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Effect of Short-Term Equal-Volume Resistance Training With Different Workout Frequency on Muscle Mass and Strength in Untrained Men and Women

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Abstract. Candow, D.G., and D.G. Burke. Effect of short-term equal-volume resistance training with different workout frequency on muscle mass and strength in untrained men and women. *J. Strength Cond. Res. 21(1):204–207. 2007.*—Changes in muscle mass and strength will vary, depending on the volume and frequency of training. The purpose of this study was to determine the effect of short-term equal-volume resistance training with different workout frequency on lean tissue mass and muscle strength. Twenty-nine untrained volunteers (27–58 years; 23 women, 6 men) were assigned randomly to 1 of 2 groups: group 1 (n = 15; 12 women, 3 men) trained 2 times per week and performed 3 sets of 10 repetitions to fatigue for 9 exercises, group 2 (n = 14; 11 women, 3 men) trained 3 times per week and performed 2 sets of 10 repetitions to fatigue for 9 exercises. Prior to and following training, whole-body lean tissue mass (dual energy x-ray absorptiometry) and strength (1 repetition maximum squat and bench press) were measured. Both groups increased lean tissue mass (2.2%), squat strength (28%), and bench press strength (22–30%) with training ($p < 0.05$), with no other differences. These results suggest that the volume of resistance training may be more important than frequency in developing muscle mass and strength in men and women initiating a resistance training program.

Key Words. periodization, intensity, recovery

Introduction

To increase muscle mass and strength, the stimulus from resistance training must be sufficient to increase neuromuscular adaptation and muscle hypertrophy (13). It is well established that repeated exposure to weight-bearing exercise has a positive effect on muscle mass and strength (4–6, 9). However, for individuals initiating a resistance training program, controversy exists with regard to volume, intensity, and/or frequency of training to optimize muscle mass and strength in a safe and effective manner (19). Single-set and multiple-set programs increase muscular strength (7, 14), with greater gains observed when multiple sets are performed (19). In examining the effects of equal-volume resistance training between 1 and 3 days per week in experienced lifters, McLester et al. (16) found that individuals who trained 1 day per week achieved 62% of the strength gains compared with those individuals who trained 3 times per week. In addition, untrained individuals who resistance trained 2 times per week attained 80% of isometric strength compared with those who trained 3 times per week, suggesting that frequency of training is more important than volume for increasing muscle strength in untrained individuals (3). Unfortunately, muscle mass was not assessed in this study. An increase in both muscle mass and strength are common goals when initiating a resistance training program. A less frequent resistance training program that increases muscle mass and strength may provide positive reinforcement in untrained individuals for maintaining a resistance training program.

The purpose of this study was to determine if short-term equal-volume resistance training 2 days per week would increase muscle mass and strength similarly to 3 days per week in untrained men and women. These results would have immediate application for individuals considering a resistance training program that is effective and time efficient and encourages participation.

Methods

Experimental Approach to the Problem

The study used a double-blind repeated measures design in which every subject participated in resistance training for 6 weeks. Six weeks of resistance training is sufficient to increase muscle mass and strength in untrained individuals (6). Prior to the first visit to the laboratory for initial testing and data collection, all subjects were instructed to refrain from physical activity for 48 hours, because it has been shown that muscle protein synthesis and degradation is elevated for 48 hours postexercise (18). The dependent variables measured before and after 6 weeks of resistance training were lean tissue mass and strength (squat and bench press, one repetition maximum [1RM]).

