed as a percentage of an individual's one-repetition maximum (1RM), defined as the maximum amount of weight that can be lifted one time with proper technique. Other terms often used to describe intensity are multiples of 1RM, such as 6RM, which indicates a load that can be lifted a maximum of six repetitions with proper technique. For those considered to be novice resistance trainers, light loads of approximately 45 to 50% of 1RM or less may increase muscular strength, as the initial adaptation to resistance training is characterized by improved motor learning and coordination (1,23). However, the ACSM recommends an intensity of approximately 50 to 70% of 1RM for the novice (2,3), but heavier loading (higher intensity) will be needed to increase maximal strength as the individual moves from novice to intermediate or advanced levels of training (8,12).

Repetitions and Training Volume

Intensity is inversely related to the number of repetitions prescribed. In general, research supports that training with an intensity corresponding to 80 to 85% of 1RM and higher resulted in one to six repetitions per set and was most effective for increasing maximal dynamic strength (5). The 6RM to 12RM loading range (70 to 80% of 1RM) is typically used in programs that target muscular hypertrophy (17). Loads lighter than this (50 to 70% of 1RM or 12RM to 15RM and lighter) are effective for increasing local muscular endurance (5).

Thus, an intensity/load continuum exists such that high loads and low repetitions are most specific to increasing strength, whereas low loads and high repetitions are most specific to increasing local muscular endurance (17). Training volume is a summation of the total number of sets and repetitions performed during a training session. The ACSM has recommended one to three sets for novice or beginning training (2,3), and not all exercises need to be performed with the same number of sets. The program designed for the novice could initially place an emphasis on lower training volume to provide a solid foundation for a long-term program.

Frequency

Frequency refers to the number of times certain exercises or muscle groups are trained per week and depends on several factors, including volume, intensity, and training goals, among others. The number of training sessions performed during a specific period (e.g., one week or one day) may affect subsequent training adaptations. Training with high intensity increases the recovery time needed between sessions, especially for multiple joint exercises involving similar muscle groups. Numerous studies have used frequencies of two to three alternating days per week in novice trainers and found that this frequency is effective, whereas 1 to 2 $d \cdot wk^{-1}$ appears to be an effective maintenance frequency for individuals already engaged in a resistance training program (2,3). A study addressing optimal number of sets for training

older women demonstrated that strength increased similarly when training 1, 2, or 3 d·wk^{-1}; however, 3 d was superior to one and two for improving coordination, balance, and muscular endurance (19). The ACSM recommends 2 to 3 d·wk^{-1} as the optimal frequency for the novice trainer (2,3).

TRAINING FOR SPECIFICITY

Rest intervals refers to the amount of time taken between sets and exercises, and the length is determined based primarily on the energy system targeted as well as the goals of the individual (17). The metabolic response to resistance training will depend on the rest interval length. In general, strength and power training that utilize high intensity/heavy loads and one to six repetitions with long rest intervals predominantly stress the ATP-PC system, the primary energy system used for high-intensity exercises lasting up to 20 s. Hypertrophy and strength training, utilizing moderate to heavy loads and 6 to 12 repetitions with moderate to short rest intervals, are supported mostly by energy provided by ATP-PC and glycolysis. Local muscular endurance training, with high repetitions and short rest intervals, involves a higher contribution of energy from aerobic metabolism. Thus, the rest interval influences the relative contribution of the three energy systems.

Strength and Power Training

For strength and power training, the ACSM has recommended at least 2 to 3 min rest intervals for multiple joint exercises and 1 to 2 min for single joint exercises for the novice (2,3). Maximal hypertrophy training may be attained through the combination of strength and standard hypertrophy training by using variation in rest interval length depending on the intensity. Thus, the ACSM has recommended 2 to 3 min of rest between high-intensity exercises and 1 to 2 min for modest-intensity exercises for advanced hypertrophy training (2,3).

Endurance Training

Training to increase local muscular endurance requires that the individual either perform high repetitions in long duration sets and/or minimize the recovery time between sets. Minimizing recovery between sets is an important stimulus to training adaptations within skeletal muscle necessary to improve local muscular endurance. The ACSM has recommended 1 to 2 min rest intervals in conjunction with high-repetition sets and less than 1 min rest intervals for moderate repetition ranges (3).

