THE EFFECTS OF ADDING SINGLE-JOINT EXERCISES TO A MULTI-JOINT EXERCISE RESISTANCE TRAINING PROGRAM ON UPPER BODY MUSCLE STRENGTH AND SIZE IN TRAINED MEN

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Abstract

The aim of this study was compare changes in upper body muscle strength and size in trained men performing resistance training (RT) programs involving multi-joint plus single-joint (MJ+SJ) or only multi-joint (MJ) exercises. Twenty young men with at least two years of experience in RT were randomized in two groups: MJ+SJ (n = 10, 27.7 ± 6.6 years) and MJ (n = 10, 29.4 ± 4.6 years). Both groups trained for 8 weeks following a linear periodization model. Measures of elbow flexors and extensors 1RM, flexed arm circumference (FAC) and arm muscle circumference (AMC) were taken pre and post training period. Both groups significantly increased 1RM for elbow flexion (4.99 and 6.42% for MJ and MJ+SJ, respectively), extension (10.60 *vs* 9.79%, for MJ and MJ+SJ, respectively), FAC (1.72 *vs* 1.45%, for MJ and MJ+SJ, respectively) and AMC (1.33 *vs* 3.17% for MJ and MJ+SJ, respectively). Comparison between groups revealed no significant difference in any variable. In conclusion, eight weeks of RT involving MJ or MJ+SJ resulted in similar alterations in muscle strength and size in trained participants. Therefore, the addition of SJ exercises to a RT program involving MJ exercises does not seem to promote additional benefits to trained men suggesting MJ only RT to be a time efficient approach.

Key words: strength training, muscle hypertrophy, training volume, exercise selection, isolation exercise, linear periodization

Introduction

Resistance training (RT) is a popular form of exercise that promotes many health benefits and increased strength and muscle mass, the primary outcomes of RT, have been evidenced to reduce the risk of all-cause mortality (Newman et al. 2006; Ruiz et al. 2008; Artero et al. 2011; Srikanthan and Karlamangla 2014). Most popular recommendations postulate that RT sessions should involve 8 to 10 exercises performed in multiple sets with both single (SJ) and multi joint (MJ) exercises (ACSM 2009; Garber et al. 2011).

These recommendations usually result in sessions lasting one hour or more, a duration that lead to a high drop-out rate (~30%) in a previous study of trained participants (Hass et al. 2000). Considering that lack of time is the most frequently cited barrier to exercise adoption (Gómez-López et al. 2010), this time commitment may not be desirable, or even suitable, for most people. Therefore, finding strategies that reduce time commitment without negatively affecting results is important in order to attempt to increase participation in RT programs. Time spent performing RT is predominantly manipulated through changes in the number of sets performed (Carpinelli and Otto 1998), training frequency (Gentil et al. 2015a) and/or exercise selection.

Regarding exercise selection, a previous study by Gentil et al. found that increases in elbow flexors muscle strength and thickness were not different between young men that performed SJ or MJ (Gentil et al. 2015b). In another study by the same group, the authors compared a group performing only MJ exercises to another performing MJ+SJ and reported no differences in elbow flexors muscle strength and thickness in young men (Gentil et al. 2013). These findings suggest that one can achieve appreciably similar gains in upper body muscle strength and size with only MJ exercises.

However, it is important to note that the participants of these studies were untrained and that trained subjects may show a different response. As noted time is also a concern for trained participants (Hass et al. 2000) and thus the benefit of including SJ exercises in an RT program already including MJ exercises for the same muscles required evaluation. Soares et al. (2015) reported that resistance trained men take longer to recover after SJ than MJ exercises(Soares et al. 2015), which suggests a higher incidence of muscle damage after SJ exercises. Given that muscle damage may be associated with muscle hypertrophy (Schoenfeld 2012), one may suggest that a trained person would benefit from using SJ exercises, as commonly suggested in bodybuilding (Mentzer and Little 2003) and as commonly employed by bodybuilders (Hackett et al. 2013). Due to the importance of finding time efficient exercise programs and the lack of study in trained subjects evaluating the advantages of performing SJ exercises, the purpose of the present study was to compare alterations in upper body muscle strength and size between RT protocols involving only MJ or MJ+SJ in trained men.

Material and methods

Experiment overview

In order to examine the effects of performing SJ exercises on upper body muscle strength and size, twenty young males with previous RT experience were randomly divided into two groups that performed RT programs containing MJ or MJ+SJ. Training followed a linear periodization model for 8 weeks. Elbow flexion and extension 1RM, flexed arm circumference (FAC) and arm muscle circumference (AMC) was measured before and after the training period. Training volume was not equated, because the difference would be inherent to the protocols and reflects the *addition* of SJ to typical MJ RT protocols.

