Influence of Adding Single-Joint Exercise to a Multijoint Resistance Training Program in Untrained Young Women

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Abstract

Barbalho, M, Gentil, P, Raiol, R, Fisher, J, Steele, J, and Coswig, V. Influence of adding single-joint exercise to a multijoint resistance training program in untrained young women. *J Strength Cond Res* XX(X): 000–000, 2018—The aim of the present study was to investigate the effects of adding single-joint (SJ) exercises to a multijoint (MJ) resistance training (RT) program on muscle strength and anthropometric measures of young women. Twenty untrained women were divided into a group that performed only MJ exercises or a group that performed both SJ and MJ exercises (MJ + SJ). Before and after 8 weeks of training, the participants were tested for 10 repetition maximum (10RM). Flexed arm circumference and triceps and biceps skinfold thickness were also measured. Both groups significantly decreased biceps (−3.60% for MJ and −3.55% for MJ + SJ) and triceps skinfold (−3.05% for MJ and −2.98% for MJ + SJ), with no significant difference between them. Flexed arm circumference significantly increased in both groups; however, increases in MJ + SJ (4.39%) were significantly greater than MJ (3.50%). Increases in 10RM load in elbow extension (28.2% for MJ and 28.0% for MJ + SJ), elbow flexion (29.8% for MJ and 28.7% for MJ + SJ), and knee extension (26.92% for MJ and 23.86% for MJ + SJ) were all significant and not different between groups. The results showed that adding SJ exercises to an MJ RT program resulted in no benefits in muscle performance or anthropometric changes in untrained women.

Key Words muscle hypertrophy, isolation exercise, training volume, exercise selection, training efficiency

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Introduction

Resistance training (RT) is practiced by both men and women, yet there is comparatively little research examining the latter. Many studies do however show benefits in outcomes for female participants, such as, increases in muscle strength and improvements in body composition, bone metabolism, and functionality (3,4,20,23). In some populations, the percentage of women performing RT has been shown to be equivalent (32) or even greater than men, as found in Australia (27); however, the scientific literature seems to have neglected to study women. Although the benefits of RT have been recognized for many decades, it was not until 1998 that standalone RT guidelines were incorporated into the recommendations of the American College of Sports Medicine (ACSM) (31), whereas the National Strength and Conditioning Association statement was published only in 2009 (34).

Numerous reviews exist in the literature, considering studies examining the manipulation of RT variables such as training frequency (9), number of sets (35,36), training load (12), and exercise selection (21). Regarding exercise selection, RT exercises can be classified as multijoint (MJ) and single joint (SJ), depending on the number of joints involved in the movement. Although most popular recommendations (17,31) postulate that RT sessions should involve both SJ and MJ exercises (1,17), recent studies challenge that recommendation showing that the addition of SJ exercises to an MJ program offers no further benefits in terms of muscle size and strength (14,22). In light of this, the inclusion of SJ exercises has been questioned because of an unnecessary time commitment (21) that may ultimately impair exercise adherence because lack of time is a common barrier to exercise adoption (11,24).

Therefore, the purpose of the present study was to evaluate the effects of adding SJ exercises to an MJ exercise RT program in the gains of upper- and lower-body muscle strength and anthropometry of untrained young women. Despite men and women producing similar strength gains when following the same RT intervention (23), there may be differences in other responses or to differing manipulations of RT variables. For example, men and women have been shown to have different acute responses to RT, especially regarding fatigability (7,15,16,26,28,30), muscle recovery (13), and muscle activation (10), which may influence the response to exercise. Thus, for these reasons and because they are often overlooked when it comes to RT research (8), we opted to study women.