Lifting Velocity

Repetition velocity is defined as the time it takes to perform a single repetition and is usually divided into the concentric (CON) and eccentric (ECC) portions of the movement. Lifting velocity is critical for power training for clinical populations and is a variable often neglected in program design. Many recent investigations have examined the impact of power training in older adults (9,18,22) as the ability to move a weight quickly is a variable closely related to balance, fall prevention, and performance of activities of daily living, and power is lost to a greater extent in this population than maximal strength. These studies have shown that power training may be more effective than traditional resistance training for improving functional capacity in older adults. Muscle strength, walking capacity, rising from a chair, reaching ability, and balance are significantly enhanced following power training (11,13). In fact, lifting velocity with a light load—40% of 1RM—correlates with improvements in balance (21). Power increases similarly when different loads are lifted at high velocities; however, muscle strength and endurance are increased to a greater extent with heavy loading (6). Research also shows that power training in the elderly is safe (11).

Given the potential importance of repetition velocity for power development in clinical populations, some background information on this training variable may be helpful to the clinician. Because force equals mass times acceleration, the application of high levels of force leads to greater acceleration of the weight. Likewise, significant reductions in force production are observed when the intent is to perform the repetition slowly. Two types of low-velocity contractions exist: unintentional and intentional. Unintentional low velocities are used during high-intensity repetitions in which either loading and/or fatigue are responsible for the low velocity. Intentional low velocities are used with submaximal weights where the individual has greater control of the velocity. CON force production is substantially lower for an intentionally slow speed of lifting (5 s CON, 5 s ECC) compared with a traditional moderate velocity (1 to 2 s CON, 1 to 2 s ECC) with a corresponding lower neural activation and hence reduced training adaptation (17). Although intentionally slow repetitions may provide some benefit for local muscular endurance and hypertrophy training, the lighter loads may not provide an optimal stimulus for improving 1RM strength (17). Critical to successful outcomes with resistance training is the *intent* to move the weight as quickly as possible to optimize neural activation and force output. Recent studies have shown intentional high velocities to be more effective for advanced training than traditionally lower velocities with similar loading (14).

Training for local muscular endurance and, in some respects, hypertrophy may require a spectrum of velocities with various loading strategies (3). High, moderate, and low velocities are effective for improving local muscular endurance depending on the number of repetitions performed. The critical component to enhance local muscular endurance is to prolong the duration of the set. Two effective strategies used to prolong set duration are moderate repetition by using an intentionally low velocity and/or high repetition by using moderate to high velocities. Training with intentionally low velocity and light loads places steady tension on the muscles for an extended period and may be more metabolically demanding than moderate and high velocities when the same number of repetitions are performed. However, it is difficult to perform a high number of repetitions by using intentionally low velocities. Training strategies that employ low

velocity with moderate repetitions and moderate to high velocities with high repetitions increase the glycolytic and oxidative demands of the stimulus, thereby serving as an effective means of increasing local muscular endurance.

PUTTING IT ALL TOGETHER: EXERCISE SEQUENCING AND PROGRAM DESIGN

Exercise sequencing refers to the order in which exercises are placed within a training session. The sequencing of exercises and the number of muscle groups trained significantly affect the acute expression of muscular strength. Prior to discussing the effects of different sequencing strategies, it is important to identify which muscle groups will be trained. Three training routine structures common to resistance training determine which muscle groups are trained: 1) total body routines, 2) upper- and lower-body split routines, and 3) muscle group split routines. Total body routines involve the performance of exercises stressing all major muscle groups and include one or two exercises for each major muscle group. Upper- and lower-body split routines involve the performance of upper-body exercises during one training session and lower-body exercises during another. Muscle group split routines involve the performance of exercises for specific muscle groups during the same session (e.g., chest and triceps during one workout, biceps and back during another, and legs and shoulders during a third, separate session). All three are effective for improving muscular fitness, and it appears that individual goals, time or frequency, and personal preferences often determine which type of program structure will be used. The major differences between these program designs lies in the magnitude of specialization observed during each training session and the amount of recovery between each session. More exercises for a specific muscle group may be performed during a muscle group split routine as opposed to fewer exercises per muscle group in a total body routine.

