Strength Training: Rationale for Current Guidelines for Adult Fitness Programs

Matthew S. Feigenbaum, Med; Michael L. Pollock, PhD

THE PHYSICIAN AND SPORTSMEDICINE - VOL 25 - NO. 2 - FEBRUARY 97

If your browser does not support tables click here.

In Brief: Strength training is an effective method for developing musculoskeletal strength and is often prescribed for fitness, health, and the prevention and rehabilitation of orthopedic injuries. Because strength training is an integral component in the comprehensive health program promoted by the major health organizations (eg, American College of Sports Medicine, American Heart Association, Centers for Disease Control and Prevention, US Surgeon General's Office), population-specific guidelines have recently been published. For the average adult beginning a strength training program, current research indicates that single-set programs performed a minimum of two times per week are recommended over multiple-set programs because they are less time-consuming, more cost-efficient, and produce most of the health and fitness benefits. The goal of this type of program is to develop and maintain a significant amount of muscle mass, endurance, and strength to contribute to overall fitness and health, not to optimize strength, power, and hypertrophy. By incorporating exercise prescription into patient counseling, clinicians can further increase their effectiveness as prevention-oriented healthcare providers.

Strength training is an effective method for developing musculoskeletal strength and is often prescribed for fitness, health, and the prevention and rehabilitation of orthopedic injuries (1-7). The physiologic adaptations most often associated with strength training include increases in muscle mass, bone mass, and connective tissue thickness and associated increases in muscle strength and endurance (8-10). Recent studies suggest that strength training, as part of a comprehensive fitness program, may reduce the risk of coronary heart disease (11,12), noninsulin-dependent diabetes (13,14), and certain types of cancer (15). It has also been shown to improve function and reduce the probability of falls in the elderly. These benefits can safely be obtained when exercise program variables (frequency, volume of training, and mode of training) are manipulated to meet the needs of the individual.

Primary care physicians need to be aware not only of the benefits of strength training, but also the specifics of prescribing a regimen for their patients. In recent years, strength...
training program guidelines have been developed specifically for elderly persons (7), patients with cardiovascular disease (1,3,5,6,16), and healthy sedentary and physically active adults (2,3,17). Table 1 summarizes the guidelines, standards, and position statements for exercise prescription established by various health organizations. The importance of a well-rounded program including aerobic endurance exercise and strength training is well recognized, but the purpose of this paper will focus on the latter component.

Table 1. Strength Training Guidelines for Sedentary Adults, Elderly People, and Cardiac Patients

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Sets</th>
<th>Repetitions*</th>
<th>Number of Exercises</th>
<th>Frequency (day/wk)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Healthy Sedentary Adults</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1990 ACSM Position Stand (2)</td>
<td>1</td>
<td>8-12</td>
<td>8-10**</td>
<td>2</td>
</tr>
<tr>
<td>1995 ACSM Guidelines (3)***</td>
<td>1</td>
<td>8-12</td>
<td>8-10</td>
<td>2</td>
</tr>
<tr>
<td>1996 Surgeon General's Report (17)</td>
<td>1-2</td>
<td>8-12</td>
<td>8-10</td>
<td>2</td>
</tr>
<tr>
<td><strong>Elderly People</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pollock et al (7), 1994</td>
<td>1</td>
<td>10-15</td>
<td>8-10</td>
<td>2</td>
</tr>
<tr>
<td><strong>Cardiac Patients</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995 AHA Exercise Standards (5)</td>
<td>1</td>
<td>10-15</td>
<td>8-10</td>
<td>2-3</td>
</tr>
<tr>
<td>1995 AACVPR Guidelines (1)</td>
<td>1</td>
<td>10-15</td>
<td>8-10</td>
<td>2-3</td>
</tr>
</tbody>
</table>

ACSM = American College of Sports Medicine; AHA = American Heart Association; AACVPR = American Association of Cardiovascular and Pulmonary Rehabilitation

* For healthy people under age 50, weight should be sufficient to induce volitional fatigue with the number of repetitions listed. For older people, lighter loads may be used.

** Minimum one exercise per major muscle group (e.g., chest press, shoulder press, triceps extension, biceps curl, pull-down [upper back], lower back extension, abdominal crunch/curl-up, quadriceps extension, leg curls [hamstrings], calf raise).