Participants

Twenty men participated in the study as volunteers. The participants were randomly divided in two groups: MJ+SJ (n = 10, 27.7 $\pm$ 6.6 year) and MJ (n = 10, 29.4 $\pm$ 4.6 years). To be included in the study, participants had to be currently practicing RT and have been continuously training for at least two years previous to the beginning of the study. Their programs had to involve both MJ and SJ exercises and be designed for muscle hypertrophy. People with historic of anabolic steroid use were not accepted. Participants were instructed to not change their nutritional habits or ingest ergogenic aids during the study. Minimum training attendance was set at 85% (Gentil and Bottaro 2013). All 20 volunteers completed the study. The participants were notified of the research procedures, requirements, benefits and risks before providing written informed consent. The Institutional Research Ethics Committee at the lead author's institution granted approval for the study.

Flexed arm circumference (FAC) and arm muscle circumference (AMC)

FAC, arm circumference (AC) and triceps skinfold (TS) were measured at the right side of the body in the week before and 5 to 7 days after the last training session. The participants were instructed to avoid RT for one week before the tests. For FAC, the arm was raised to a horizontal position in the sagital 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. AC and TS were measured at the same anatomical point of FAC while the arm was in the anatomical position hanging down the side of the body and relaxed.

AMC was calculated using the AC and TS, according to the formula proposed by Gurney e Jelliffe (1973): AMC (cm) = AC (cm) –[π x TS (cm)] as used in previous studies (Geliebter et al. 1997; McGinley et al. 2007; Araujo et al. 2008).

1RM tests

After the FAC and AMC measures, 1RM was tested for elbow flexors and extensors, based on the procedures proposed by Brown and Weir (2001). After a general warm-up, subjects performed a specific warm-up set of 8 repetitions at 50% of the estimated 1-RM followed by another set of 3 repetitions at 70% of the estimated 1-RM. Subsequent lifts were single repetitions of progressively heavier weights until failure. Minimum load increases was 1kg (0.5kg plates). Five minutes of rest were given between attempts and no more than five attempts were allowed.

Elbow extension 1RM was tested with the subjects lying down on a flat bench holding a barbell. The initial position was with the arms extended and forming a 90 degree angle perpendicular with the torso and floor, with the wrists pronated. The bar was then lowered until touch the forehead and returned to the initial position. A leather strap was used to keep the elbows at shoulder-width, preventing undesirable elbow movement in the frontal plane. Elbow flexor 1RM was tested with the subject upright and with the back against a wall while holding a barbell at a shoulder-width grip with wrists supinated and the elbows touching the sides of the torso. The movement started with the elbow fully extended, then the elbow was flexed raising the bar through a full range of motion (determined visually during warm-up repetitions) approaching the chest and returned to the initial position. Participants were informed that only the elbow should flex and the back should not separate from the wall.

Training

In order to increase ecological validity, RT program design and exercise choice were based on the common practices used in gyms and fitness centers by experienced trainees who desire to increase muscle strength and size. RT followed a linear periodization model with sequences of ordinary (two), shock (one) and restorative (one) microcyles as shown in Table 1.

During the ordinary microcycle, sets were performed until concentric failure with one minute rest interval between sets. During the shock microcycle, training was performed with the same load of the ordinary week; however, after failure, external assistance was given during the concentric phase to allow the performance of 2-5 additional repetitions, a method so-called forced repetitions (Ahtiainen et al. 2003b). During the ordinary and shock microcycles, loads were reduced by ~10% from set to set to maintain the designated number of repetitions (Willardson et al. 2012). During the restorative microcycle, the loads were equivalent to 50% of the load used in the previous microcycle but the number of repetitions was kept at 10 and no load adjustment were necessary from set to set. Participants were instructed to take one second to perform the concentric and two seconds to perform the eccentric phase, whenever possible. Rest intervals were set at one minute between sets and two minutes between exercises. Each session lasted approximately 35 and 50 minutes for MJ and MJ+SJ, respectively. RT was performed over two sessions and each one was performed twice a week. As show in table 2, both groups performed the same MJ exercises, but the MJ+SJ groups also performed the exercises marked with asterisks. The lower limbs, low back and abdominal muscles were trained on Wednesdays and Saturdays through the same complementary training program for both groups.

