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Effects of equal-volume resistance training performed one or two times a week in upper body muscle size and strength of untrained young men

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Abstract

Aim. The purpose of the present study was to compare the effects of equal-volume resistance training (RT) performed once or twice a week on muscle mass and strength of the elbow flexors in untrained young men. **Methods.** Thirty men (23.0 ± 3.0 years) without previous resistance training experience were divided into two groups: Group 1 (G1) trained each muscle group only once a week and group 2 (G2) trained each muscle twice a week during 10 weeks. Baseline and 10 weeks post-test elbow flexors muscle thickness (MT) were measured using a B-Mode ultrasound. Peak torque (PT) was assessed by an isokinetic dynamometer before and after the training program. **Results.** Elbow flexors MT increased significantly ($P < 0.05$) from 31.70 ± 3.31 to 33.43 ± 3.46 mm in G1, and from 32.78 ± 4.03 to 35.09 ± 3.55 mm in G2. Elbow flexors PT also increased ($P < 0.05$) from 50.77 ± 9.26 to 54.15 ± 10.79 N.m in G1, and from 48.99 ± 11.52 to 55.29 ± 10.24 N.m in G2. The results of ANOVA did not reveal group by time interactions for any variable, indicating no difference between groups for the changes in MT or PT. **Conclusions.** The results from the present study suggest that untrained men experience similar gains in muscle mass and strength with equal volume RT performed one or two days per week.

Key words: muscle hypertrophy, recovery, ultrasound, isokinetic, weight training, frequency

Introduction

Resistance training (RT) is established as an effective method for developing musculoskeletal fitness and is currently recommended by a variety of authors and health-related organizations for improving health and fitness outcomes [1-5]. Despite these consistent evidences, many people do not practice RT or any other type of physical activity [6] and most of them report lack of time as the principal barrier to exercise adoption [7-10]. Therefore, description of exercise programs that are less time consuming may be of great value to increase physical activity adherence.

The American College of Sports Medicine recommends a training frequency of 2–3 weekly sessions for novice, 3–4 for intermediate and 4–5 for advanced individuals with the purpose of increaseasing muscle size and strength [1]. However, due to time constraint, some individuals may choose to compress their exercise into fewer days, such as during weekends only. Although these people exercise each muscle group only once or twice a week, each training session can be prolonged and/or intensified in order to attain the expected goals. In fact, previous studies have shown that performing exercise only once or twice a week lead to a lower mortality risk compared with being sedentary [11]. However, little is known about the benefits of performing RT at low training frequencies in the gains of muscle size and strength in untrained people.

Previous studies investigated the effects of training a muscle group once a week in untrained subjects [12-16], however, most of them had focused on stabilizing and postural muscles and used isometric tests to measure strength [12,14-16]. In this regard, Pollock et al. [12] reported greater increases in isometric cervical extension strength in groups that

trained two times a week compared to those who trained only once per week. Similar results were reported by Graves et al. [14] and Carpenter et al. [16] for lumbar extension and by De Michele [15] for torso rotation. McKenzie Gillam et al. [13], found that the increases in bench press 1 repetition maximum (RM) of training three, four and five sessions a week are superior to training once a week, but there were no difference between training once or twice a week.

However, these previous studies did not made an attempt to balance weekly training volume and the groups that trained more frequently performed a higher training volume, therefore, it is not possible to establish if the differences in the results were due to a higher training volume or frequencies. Another point that needs to be clarified is the effect of different training frequencies in muscle mass in untrained individuals since the available studies were limited to strength measurements. If untrained individuals can obtain increases in muscle mass and strength with low training frequencies, this could be a valuable strategy for prescribing RT programs for people with low time availability. Therefore, the purpose of this study was to determine the effect of equal-volume RT for elbow flexors performed once or twice a week on muscle mass and strength of untrained young men. The hypothesis of study is that training one day a week induce gains in muscle size and strength, but the gains are less than the induced by two session per week.

Materials and methods

Experimental design

The participants were randomly assigned into two groups: Group 1 (G1, n = 15) trained the elbow flexors once a week and group 2 (G2, n = 15) trained twice a week. Weekly training volume was the same for both groups. G1 and G2 performed the same exercises, with the same number of sets and repetitions. All exercises were performed with three sets of 8-12 maximum repetitions. Before and after the 10 week training period, participants were evaluated for elbow flexors muscle thickness (MT) and peak torque (PT).