***1995 ACSM guidelines also included low-risk diseased populations.

The effectiveness of a strength training program depends on several factors, including frequency, volume (sets x repetitions x resistance), and mode (free weights vs variable resistance machines, dynamic vs isometric exercises, concentric vs eccentric contractions) (2,18). When prescribing a strength training program, the clinician must decide what constitutes an optimal balance of these factors. He or she must also consider the patient's health, fitness, rationale for strength development, and personal goals.
**Scientific Basis for Strength Exercise Prescription Variables**

Programs prescribed for competitive athletes often use heavy weights performed a few times using multiple sets and include exercises designed specifically to improve the athletes' development of explosive power (e.g., clean and jerk, snatch, plyometrics). This type of program, however, is usually not appropriate for the average adult, elderly person, cardiac patient, or person with orthopedic limitations.

One common factor in most effective strength training and rehabilitation programs is the inclusion of at least one set of the maximal or near-maximal number of repetitions possible for each exercise performed. The amount of weight to be used should be based on a percentage of the maximum amount of weight that can be lifted one time, generally referred to as a one-repetition maximum (1-RM). The maximum number of repetitions performed before fatigue prohibits the completion of an additional repetition is a function of the weight load used, is referred to as repetition maximum (RM), and generally reflects the intensity of the exercise. Consequently, a weight load that produces fatigue on the third repetition is termed a three-repetition maximum (3-RM) and corresponds to approximately 85% of the weight that could be lifted for a 1-RM. The number of repetitions performed to fatigue is an important consideration in designing a strength training protocol, with the greatest strength gains appearing to result from resistances yielding 4- to 6-RM (18-20). Increasing the number of repetitions to 12- to 20-RM by decreasing the relative amount of resistance will favor increases in muscle endurance (18). In this regard it appears that the intensity of training is the most important factor for developing muscle strength (4,19), while lower-intensity programs emphasizing the completion of a greater number of repetitions per set and greater number of sets is more important for the development of muscle endurance and mass (21-23). While the term "high-intensity" strength training is usually reserved for 1- to 6-RM training loads, programs that emphasize exercising with a resistance that allows 8- to 15-RM are traditionally classified as "moderate intensity." Moderate-intensity programs are usually recommended for most of the adult nonathlete populations, including programs designed for adult fitness and health maintenance and for orthopedic rehabilitation. The purpose of this article will be to review two important components of the exercise prescription related to strength training or adult fitness and health maintenance programs found in the guidelines recommended by leading health organizations: volume of exercise and frequency of training.

**Single vs Multiple Sets**

The volume of training is a product of the number of sets performed for each exercise, the number of repetitions completed within each set, and the amount of weight (resistance) lifted. Although three sets of 8 to 12 repetitions performed 3 days/wk is a typical prescription for many strength training programs, the optimal number of sets of an exercise to develop muscle strength remains controversial. It is surprising that there is a lack of well-controlled studies existing in the literature comparing single-set versus multiple-set strength training programs. Table 2 (not shown) summarizes the results from strength training studies comparing varying numbers of sets. As depicted in the table, only one study (21) found a multiple-set protocol to elicit greater strength gains than a single set, whereas the majority of studies (21,22,24-28) indicate that there is not a significant difference. The results of Berger's study (20), from which originated the basis for prescribing three sets of 6 to 10 repetitions, indicated that three sets of bench presses were superior to one or two sets with similar repetitions following 12 weeks of bench press
exercise performed 3 days/wk. Berger's analysis of covariance (ANCOVA) data showed that the groups started with a 1-RM bench press of 124.5 lb and finished with 152.4 lb (22.4% increase; 1-set group), 151.6 lb (21.8% increase; 2-set group), and 156 lb (25.3% increase; 3-set group). Although there was a statistically significant difference, the magnitude between the groups training with one set versus three sets was small (2.9%). Furthermore, there are no studies existing in the literature including the Berger study that indicate that two sets are superior to one set.