Statistical analyses

All values are reported as mean ± standard deviation (SD). Effect sizes (ES) were calculated following the procedures suggested by Rhea (2004). Two way mixed factor ANOVA 2 x 2 (time by group), with a within-between design, were used to compare means. When necessary, multiple comparisons with confidence interval adjustment by the Bonferroni procedure were used for post hoc analysis. Statistical significance was set at $P \leq 0.05$. The version 17.0 of SPSS (SPSS, Chicago, IL) was used in the statistical analysis.

Results

Values for means±SD, percent changes from initial values (Δ), 95% CIs and ES are shown in table 3. Significant differences between pre and post tests ($p<0.05$) were found for all variables analyzed. Comparison between groups did not show significant differences for any variable ($p>0.05$).

Discussion

The purpose of the present study was to test if the addition of SJ exercises by trained men would bring additional benefits in terms of upper body muscle size and strength in comparison to a RT program involving only MJ exercises. Given that response to RT may be diminished in trained persons (Ahtiainen et al. 2003a; Nader et al. 2014), many advanced trainees seek strategies to provide enhanced stimuli and adaptation to the trained muscles.

However, contrary to this hypothesis, the results of the present study suggest that the addition of SJ to a RT program involving MJ exercises does not result in additional benefits to trained men over an 8 week period. Both MJ and MJ+SJ were equally effective for increasing muscle size and strength after the mentioned period. Effect sizes were also similar in both groups with the exception of AMC, that revealed a marked difference between MJ and MJ+SJ. It does thus remain a possibility that significant differences might manifest in trained participants over a longer training duration with the inclusion of SJ exercises. It is however also important to note that the participants of the present study habitually performed SJ prior to participation and the exclusion of these exercises did not appear to significantly compromise their results.

These results are in agreement with a previous study performed in untrained men (Gentil et al. 2013). In the study by Gentil et al. (2013), the MJ group performed only the bench press and lat pull down exercises, while the MJ+SJ group performed bench press, lat pull down, triceps extension, and elbow flexion exercises. The results revealed that increases in elbow flexion isokinetic peak torque and muscle thickness were similar between groups. It is important to note that the protocol used in the study of Gentil et al. (2013) involved only one MJ and one SJ exercise, while the present study used four MJ and two SJ exercises. Although it is questioned by some authors (Carpinelli and Otto 1998), this increased training volume was used in order to approximate the protocol to that commonly used and gyms and fitness centers by most trained subjects. Further, despite this greater volume overall which is suggested as necessary for trained individuals (ACSM 2009), and the additional volume provided by the addition of SJ exercises to the MJ+SJ group, our results suggest that this had little impact upon adaptations. Indeed, a further study by Gentil et al. (2015) in which the volume of exercise for the elbow flexors (sets per muscle group) was equated between MJ and SJ groups also revealed no differences in strength and hypertrophy adaptations.

Rogers et al. (2000) investigated the effects of adding SJ exercises to a MJ exercise program in national-level baseball players. Their results showed no difference in upper arm circumference and 5RM load in the bench press and lat pull down exercises between groups performing MJ of MJ+SJ. However, in comparison to the present study and those of Gentil et al. (2013; 2015), the exercises tested by Rogers et al. (2000) were MJ (bench press and lat pulldown). This appears to suggest that the use of MJ exercises for the upper body appears to provide sufficient stimuli for adaptation in the upper arm musculature, and also that the inclusion of SJ exercises neither enhances this nor enhances strength in MJ exercises despite potentially addressing the smaller musculature involved.

The fact that SJ exercise did not bring additional benefits in muscle strength and size supports that the stimuli brought by MJ exercises are sufficient to induce appreciably similar adaptations in all muscles primarily involved in the movement. It has been suggested that upon reaching muscular failure in MJ exercises not all involved muscles have achieved maximal motor unit recruitment (Jones 2010). Thus SJ exercises are intended to ensure optimal stimulation of musculature not adequately stimulated during MJ. However, it appears that most muscles involved in MJ exercises are maximally active upon reaching failure. Brennecke et al. (2009) report that activation of the pectorals, anterior deltoids, and triceps are similar during upper body pushing MJ exercise. Muscular activation patterns during MJ exercises are likely dynamic in nature and even if a muscle was preferentially activated in the beginning of the exercise, the onset of fatigue may lead to decreased activation and/or increased activation of others muscles involved in the movement (Akima et al. 2002; Gentil 2014). Therefore, when concentric failure is reached, it is possible that all muscles involved in MJ exercise have been adequately stimulated.