Participants

Thirty four college aged men volunteered to participate in the study. Volunteers were selected at random from respondents to fliers distributed over the university campus, and by word-of-mouth. The criteria for entering the study included being at least 18 years old, having no previous RT experience and being free of clinical problems that could be aggravated by the study procedures. To be included in the analyses, subjects had to attend at least 80% of the training sessions. The volunteers were instructed to not change their nutritional habits during the study period, and if any relevant change was detected (i.e. becoming a vegetarian, restricting calories, taking nutritional supplements or ergogenic aids, etc.) participants' data were excluded from the analysis. At the end of the study, 30 subjects met the criteria for entering the analysis (23.0 ± 3.0 years; 175.0 ± 8.0 cm; 72.9 ± 10.9 kg). The exclusions (two in each group) were due to engagement in strength training sessions other than the study protocol, changes in nutritional habits

and/or low training attendance. The excluded subjects were similar to the others regarding physical characteristics.

The study conforms to the Code of Ethics of the World Medical Association. All participants were notified of the research procedures, requirements, benefits and risks before providing written informed consent. The Institutional Research Ethics Committee granted approval for the study.

Muscle thickness

Participants were tested before and after the 10-week training period for muscle thickness (MT) of the elbow flexors of the right arm. All tests were conducted at the same time of the day, and participants were instructed to hydrate normally 24 hours before the tests. Measures were taken 3-5 days after the last training session to prevent any swelling from contributing to the MT measurement [17]. During this time, participants were instructed to not participate in any other exercise sessions or intense activity. MT was measured using B-Mode ultrasound (Philips-VMI, Ultra Vision Flip, model BF). A water soluble transmission gel was applied to the measurement site and a 7.5 MHz ultrasound probe was placed perpendicular to the tissue interface while not depressing the skin. MTs of the elbow flexors were measured according to Bemben [18] procedures. Once the technician was satisfied with the quality of the image produced, the image on the monitor was frozen. With the image frozen, a cursor was enabled in order to measure MT, which was taken as the distance from the subcutaneous adipose tissue-muscle interface to muscle-bone interface [19]. A trained technician performed all analyses. The coefficients of variation for elbow flexors MTs were less than 3.0%.

Baseline test and retest intraclass correlation coefficient (ICC) for elbow flexors MT was 0.96 (0.93 - 0.98).

Flexed arm circumference

Flexed arm circumference (AC) was taken on the right side of the body. The arm was raised to a horizontal position in the sagittal (forward) plane, with the elbow at 90 degrees. The subject maximally contracted the elbow flexors, and the largest circumference was measured. Three measures were taken and the average of the values was used during the analysis.

Isokinetic Peak torque

Unilateral elbow flexion isokinetic peak torque (PT) was tested using two sets of four concentric contractions at $60°s^{-1}$, on a Biodex System 3 isokinetic dynamometer (Biodex Medical, Inc., Shirley, NY) with 60s rest between sets [20]. Calibration of the dynamometer was performed prior to each testing session according to manufacturer's specifications. Participants were seated on a Scott Bench with their elbow aligned with the axis of rotation of the dynamometer's lever arm. The forearm remained in a supinated position throughout the test. Verbal encouragement was given throughout the test. Baseline test and retest ICC for peak torque were 0.96.

Resistance training intervention

The subjects were divided in two groups. G1 (n = 15) trained the elbow flexors once a week and G2 (n = 15) trained twice a week, according to table 1. Both groups performed the following exercises: lat pull down, seated row, barbell bench press, seated chest press, standing barbell biceps curl, Scott bench biceps curls, lying barbell triceps extensions and high pulley triceps extension. All exercises were performed with three sets of 8-12 maximum repetitions. Participants were verbally encouraged to perform all sets until concentric failure. If necessary, loads were adjusted from set to set to maintain the designated number of repetitions. Training sessions were closely supervised by experienced trainers, since previous research has demonstrated greater gains in supervised vs. unsupervised training [21]. The sets started every three minutes, leading to a rest interval of approximately two minutes. Each subject was instructed to record training logs for each workout day. All training logs for the 10-week study were completed and verified by a researcher/supervisor following each exercise session.

The training period lasted 10 weeks, but before the training period, there were three weeks of familiarization. During the familiarization sessions, participants were instructed how to correctly perform the exercises and the initial loads were obtained.

Table 1

Statistical analysis

Normality of the data was confirmed using the Kolmogorov-Smirnov test. Data are presented as mean ± standard deviation. Groups were compared using factorial mixed model ANOVA 2 x 2 (Group x Time). When necessary, multiple comparisons with confidence adjustment by the Bonferroni procedure were used for post hoc analysis.

Data were considered significant at $P < 0.05$ and statistical analyses were performed using the Statistical Package for the Social Sciences 15.0 software (SPSS, Chicago, IL).

Results

Characteristics of the subjects are presented in table 2. There was no significant difference in baseline values for age, height and body mass between G1 and G2. Results from flexed arm girth, MT and PT are presented in table 3. Flexed arm girth significantly increased 4.66% in G1 ($P < 0.05$) and 6.58% in G2 ($P < 0.05$). Elbow flexors muscle thickness also increased significantly in both groups (5.46% in G1 and 7.05% in G2, $P < 0.05$). With regard to elbow flexors peak torque, the increases were 6.66% in G1 and 12.85% in G2 ($P < 0.05$). The results of ANOVA did not reveal group by time interactions for any variable, indicating no difference between groups for the changes in any of the muscle size and strength variables.