With the exception of the Berger study (20), the literature supports the recommendation of prescribing single-set programs performed to fatigue and indicates that the quality (intensity) and not the quantity of strength training may be the most important factor for developing muscle strength in sedentary persons (21-23). Several studies conducted in our laboratory (24,25,29-33) have also found significant gains in strength in response to one set of variable strength exercise performed to volitional muscular fatigue. Most recently, a study conducted by Starkey et al (26) concluded that one set of moderate intensity strength training (approximately 10 repetitions to volitional fatigue) was as effective as three sets for increasing knee extension and knee flexion dynamic strength and isometric torque, and muscle thickness, in previously untrained adults. Despite the variety of muscle groups tested (pectoralis, biceps, lumbar extensors, quadriceps, etc), most studies in the literature have concluded similar results (table 2: not shown). It should be noted that all of the studies described were conducted over a 4- to 20-week period, and longer-duration studies may show greater strength gains with multiple-set programs. However, the existing literature clearly indicates that for the first 3 to 4 months of strength training, single-set programs are equally effective as multiple-set programs for improving muscle strength in previously untrained persons.

In addition, the amount of time required to complete a single-set program is substantially less than one-half the time required to complete multiple-set protocols. Messier and Dill (21) reported that the time required to complete a three-set free weight strength training program averaged 50 minutes compared with 20 minutes for a one-set variable strength program. This time efficiency should generally translate into improved exercise program compliance. Considering the similarities in strength gains for single- and multiple-set programs, single-set programs are recommended by current guidelines because they are less time-consuming, more cost-efficient, improve program compliance (2,17), and produce similar health and fitness benefits in the adult fitness and health maintenance setting.

**Frequency of Training**

The frequency of training for a muscle group is also an important component of a strength training program design (18,29,30,34). The rest period must allow for muscle recuperation and development and prevent overtraining. However, too much rest between training sessions can result in detraining. A 48-hour rest between concurrent training sessions is generally recommended (18), which corresponds with a 3-days/wk frequency of training for individual muscle groups. Although 3 days/wk of strength exercise is generally recommended for maximal strength gains, the literature does not always support this. Research indicates that isolated muscle groups are unique in their trainability and adaptability to strength training (18,30,35). Table 3 (not shown) summarizes the results from strength training studies comparing frequency of training using a variety of muscle groups.
Several studies (34,36,37) evaluating the effects of frequency of training have shown that four or more training sessions per week produced optimal strength gains in several muscle groups. Using the standard bench press exercise, Gillam (34) indicated that training 5 days/wk over a 7-week period was superior to 1, 2, 3, or 4 days/wk training regimens. Interestingly, training 3 or 4 days/wk produced similar results, which were significantly greater than those obtained by the groups training 1 or 2 days/wk. Hunter (37) and Henderson (36) also found that increasing the frequency of bench press training to 4 and 3 days/wk, respectively, produced greater strength gains than lesser-frequency protocols. In contrast, Berger (38) found that bench pressing either 2 or 3 days/wk produced similar strength gains over the course of 12 weeks. Similar findings have also been reported for studies evaluating strength gains in the lower limb muscles. Braith et al (29) found 3 days/wk to be superior to 2 days/wk in increasing quadriceps (knee extension) strength, and an earlier study by Barham (39) showed that performing the squat exercise 3 days/wk was as effective as 5 days/wk, and that both training frequencies were superior to squatting 2 days/wk.

While the chest, arms, and legs may require a training frequency of 3 days/wk or more to develop optimal strength gains, additional studies suggest that the muscles supporting the spine (eg, lumbar extensors) and smaller muscles of the torso may respond maximally with fewer training sessions per week. For example, Graves et al (30) found no significant differences in dynamic and isometric strength generated by isolated lumbar extensor muscles among groups training 1, 2, or 3 days/wk for 20 weeks. In a follow-up study (40), it was demonstrated that these maximal strength gains could then be maintained for up to 12 weeks when training frequency was reduced to one training session every 2 to 4 weeks. When assessing cervical rotation strength, Leggett et al (31) and DeFilippo (41) found that training frequencies of 2 and 3 days/wk were superior to 1 day/wk or 1 day/2 wks over a 12-week training period. Pollock et al (24) indicated that training 2 days/wk is superior to 1 day/wk for increasing cervical extension strength, but because training 3 days/wk was not evaluated, no inferences can be made in this regard. As for the muscles involved in torso rotation, DeMichele et al (35) concluded that the 2 days/wk training frequency obtained better adherence and equal strength gains compared with 3 days/wk, and that both 2 and 3 days/wk programs were superior to 1 day/wk.