Methods

Experimental Approach to the Problem

Twenty young women with no previous RT experience performed either an RT program containing only MJ exercises (MJ group) or another with MJ exercises plus SJ exercises (MJ + SJ group). Training was performed for 8 weeks following a linear periodization model (25). Measures of muscle performance involved 10 repetition maximum (10RM) tests in both MJ (bench press, lat pull down, and leg press) and SJ exercises (elbow extension, elbow flexions, and knee extensions). Anthropometric changes were evaluated by measures of flexed arm circumference (FAC) and biceps and triceps skinfold. All measures were taken before the beginning of the experiment and 5–7 days after the last training session. In addition, at the beginning, retests were performed for all measures with at least 48 hours between tests to calculate test-retest reliability coefficient (intraclass correlation coefficient [ICC]), $SEM = SD\ (\sqrt{1} - \text{ICC})$ and minimal detectable change ($\text{MDC} = SEM \times [\sqrt{2}]$). Training volume was not equated because the difference was intended to be inherent to the protocols and to reflect the addition of SJ exercises to typical MJ exercise RT protocols.

Subjects

A priori power analysis revealed that a total of 16 participants would be necessary to detect an effect size of 0.5. Twenty participants were recruited to account for possible attrition during the study. Volunteers were selected at random from respondents to fliers distributed over the university campus, by social media, 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. The volunteers were instructed to not change their nutritional habits during the study period and were intermittently questioned to investigate any possible relevant change (i.e., becoming a vegetarian, restricting calories, taking nutritional supplements or ergogenic aids, etc.). All participants attended at least 80% of the training sessions (19), with a mean attendance rate of 90%. 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 (University Center of the State of Pará–CAAE 69724617.7.0000.5169).

Procedures

Ten Repetition Maximum Tests. Before and after the intervention, 10RM tests were performed in the bench press, elbow extensors, lat pull down, elbow flexors, leg press, and knee extension (all equipment was Physicus, Auriflama, São Paulo, Brazil). Tests were divided in 3 consecutive days. In the first day, participants were tested for bench press and knee extension; the second involved lat pull down and biceps; and leg press and triceps were tested in the third day. Participants warmed up with 10 repetitions at a comfortable self-selected load and then rested for 5 minutes. After the warm-up, an estimated 10RM load was set based on the participants' characteristics. If the participant was not able to perform 10 repetitions or performed more than 10 repetitions, the load was adjusted starting at 1 kg. Rest between attempts was set at 5 minutes, and no more than 3 attempts were allowed in each session. The test-retest reliability coefficient (ICC) of this procedure was determined by performing 2 identical test sessions 1 week apart, the values ranged between 0.97 and 0.99. In that analysis, the *SEM* ranged from 0.4 to 0.8%, whereas MDC ranged from 0.6 to 1.2%.

Anthropometric Measures. Flexed arm circumference and biceps and triceps skinfold were measured at the right side of the body in the week before the first training session and 5–7 days after the last training session. For FAC, the arm was raised to a horizontal position in the sagittal plane, with the elbow at 90°. The subject maximally contracted the elbow flexors, and the largest circumference was measured. Biceps and triceps skinfold were measured at the meso-humeral point while the arm was in the anatomical position hanging down the side of the body and relaxed (Adip Plicometer Scientific Cescorf, Porto Alegre, Rio Grande do Sul, Brazil). Three measures were taken, and the average of the values was used during the analysis. Reliability analysis

Table 1. Training protocols.

Session A (Monday/Thursday)	Session B (Tuesday/Friday)
Barbell bench press	45° leg press
Military press	Seated knee flexion
Lat pull down	Calf raises
Seated cable row	Knee extension*
Cable triceps*	
Barbell biceps curl*	

*Used only by the MJ + SJ group.

TABLE 2. Characteristics of the participants (mean ± *SD*).*

	MJ ($n = 10$)		MJ + SJ ($n = 10$)	
	Mean	*SD*	Mean	*SD*
Age (y)	22	2	22	2
Height (m)	165.3	4.06	168.8	3.39
Body Mass (kg)	63.3	4.03	65.4	4.81

*MJ = multijoint; SJ = single joint.

showed ICC values of 0.96 (*SEM* = 0.16 mm; MMD = 0.23 mm) for biceps skinfold, 0.97 (*SEM* = 0.12 mm; MDC = 0.17 mm) for triceps skinfold, and 0.96 for FAC (*SEM* = 0.19 cm; MDC = 0.27 cm).