General recommendations for exercise sequencing can be made depending on whether a person is training for strength, hypertrophy, power, or local muscular endurance. Acute lifting performance and optimal strength increases depend on where an exercise is placed in a workout sequence (24,25,26). For example, an individual will usually be able to perform more repetitions or use heavier weights during multiple joint exercises when those exercises are performed early in a workout rather than toward the end. In addition, large muscle mass exercises performed early have a stimulatory effect on small muscle mass exercises performed later in the workout. Hansen and colleagues (10) reported greater isometric strength increases in arm musculature when arm training was preceded by lower-body exercises. They also found greater acute elevations in growth hormone and testosterone when large muscle mass exercises preceded small muscle mass exercises. Considering that multiple joint exercises have been shown to increase muscular strength, hypertrophy, and power, maximizing performance of these exercises by including them early in the training session, when fatigue is minimal, may be necessary for optimal gains (3).

TABLE 3. Exercise sequencing strategies for strength and power training.

Total Body Routine
- Perform large muscle group exercises before small muscle group exercises.
- Perform multiple joint exercises before single joint exercises.
- Perform Olympic lifts before basic strength exercises (e.g., squats, bench presses), and do the most complex exercises first.
- Rotate upper- and lower-body exercises and opposing (agonist–antagonist) exercises.

Upper- and Lower-Body Split Routine
- Perform large muscle group exercises before small muscle group exercises.
- Perform multiple joint exercises before single joint exercises.
- Rotate opposing (agonist–antagonist) exercises.

Muscle Group Split Routines
- Perform multiple joint exercises before single joint exercises.
- Perform high-intensity exercises (i.e., those having a higher percent of one-repetition maximum [1RM]) before low-intensity exercises.

Adapted from Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. Med. Sci. Sports Exercis. 2004;36:674-88.

The sequencing of exercises for local muscular endurance training may not be as critical in comparison to strength and power training because fatigue is a necessary component of local muscular endurance training. Therefore, other variations in addition to the aforementioned strategies may be used for local muscular endurance training. The sequencing strategies for strength, power, and hypertrophy training suggested by the ACSM (3) are presented in Table 3. Exceptions to these recommendations do exist, especially if the individual is training specifically for muscle endurance or, to a certain extent, muscle hypertrophy. In addition, other exceptions may relate to warm-up exercises and weakness prioritization.

SUMMARY

Successful outcomes related to resistance training are achieved with proper manipulation of the acute training variables presented. Manipulation of the program variables may be performed in numerous ways to accomplish the specific goals of the individual. Specific needs and goals of the individual as well as limitations should be addressed prior to beginning a resistance training program. The resistance training program should be initially basic for the novice but should become more specific with greater variation in acute program variables during progression.