Our results may seem contrary to what might be hypothesized based upon the findings of Soares et al. (2015) who reported that elbow flexor DOMS is greater, and muscle strength takes longer to recover, after biceps curls in comparison to seated row, suggesting that SJ may provoke a higher degree of muscle damage than MJ. Given that muscle damage may be associated with muscle hypertrophy (Schoenfeld 2012), this could suggest an advantage for SJ over MJ exercises for stimulating certain musculature.

However, it is important to note that Soares et al. (2015) used only seated rows, while the present and previous studies (Gentil et al. 2013; Gentil et al. 2015b) involved pull downs. Evidence suggests that seated rows promote a higher latissimus dorsi to biceps ratio of activation than pull downs (Lehman et al. 2004), which could lead to a lower elbow flexor damage related stimuli. Moreover, although muscle damage may be involved with muscle hypertrophy, a dose-response relationship is difficult to establish (Schoenfeld and Contreras 2013), so one cannot assume that increased muscle damage would reflect in increased muscle adaptations.

One 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 (Cureton et al. 1988; Argus et al. 2010; Yamanaka et al. 2012). Although one may argue that a more sensitive method would show different results, this is improbable because of the lack of difference in muscle strength between groups. Previous research showed that, after 4-12 weeks of training, increases in muscle strength during single joint movements are mainly due to muscle hypertrophy (Moritani and deVries 1979; Hakkinen and Hakkinen 1995; Ebersole et al. 2002; Stevens et al. 2006). As the subjects in the present study had habitually performed SJ exercises for more than two years, one can expect that increases in strength would reflect in an increased muscle hypertrophy and vice versa

In conclusion, the present results show that 8 weeks of linear periodized RT involving MJ or MJ+SJ exercises produce similar increases in muscle strength and size in trained participants. Therefore, considering that lack of time is the most common cited barrier for exercise adoption (Goméz-Lopez et al. 2010), the present results may provide elements for the design of time efficient strategies, as one may include MJ exercises only in RT programs and still obtain optimal gains in muscle size and strength.

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1 Table 1. RT periodization

Week	Microcycle	Sets	Reps	Rest	Method
1	Ordinary	3	10	1'	Maximum repetitions
2	Ordinary	3	10	1'	Maximum repetitions
3	Shock	3	12-15	1'	Forced repetitions
4	Restorative	3	10	1'	50% of the load used in the previous week
5	Ordinary	3	10	1'	Maximum repetitions
6	Ordinary	3	10	1'	Maximum repetitions
7	Shock	3	12-15	1'	Forced repetitions
8	Restorative	3	10	1'	50% of the load used in the previous week

Table 2. RT programs

Session A (Mondays and Thursdays)	**Session B (Tuesdays and Fridays)**
Incline bench press (barbell)	V bar lat pull down
Flat bench press (barbell)	Seated row (machine)
Decline bench press (barbell)	Supinated grip lat pull down
Weighted push ups	Seated row (pulley)
Shoulder press (barbell)	Upright row (barbell)
Pulley elbow extensions (pronated grip)*	Standing dumbell biceps curls*
Pulley elbow extensions (neutral grip)*	Seated dumbell unilateral biceps curls*

Legend: * exercises performed only by the MJ+SJ groups.

Table 3. Pre and post training values, expressed as mean+SD for the groups that performend only multi joint exercises (MJ) and multi plus single joint (MJ+SJ) exercises.

Group	Pre	Post	Δ(%)	95% CI	ES
Flexed arm circumference (cm)					
MJ+SJ	37.95±2.31	38.50±2.56*	1.45	38.56, 39.89	0.23
MJ	37.85±2.65	38.50±2.58*	1.72	36.51, 39.42	0.24
Arm muscular circumference (cm)					
MJ+SJ	32.20±2.48	33.22±2.67*	3.17	30.87, 34.56	0.41
MJ	31.57±3.13	31.99±2.86*	1.33	29.94, 33.63	0.13
Elbow flexors 1RM (Kg)					
MJ+SJ	59.20±5.37	63.00±4.99*	6.42	56.88, 65.32	0.70
MJ	60.20±7.73	63.20±7.27*	4.99	57.48, 65.92	0.38
Elbow extensors 1RM (Kg)					
MJ+SJ	47.00±7.24	51.60±7.72*	9.79	44.52, 54.08	0.63
MJ	43.40±6.72	48.00±7.32*	10.60	40.92, 50.48	0.68

Legend:* significantly different from pre values ($p < 0.05$)