Subjects

Twenty-nine untrained (i.e., no prior participation in resistance training) healthy subjects (23 women, 6 men; 27–58 years) volunteered for the study. Forty-eight subjects were needed to achieve 80% power as determined using the nomogram of Day and Graham (11), based on a lean tissue mass mean of 51 kg (6, 9) with a standard deviation of 1.6, assuming a difference parameter (i.e., standard deviation of the mean/standard deviation of measurements) of 0.6 at an alpha value of 0.05. All subjects were required to fill out a Physical Activity Readiness Questionnaire, which screens for health problems that may present a risk with performance of physical activity (20). Subjects who indicated a health problem were required to have medical approval before participating in the study. Subject characteristics are presented in Table 1. The study was approved by the University Ethics Review Board for Research in Human Subjects at St. Francis Xavier University. The subjects were informed of the risks and pur-

TABLE 1. Mean (standard error) subject characteristcs at baseline for groups 1 and 2.*

Group	Age (y)	Height (cm)	Weight (kg)	Squat 1RM (kg)	Bench Press 1RM (kg)	LTM (kg)
(1) 12 women, 3 men	43 (2.7)	166.8 (5.6)	74.3 (3.2)	109.4 (8.5)	39.0 (3.4)	47.6 (2.4)
(2) 11 women, 3 men	46 (3.1)	167.6 (4.4)	73.3 (3.6)	112.1 (8.7)	37.1 (3.8)	49.5 (2.8)

* 1RM = 1 repetition maximum; LTM = lean tissue mass.

poses of the study before their written consents were obtained.

Procedures

Lean Tissue Mass. Lean tissue mass was assessed by dual energy x-ray absorptiometry (DXA) at the beginning of the study and following 6 weeks of resistance training. Whole-body DXA scans were performed using a Hologic QDR-1000 (Bedford, MA) in array mode and were analyzed (excluding the head region) using system software 7.01. The same technician analyzed all DXA scans. Reproducibility was previously determined for 10 participants on 2 separate occasions. The coefficient of variation for lean tissue mass was 0.71%.

Muscle Strength. Squat and bench press were assessed using a 1RM standard testing procedure (9) prior to and following supplementation and resistance training. These 2 exercises were chosen as an index of muscular strength, because they involve the major muscle groups in the lower and upper body. To measure the 1RM squat, each subject positioned his or her feet approximately shoulder width apart inside the squat rack and in front of a full-body mirror. The position of feet placement was recorded using landmarks on the floor grid inside the squat rack to allow identical placement during the tests after the 6 weeks of training. Subjects were instructed to lower the Olympic barbell until an internal angle of 90° at the knees was achieved before returning to the upright position (6). A warm-up consisted of 10 repetitions of squat using a weight determined by each subject to be comfortable. Weight then was increased progressively for each subsequent 1RM attempt, with a 2-minute rest interval. The 1RM usually was reached in 4–6 trials, including the warm-up set.

For bench press, subjects were positioned on the bench with both feet flat on the floor. Subjects were not allowed to lift their buttocks off the bench or to arch their backs during a lift. A complete repetition went from the top straight-arm position, down until the bar touched the chest, and then ended with the bar returning to the top straight-arm position (6). A warm-up consisted of 10 repetitions, with a comfortable starting weight determined by each subject. Weight then was increased progressively for each subsequent 1RM attempt, with a 2-minute rest interval. The 1RM usually was reached in 4–6 trials, including the warm-up set. The reproducibility of the squat and bench press was assessed by testing 1RM strength for 12 subjects on 2 occasions, 1 week apart. Coefficients of variation were 6.32% for squat and 3.4% for bench press.