Training. Training was performed 4 times a week, divided into 2 different muscle groups, as shown in Table 1. Both groups performed seated knee flexion, an SJ exercise, to avoid possible imbalances, as previously suggested (21). Because we did not include knee flexion as an outcome measure, this was considered unlikely to influence the outcomes examined. Each muscle group was trained twice a week with at least 72 hours between sessions. All sessions were supervised with a ratio of at least 1 supervisor to 5 trainees (18).

Both groups performed the same MJ exercises using the same number of sets, repetition ranges, set end points (to momentary failure), and rest intervals. The difference was only the inclusion of SJ exercises for the MJ + SJ group. The protocol was based on a linear periodization. During weeks 1 and 2, participants used loads permitting 12–15 repetitions before reaching momentary failure with 30–60 seconds of rest between sets. During weeks 3 and 4, loads permitting 10–12 repetitions before reaching momentary failure were used with 1–2 minutes of rest between sets. During weeks 5 and 6, loads permitting 6–8 repetitions before reaching momentary failure were used with 2–3 minutes of rest between sets. During weeks 7 and 8, participants used loads permitting 4–6 repetitions before reaching momentary failure with 3–4 minutes of rest between sets. Participants were instructed to perform every set to momentary failure, as previously defined by Steele et al. (39), and when they were able to perform more repetitions than suggested, the load was increased (1–5 kg) in alignment with the desired repetition range for the next training session. Training loads were initially prescribed based on estimations from the 10RM tests. The volunteers were instructed to perform the concentric and eccentric phases in 2 seconds each, without pausing between contractions.

Statistical Analyses

All values are reported as mean ± *SD*. The independent variable was the group (MJ or MJ + SJ), and the dependent variables were the absolute change in the outcome variables (post- minus pre-test scores). Analysis of covariance (ANCOVA) was used to compare absolute change in each outcome variable between groups with pretest scores used as a covariate. Furthermore, 95% confidence intervals (CI) were examined for within-group change. Significant within-group change was considered to have occurred if 95% CIs for changes did not cross zero. Statistical analysis was performed using JASP (version 0.8.1.2; University of Amsterdam, Netherlands), with alpha level for significance accepted at ≤0.05.

RESULTS

Table 2 shows participant baseline demographic characteristics, and Table 3 shows estimated marginal mean values for

TABLE 3. Change in outcomes over the training period (marginal mean ± *SE*) in addition to 95% CIs.*

	MJ		MJ + SJ			
	Change	95% CIs	Change	95% CIs	*F*	*p*
Body mass (kg)	1.8 ± 0.5	0.6 to 2.9	2.1 ± 0.5	1.0 to 3.3	0.225	0.641
Bench press 10RM (kg)	5.5 ± 0.4	4.6 to 6.5	5.9 ± 0.4	5.0 to 6.8	0.327	0.575
Elbow extension 10RM (kg)	2.1 ± 0.3	1.5 to 2.8	2.9 ± 0.3	2.2 to 3.5	2.475	0.134
Pull down 10RM (kg)	4.4 ± 0.3	3.8 to 6.1	5.0 ± 0.3	4.3 to 5.6	1.522	0.234
Elbow flexion 10RM (kg)	3.4 ± 0.3	2.8 to 4.0	3.8 ± 0.3	3.2 to 4.4	0.683	0.42
Leg press 10RM (kg)	9.0 ± 0.4	8.2 to 9.7	8.5 ± 0.4	7.7 to 9.2	0.905	0.355
Knee extension (10RM)	4.1 ± 0.2	3.7 to 4.6	4.3 ± 0.2	3.8 to 4.77	0.281	0.603
Triceps skinfold (mm)	−0.49 ± 0.03	−0.55 to −0.43	−0.47 ± 0.03	−0.53 to −0.41	0.194	0.665
Biceps skinfold (mm)	−0.53 ± 0.02	−0.57 to −0.48	−0.53 ± 0.02	−0.58 to −0.49	0.073	0.79
Flexed arm circumference (cm)	0.93 ± 0.05	0.82 to 1.05	1.22 ± 0.05	1.10 to 1.33	13.373	0.002