Keywords: training, clinical populations, exercise

REFERENCES

1. Anderson T, Kearney JT. Effects of three resistance training programs on muscular strength and absolute and relative endurance. Res Q. 1982;53:1-7.
2. American College of Sports Medicine. Position stand: the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness and flexibility in healthy adults. Med Sci Sports Exerc. 1998;30:975-91.
3. American College of Sports Medicine: Position stand: progression models in resistance training for healthy adults. Med Sci Sports Exerc. 2002;34:364-80.
4. Baechle TR and Earle RW. Essentials of Strength and Conditioning. National Strength and Conditioning Association. 3rd ed. Champaign, IL: Human Kinetics; 2008.
5. Campos GER, Luecke TJ, Wendeln HK, et al. Muscular adaptations in response to three different resistance-training regimens: specificity of repetition maximum training zones. Eur J Appl Physiol. 2002;88:50-60.
6. De Vos NJ, Singh NA, Ross DA, Stavrinos TM, Orr R, Fiatarone-Singh MA. Optimal load for increasing muscle power during explosive resistance training in older adults. J Gerontol A Biol Sci Med Sci. 2005;60:638-47.
7. Fleck SJ, Kraemer WJ. Designing Resistance Training Programs. 3rd ed. Champaign, IL: Human Kinetics; 2003.
8. Häkkinen K, Alen M, Komi PV. Changes in isometric force and relaxation time, electromyographic and muscle fibre characteristics of human skeletal muscle during strength training and detraining. Acta Physiol Scand. 1985;125:573-85.
9. Häkkinen K, Kraemer WJ, Newton RU, Alen M. Changes in electromyographic activity, muscle fibre, and force production characteristics during heavy resistance/power strength training in middle-aged and older men and women. Acta Physiol Scand. 2001;171:51-62.
10. Hansen S, Kvorning T, Kjaer M, Sjogaard G. The effect of short-term strength training on human skeletal muscle: the importance of physiologically elevated hormone levels. Scand J Med Sci Sports. 2001;11:347-54.
11. Henwood TR, Taaffe DR. Improved physical performance in older adults undertaking a short-term programme of high-velocity resistance training. Gerontology. 2005;51:108-15.
12. Hoffman JR, Kang J. Strength changes during an in-season resistance-training program for football. J Strength Cond Res. 2003;17:109-14.
13. Holviala JH, Sallinen JM, Kraemer WJ, Alen MJ, Häkkinen K. Effects of strength training on muscle strength characteristics, functional capabilities, and balance in middle-aged and older women. J Strength Cond Res. 2006;20:336-44.
14. Jones K, Bishop P, Hunter G, Fleissig G. The effects of varying resistance-training loads on intermediate- and high-velocity-specific adaptations. J Strength Cond Res. 2001;15:349-56.
15. Keogh JWL, Wilson GJ, and Weatherby RP. A cross-sectional comparison of different resistance training techniques in the bench press. J Strength Cond Res. 1999;13:247-58.
16. Kraemer WJ, Ratamess NA. Physiology of resistance training: current issues. Orthop Phys Therapy Clin North Am Exerc Tech. 2000;9(4):467-513.
17. Kraemer WJ, Ratamess NA. Fundamentals of resistance training: progression and exercise prescription. Med Sci Sports Exerc. 2004;36:674-88.
18. Miszko TA, Cress ME, Slade JM, Covey CJ, Agrawal SK, Doerr CE. Effect of strength and power training on physical function in community-dwelling older adults. J Gerontol A Biol Sci Med Sci. 2003;58:171-75.
19. Nakamura Y, Tanaka K, Yabushita N, Sakai T, Shigematsu R. Effects of exercise frequency on functional fitness in older adult women. Arch Gerontol Geriatr. 2007 44(2):163-73.
20. National Strength and Conditioning Association. Strength and conditioning professional standards and guidelines. J Strength Conditioning Res. 2009;31(5):14-38.
21. Orr R, De Vos NJ, Singh NA, Ross DA, Stavrinos TM, Fiatarone-Singh MA. Power training improves balance in healthy older adults. J Gerontol A Biol Sci Med Sci. 2006;61:78-85.
22. Porter MM. Power training for older adults. Appl Physiol Nutr Metabol. 2006;31:87-94.
23. Rutherford OM, Jones DA. The role of learning and coordination in strength training. Eur J Appl Physiol. 1986;55:100-05.
24. Sforzo GA, Touey PR. Manipulating exercise order affects muscular performance during a resistance exercise training session. J Strength Cond Res. 1996;10:20-4.
25. Simao R, Farinatti PTV, Polito MD, Maior AS, Fleck SJ. Influence of exercise order on the number of repetitions performed and perceived exertion during resistance exercises. J Strength Cond Res. 2005;19:152-56.
26. Spreuwenberg LP, Kraemer WJ, Spiering BA, et al. Influence of exercise order in a resistance-training exercise session. J Strength Cond Res. 2006;20:141-44.
27. Swank AM, Hagerman P. Resistance Training for Special Populations. 1st ed. Albany, NY: Delmar Publishing; 2010.