Resistance Training Program. Prior to the start of the study, subjects familiarized themselves with the resistance training equipment by participating in 3 supervised resistance training sessions 3 times a week for 2 weeks in the research weight training room located in the Department of Human Kinetics, St. Francis Xavier University. Familiarization with the resistance training equipment helped decrease the amount of learning (i.e., rapid improvement in the ability to perform a training exercise), which may contribute to the increase in strength during the initial stages of resistance training (8). After matching subjects for age and body mass to minimize differences between groups, each subject was assigned randomly to participate in 6 weeks of resistance training. All participants followed the same free-weight resistance training program for 6 weeks under supervision. Training sessions were supervised, because previous research has demonstrated greater gains in supervised vs. unsupervised training (15). The resistance training program consisted of 2 sets (group 1) or 3 sets (group 2) of 10 repetitions at 60–90% 1RM to fatigue. Subjects were instructed to adjust the weight for each set so that muscular fatigue occurred near the end of each set. This program was designed to induce muscle strength and hypertrophy. Both groups performed the same 9 whole-body resistance training exercises in order: (a) flat bench press, (b) squat, (c) incline dumbbell press, (d) lateral pull-down, (e) seated row, (f) shoulder dumbbell press, (g) leg extension/curl combination, (h) triceps overhead press, and (i) bicep barbell curl. Total training volume per session over the 6-week resistance training program was calculated by multiplying the weight used by the number of sets and repetitions for each exercise.

Training Logs. Each subject was instructed to record training logs for each workout day. The workout date, number of repetitions, and sets were recorded for each training day of the program. All training logs for the 6-week study were completed and verified by a researcher/supervisor immediately following each exercise session. Total training volume per session over the 6-week resistance training program was calculated by multiplying the weight used by the number of sets and repetitions for each exercise.

Statistical Analyses

A 2 (groups) × 2 (before vs. after training) analysis of variance with repeated measures on the second factor was used to assess changes in lean tissue mass and strength. An independent sample *t*-test was used to determine if there was a difference in training volume between groups. An independent sample *t*-test also was used to assess any baseline differences in participant characteristics prior to resistance training. The magnitude of the difference between significant means (i.e., effect size) was determined by eta squared (η^2). Eta squared is a measure of the proportion of the total variance that is explained by the treatment effects. An η^2 value of 0.8 represents large differences, 0.5 represents medium differences, and 0.2 represents small differences. Significance was set at $p \leq 0.05$. Statistical analyses were carried out using SPSS (version 11.5 for Windows XP; SPSS, Inc., Chicago, IL).

RESULTS

There were no differences between groups at baseline (Table 1). Changes in all measurements over the resistance training program were similar between men and women (i.e., there was no sex × time interaction). For

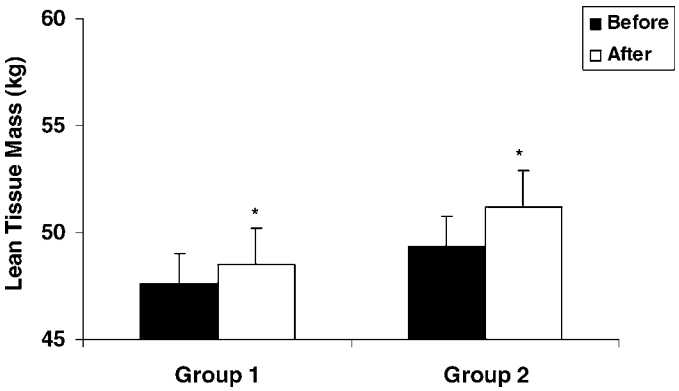

FIGURE 1. Lean tissue mass before and after 6 weeks of training in groups 1 and 2. Values are mean ± standard error. * Significantly different from pretraining ($p < 0.05$).

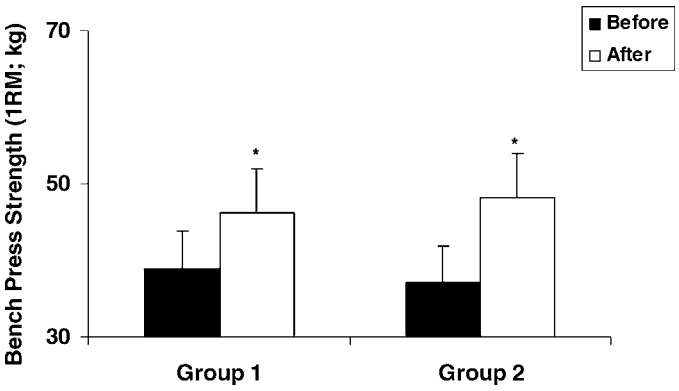

FIGURE 3. Bench press strength before and after 6 weeks of resistance training in groups 1 and 2. Values are mean ± standard error. 1RM = 1 repetition maximum. * Significantly different from pretraining ($p < 0.05$).

clarity, only comparisons between groups with sexes combined are presented.