Table 2

Table 3

Discussion

In order to attain optimal results in any physical activity program, it is important to alternate training sessions with adequate rest periods. This interaction between load and recovery is the basis of the supercompensation phenomenon [22]. According to these concept, there is an acute period of protein degradation and performance reduction after a training session. The next period is characterized by the initiation of the recovery process, until the organism reach the pre-load levels. However, the capability continues to increase, surpassing the initial levels, which corresponds to the supercompensation phase [22]. After these supercompensation phase, the capability would again return to the initial levels if the stimulus is not repeated. Therefore, repeating the stimulus with an adequate frequency is essential for achieving the expected results.

In fact, it is important to note that protein synthesis may return to basal levels in few days after the training session [23-28]. Therefore, the RT stimulus must be repeated in an adequate time, in order to attain chronic improvements in muscle function. Due to the transitory characteristics of the morphofunctional alterations induced by a training session, one could argue that a low training frequency may alter the balance between training and recovery, hindering long-term results. But this was not observed in the present study. One novel finding of the current investigation is that training a muscle group only once a week is as efficient as training twice a week to promote increases in muscle size and strength in untrained young men.

To our knowledge, this is the first study to determine if short-term equal-volume resistance training performed one day per week is as effective as two days per week in increasing muscle size and strength in untrained men, and the results showed no

difference between groups, suggesting that training volume may have a greater importance than frequency. This is in agreement with the study of Candow & Burke [29] who used equal-volume resistance training programs performed two or three times a week and found that both groups had similar increases in muscle size and strength. On the other hand, when analyzing experienced weightlifters, McLester, Bishop & Guilliams [30], concluded that three day per week of equal-volume resistance training was superior to one day per week, suggesting that frequency of training was more important than training volume in trained individuals. The discrepancies among the studies are mostly likely related to methodological differences, in particular, differences in the training status of the participants and the type of resistance training.

Our results are in contrast with those of previous studies that found that training two times a week was more effective than training once a week for increasing isometric strength [12-16]. However, the difference between these studies and the present may be related to the manipulation of training volume, since there was no attempt to equate training volume in those previous studies, leading the groups with higher frequencies to perform higher weekly training volume.

Conclusions

Based on the present results, we suggest that untrained men experience similar gains in muscle mass and strength with equal volume RT performed one or two days per week. The results of the present study have immediate applications for health professionals when designing safe and effective resistance training programs for individuals initiating a RT program. As lack of time is the most frequently cited barrier to exercise adoption [7-10] design an exercise program that can be performed only once a week may improve adherence. However, it is important to note that a high-volume resistance training program adds additional stress during each workout session and the participants of G1 reported severe muscle soreness, especially during the initial sessions. In addition, future studies should investigate the effects of training frequency on different muscle groups and population.

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List of tables

Table 1: Training sessions for groups 1 and 2

Table 2: Characteristics of the subjects (mean ± standard deviation)

Table 3: Results from flexed arm girth, peak torque and muscle thickness before and after 10 weeks of training.

Table 1: Training sessions for groups 1 and 2

	Session 1	Session 2
Group 1	Lat pull down Seated row Standing barbell biceps curl Scott bench biceps curls Barbell bench press Seated chest press Lying barbell triceps extensions High pulley triceps extension	xxxx
Group 2	Lat pull down Standing barbell biceps curl Barbell bench press Lying barbell triceps extensions	Seated row Scott bench biceps curls Seated chest press High pulley triceps extension

Table 2: Characteristics of the subjects (mean ± standard deviation)

	Group 1	Group 2
N	15	15
Age	23.1 ± 3.4	22.8 ± 2.6
Height (cm)	174.8 ± 7.5	175.2 ± 8.7
Body weight (kg)	73.1 ± 11.1	72.7 ± 11.1

Table 3: Results from flexed arm girth, peak torque and muscle thickness before and after 10 weeks of training.

	Group 1	Group 2
N	15	15
Flexed arm girth (cm)		
Pre	32.36 ± 2.42	31.29 ± 2.78
Post	33.87 ± 2.40*	33.35 ± 2.15*
Δ%	4.66%	6.58%
Elbow flexor thickness (mm)		
Pre	31.70 ± 3.31	32.78 ± 4.03
Post	33.43 ± 3.46*	35.09 ± 3.55*
Δ%	5.46%	7.05%
Peak torque (N.m)		
Pre	50.77 ± 9.26	48.99 ± 11.52
Post	54.15 ± 10.79*	55.29 ± 10.24*
Δ%	6.66%	12.86%

* $p < 0.05$ - pre vs post