Based on the findings of these studies, it is clear that there is no single optimal frequency of strength training for all muscle groups. Whether the differences in the time course of strength gains occurring in isolated muscle groups are due to variations in neural integration, muscle morphology, autoregulation, or other mechanisms warrants further investigation. Although clinicians must consider the specific needs of individual patients, particularly those whose orthopedic limitations may improve or be aggravated by adjusting the frequency of training, the current guidelines seem appropriate: a minimum of 2 or 2 to 3 days/wk (table 1). When prescribing traditional strength exercise programs for beginners (8 to 10 exercises, emphasizing the major muscle groups), a minimum of 2 days per week training frequency is recommended over more frequent training sessions because it allows time for recuperation, is less time-consuming, improves compliance (2,17), and produces most of the health and fitness benefits in the untrained person.

**Current Guidelines for Strength Training**

The updated versions of the American College of Sports Medicine (ACSM) position stand for exercise training (2), the *Guidelines for Exercise Testing and Prescription* developed
by the ACSM (3), the revised exercise standards of the American Heart Association (AHA) (5), and the American Association of Cardiovascular and Pulmonary Rehabilitation's (AACVPR) Guidelines for Cardiac Rehabilitation Programs serve as the foundation for most recommendations regarding physical activity program design (1). These guidelines/statements reflect the scientific-based research conducted to determine minimal and optimal levels of exercise needed to induce health- and fitness-related adaptations in the cardiovascular-respiratory and musculoskeletal systems. At first glance, the ACSM recommendation for strength training may appear minimal, but these minimal standards were based on the following premises: "First, the time it takes to complete a comprehensive, well-rounded program is important. Programs lasting more than 60 minutes per session are associated with higher dropout rates. Second, although greater frequencies of training and additional sets or combinations of sets and repetitions may elicit larger strength gains, the magnitude of difference is usually small (2)." Taking these assumptions into consideration, the minimal is acceptable for the sedentary person beginning a strength training program or for those who do not desire to attain the highest level of strength. For safety and time allotment considerations, most strength training programs should incorporate 8 to 10 strength exercises that condition the major muscle groups a minimum of 2 days/wk. Intensity should progress slowly, allowing time for adaptation. To develop or maintain range of motion, special calisthenic and flexibility exercises should be included. The goal is to be able to complete one set of 8 to 12 repetitions to volitional fatigue (8-RM to 12-RM) for healthy persons under 50 years of age. The AHA (5) and AACVPR (1) guidelines for cardiac patients and Pollock et al (7) for persons over 50 years of age recommend a lower-intensity program that may reduce the risk of orthopedic injury. For the more fragile populations, one set of 10 to 15 repetitions is recommended. Depending on patient status, this lower-intensity program would be performed to a level perceived as moderate or comfortably hard or to volitional fatigue. It is interesting to note that both the ACSM (3) and AACVPR (1) have reduced the recommendation for number of sets from two or three to one in their latest statements. Further research is needed to determine the ideal number of repetitions for fragile populations as well as for persons participating in rehabilitation programs.

Conclusion

When prescribed appropriately, strength training is effective for developing fitness and health and for the prevention and rehabilitation of orthopedic injuries. Although recent studies indicate that strength training may reduce the risks for several debilitating diseases such as cancer, heart disease, diabetes, low-back pain, and osteoporosis, further research is warranted regarding these matters. There is enough existing evidence to conclude that strength training, particularly when incorporated into a comprehensive fitness program, can offer substantial health benefits that can be obtained by persons of all ages. These benefits, including improvements in functional capacity, translate into an improved quality of life. Consequently, clinicians who understand the benefits of strength training and incorporate exercise prescription as part of their patient counseling further increase their effectiveness as prevention-oriented healthcare providers.

References

1. American Association of Cardiovascular and Pulmonary Rehabilitation: Guidelines for Cardiac Rehabilitation Programs, ed 2. Champaign, IL, Human Kinetics, 1995
2. American College of Sports Medicine: The recommended quantity and quality of


12/8/2002

Mr Feigenbaum is an assistant professor in the Department of Health and Exercise Science at Furman University in Greenville, South Carolina, and a member of the American
College of Sports Medicine (ACSM). Dr Pollock is director of the Center for Exercise Science in the departments of medicine and exercise and sport sciences at the University of Florida in Gainesville and a past president of the ACSM. Address correspondence to Michael L. Pollock, PhD, Dept of Medicine, Box 100277, JHMHC, University of Florida, Gainesville, FL 32610.