There was a significant time main effect for lean tissue mass ($p < 0.05$; $\eta^2 = 0.21$), with no differences among groups (Figure 1). The relative increase in lean tissue mass for groups 1 and 2 were 2.9 and 3.0%, respectively.

There was a significant time main effect for squat and bench press strength with training ($p < 0.05$; $\eta^2 = 0.84$) (Figures 2 and 3). The relative increases in squat 1RM for groups 1 and 2 were 29 and 28%, respectively. The relative increases for bench press 1RM for groups 1 and 2 were 22 and 30%, respectively. There were no differences between groups for changes in strength with training.

There was a trend for a greater increase in training volume in group 2 compared with group 1, however this trend was not statistically significant ($p = 0.09$) (Figure 4). Group 1 had an average volume of 2,022.45 ± 67.2 (kg) per exercise session, whereas group 2 had an average total of 2,194.34 ± 69.5 (kg) per session.

DISCUSSION

To our knowledge, this is the first study to determine if short-term equal-volume resistance training 2 days per week is as effective as 3 days per week in increasing muscle mass and strength in untrained men and women. Results showed no difference between muscle accretion and strength gains when short-term equal-volume resistance training was performed 2 or 3 days per week. This suggests that training volume may be more important than training frequency for increasing muscle mass and strength during the initial stages of resistance training in untrained men and women. These results have immediate application for health professionals for designing safe and effective resistance training programs for individuals initiating an exercise program for the first time. It is important to note that a high-volume resistance training program adds additional stress during each workout session, possibly leading to greater muscle soreness and muscle pulls or strains. This issue should be considered by the health professional when designing an optimal resistance training program for untrained men and women. Our results are in contrast to those of Braith et al. (3), who found that equal-volume resistance training 3 times per week was more effective than 2 times per week for increasing isometric strength in untrained men and women. In addition, 1 day per week of equal-volume resistance training in experienced weightlifters did not increase muscle strength similarly to 3 days per week, suggesting that frequency of training was more important than training volume in trained individuals (16). It is difficult to compare results across studies. However, discrepancies between studies are mostly likely related to methodological differences. In particular, differences in subject training status and the type of resistance training may account for these inconsistent findings.

Muscle strength (22–30%) increased to a larger degree than muscle mass (3%) did, suggesting greater neural than muscular adaptations (8). Complex exercises, such

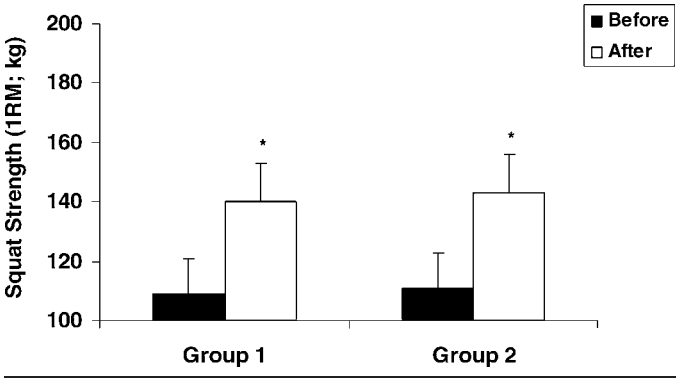

FIGURE 2. Squat strength before and after 6 weeks of resistance training in groups 1 and 2. Values are mean ± standard error. 1RM = 1 repetition maximum. * Significantly different from pretraining ($p < 0.05$).