*MJ = multijoint group; MJ + SJ = multi and single-joint group; CI = confidence interval; RM = repetition maximum.

absolute change in each outcome in addition to the 95% CIs for the changes, *F* statistics, and *p* values for between-group comparisons.

Muscle Performance Outcomes (Ten Repetition Maximum)

Between-group comparisons using ANCOVA revealed no significant differences for changes in any muscle performance outcome. The 95% CIs also suggested that both groups significantly increased in the 10RM load in the bench press (39.1% for MJ and 39% for MJ + SJ), triceps (28.2% for MJ and 28.00% for MJ + SJ), pull down (29.5% for MJ and 27.6% for MJ + SJ), biceps (29.8% for MJ and 28.8% for MJ + SJ), leg press (44.1% for MJ and 38.2% for MJ + SJ), and knee extension (26.9% for MJ and 23.9% for MJ + SJ).

Anthropometric Measures (Flexed Arm Circumference and Biceps and Triceps Skinfolds)

Between-group comparisons using ANCOVA revealed no significant differences for changes in body mass or biceps and triceps skinfolds. The 95% CIs also suggested that both groups significantly increased body mass (3% for MJ and 3.1% for MJ + SJ) and significantly decreased both biceps skinfold (−3.6% for both MJ and MJ + SJ) and triceps skinfold (−3.1% for MJ and −3% for MJ + SJ). Between-group comparisons using ANCOVA revealed a significant difference for change in FAC favoring the MJ + SJ group. The 95% CIs suggested that both groups significantly increased FAC, yet the change in the MJ + SJ group was significantly greater than that in the MJ-only group (4.4% for MJ + SJ and 3.5% for MJ).

Discussion

The present study investigated the effects of adding SJ exercises to an MJ exercise RT program in untrained women. According to our results, the additional performance of SJ exercises did not increase muscle performance or reduce skinfold thickness more so than MJ exercises alone. In addition, although changes in FAC were higher with the addition of SJ exercises, the differences are likely of little practical significance. This suggests that the inclusion of SJ exercises might provide little benefit to muscle hypertrophy in the upper limb muscles in untrained women.

The analysis of muscle performance was similar to that previously reported in both trained (14) and untrained (22) men. In a previous study with untrained men, Gentil et al. (22) examined the effect of adding SJ exercise to MJ exercise RT program on upper-body muscle size and strength. The MJ group performed lat pull down and bench press, whereas the MJ + SJ group performed the same MJ exercises plus elbow flexion and elbow extension. There were significant increases in elbow flexors peak torque (10.40% for MJ and 12.85% for MJ + SJ) in both groups, with no significant difference between them. Therefore, it seems that untrained women might not benefit from the addition of SJ to increase muscle performance.

Interestingly, the MJ group had similar increases to MJ + SJ group in elbow flexion, elbow extension, and knee extension, despite not performing these exercises in their routine. It may be that the performance of additional SJ movements did not bring increased gains in performance because these exercises involve simple tasks that do not have a high reliance on motor learning (29,33). Therefore, the performance of specific SJ exercises did not seem to be necessary even when the task tested involved SJ movements (37). The use of 10RM test, instead of 1RM, might have affected the results. Considering that 1RM may require a higher skill component than 10RM and, therefore, have a higher reliance on learning (6), it is possible that the performance of specific exercises would have a greater impact on the results. However, it is important to note that de França et al. (14) evaluated muscle strength by 1RM tests and did not find differences between MJ and MJ + SJ in trained men.