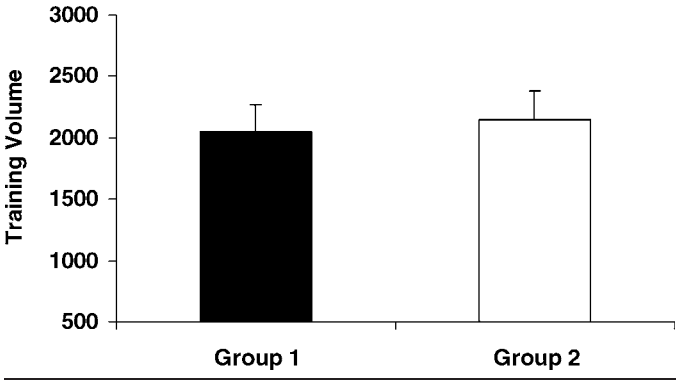

FIGURE 4. Training volume following 6 weeks of resistance training in groups 1 and 2. Values are mean ± standard error.

as those involving movement at one or more joints (i.e., squat, bench press), may involve a longer initial neural adaptation, resulting in delayed muscle hypertrophy (8). For example, in a study by Chilibeck et al. (8), leg press strength increased significantly after 10-weeks of resistance training in young women, with a nonsignificant increase in leg muscle mass. Although statistically significant, the small increase in lean tissue mass (2.2 kg; $\eta^2 = 0.21$) after 6 weeks of resistance training warrant future research with a larger sample size and a longer training period. The significant increase in muscle strength in both groups suggests that untrained individuals are sensitive to training volume, possibly because of an enhanced physiological response to training stimuli.

Our results of a significant increase in muscle mass and strength with resistance training is in agreement with our previous findings (4–6, 9). It is well known that the initial increase in muscle strength from resistance training is the result of increased neuromuscular demand and adaptation (2). For muscle mass and strength to proceed, muscle overload must occur (12). Through the concept of periodization, we manipulated the number of sets, repetitions, frequency, and intensity of training to ensure muscle overload and adequate recovery between subsequent workouts. This training philosophy has been shown to be very effective for promoting muscle mass and strength (12, 13). We believe our resistance training program was effective, because both groups increased muscle mass and strength over time. It is interesting to note that the change in muscle mass and strength between groups over the 6 weeks of resistance training was relatively similar, even with different resting periods between subsequent workouts. There is disagreement regarding the minimal amount of recovery required between subsequent training bouts to optimize muscle mass and strength in untrained individuals. Subjects in group 1 resistance trained on Tuesday and Thursday, whereas subjects in group 2 trained on Monday, Wednesday, and Friday. Rest intervals varied from 48–96 hours for group 1 to 48–72 hours for group 2. Even with the large variations in recovery intervals between subsequent workouts, we did not observe a significant difference in muscle mass or strength between groups over 6 weeks of resistance training. These results suggest that recovery intervals of 48 hours between subsequent workout bouts is sufficient to increase muscle mass and strength in untrained men and women.

A potential limitation of this study may be the use of both men and women as subjects. This most likely had minimal effect on our results, however, because there were equal numbers of men and women in both groups and sex was not a factor in adaptations to resistance training. Men and women had similar increases in muscle mass and strength. This is in agreement with other studies of short duration that have compared men and women (1, 10, 17).

PRACTICAL APPLICATIONS

Many individuals wanting to become physically active have limited time for resistance-type training. Effective training programs of increased volume and reduced frequency may be more attractive and attainable for novice lifters, patients in rehabilitation, and athletes during competition. Traditionally, 3 training sessions per week have been recommended. However, this time commitment is not always achievable over multiple days. Results from the present study suggest that untrained men and women initiating a resistance training program for the first time experience similar gains in muscle mass and strength when training 2 vs. 3 days per week with a controlled training volume. These results have immediate application for health professionals, coaches, and personal trainers when designing optimal resistance training programs that are time efficient, effective, and attainable. Once the individual has physiologically adapted to the training stimuli, further increasing the volume and frequency of training may be warranted.

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