Previous studies in both trained (14) and untrained (22) men reported that the addition of SJ exercises also did not result in additional increases in muscle size. Gentil et al. (22) reported increases of 6.5% for MJ and 7% for MJ + SJ, with no significant difference between them. Although not significantly different, the increases in FAC were 50% higher in SJ + MJ (4.1 vs. 6.6%); a difference greater than the ~25% difference found in the present study (4.4 vs. 3.5%). However, 1 limitation of the study by Gentil et al. (22) is the absence of skinfold thickness measure, so it is not possible to discard if the increases in circumference were influenced by increases in subcutaneous fat. Moreover, ultrasound measures were limited to elbow flexors, whereas circumference measures involve all muscles in the region (i.e., triceps brachii). It is not known whether biceps and triceps muscles respond differently to MJ and SJ exercises; however, there is evidence that different MJ and SJ exercises may promote increases in different regions of the triceps (40,41), which might have influenced anthropometric measures.

It is important to highlight that the difference between the increases in FAC for the MJ + SJ and SJ was only 0.2 cm (1.2 vs. 1 cm). Although it reached statistical significance, the difference was relatively small and lower than error thresholds (*SEM* = 0.19 cm; MDC = 0.27 cm). Therefore, one should consider this when evaluating the cost-benefit of performing additional SJ exercises. Future studies should investigate whether this difference would persist in long-term training such that it would result in practically relevant changes over time. A further point to note is that anthropometric measures of the lower body were not performed and so, although strength gains may be similar between MJ only exercise and MJ + SJ exercise for the lower body, it is not known whether hypertrophic adaptations may differ in this population.

As noted, 1 important limitation of the present study is the lack of anthropometric measures for the lower body. This was due to the inability to obtain precise measures because of high subcutaneous fat tissue in this region in some participants. Another possible limitation is the relatively short duration. Notwithstanding, previous studies showed that the highest increases in muscle size and strength occur in the first week of training (4,38). Therefore, we opted to use a shorter period of training to avoid attrition.

A further limitation of the present study is the absence of a more precise method for analyzing increases in muscle size. However, it is important to note that measures of arm girth are popular and reliable methods for estimating changes in muscle size during RT (2,14). It could be argued that a more sensitive method would show different results. The lack of difference in muscle performance gains between groups might suggest otherwise, although the primary contributor to strength gains in most populations would seem to be neural and practice related (5) and so it remains a possibility that hypertrophy may differ. The use of a single test for muscle strength assessment is another limitation because multiple measures (e.g., 1RM, dynamometry, etc.) could provide a better understanding of the spectrum of strength adaptations.

In summary, the results of the present study showed that the stimuli provided during MJ exercises were sufficient to promote gains in muscle performance in previously untrained women, and no additional benefit was obtained by the inclusion of supplemental SJ exercises over a period of 8 weeks. Our results showed greater increases in FAC, suggesting that the addition of SJ exercises may provide increased results in upper-body muscle size. However, the absolute difference between MJ and MJ + SJ was relatively small, and it would be necessary to investigate whether they are maintained in the long term. Based on the present findings, using only MJ exercise might be recommended as a time-efficient strategy for untrained women.

Practical Applications

Our data show that the addition of SJ exercises to an MJ program did not induce additional gains in muscle strength and skinfold thickness in untrained women. Although the differences in FAC were significant, the differences were not considered to be meaningful. We believe that these findings are relevant for coaches and trainers because it directly affects RT prescription, especially when a time-efficient approach is needed. The main message is that although SJ should not necessarily be discouraged, its addition to an MJ exercise program is not mandatory. An RT program might be based solely on MJ exercises to reduce time commitment, which could be advantageous for stimulating RT practice and for long-term adherence.

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