Effects of Upper-Body Exercise Order with Short Rest Interval Length in Strength Training

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Abstract: The purpose of this study was to investigate the influence of different upper body exercise orders on the number of repetitions performed to failure with one minute rest interval between the sets. Sixteen strength trained men completed two experimental training sessions were consisted of three sets with 8 repetition maximum loads for exercises with one minute rest intervals between sets and exercises. For sequence A, the exercises were performed in the following order: lat pull-down with a wide grip (LPD-WG), lat pull-down with a close grip (LPD-CG), machine seated row (SR-M), barbell row lying on a bench (BR-B), dumbbell seated arm curl (SAC-DB), and machine seated arm curl (SAC-M). Conversely, for sequence B, the exercises were performed in the opposite order: SAC-M, SAC-DB, BR-B, SR-M, LPD-CG, LPD-WG. Significant differences between sequences were observed in all exercises for the number of repetitions completed, with exception of the SR-M, with small number of repetitions when the exercises were performed last in the session. The results demonstrate that target exercises, involving whether large or small muscle groups, should start the sequence of training, because it will result in a better performance in relation to the exercises performed at the end of the sequence.

Keywords: Strength training, performance, training volume, fatigue.

INTRODUCTION

Resistance training can increase maximal strength, hypertrophy, power, and localized muscular endurance. The prescriptive variables are numerous, and may include: exercise order, rest intervals between sets and exercises, frequency, velocity of movement, number of sets and repetitions, and load or intensity. All of these variables can be manipulated to meet specific training goals and address individual [1-4].

The traditional recommendation regarding exercise order has been to perform multiple-joint exercises prior to single joint exercises, because this allows for a greater volume of work (load x repetitions) compared to when single-joint exercises are performed first [1,2,5,6]. However, contrary to these recommendations, Simão *et al*. and Gentil *et al*. demonstrated that performing exercises for either large or small muscle groups at the end of an exercise sequence resulted in significantly fewer repetitions, concluding that the order of exercises should be prioritized based on individual weaknesses or muscle groups/movements in greatest need to improvement [7-9]. In a recent study, Bellezza *et al*. show that the small to large exercise order resulted in more repetitions, lower blood lactate, and more positive affect during the exercise session, concluding that small to large exercise order may have beneficial physiological and psychological outcomes and potentially influence exercise adherence [10].

Up to the present moment, studies investigating the influence of the exercise order on the number of repetitions performed for the same muscular group in men have not been found, and rest intervals of one minute were not used. The length of the rest interval between sets is an important factor when designing a strength training program and has a directly influence on the amount of repetitions performed in each exercise [2, 11-18] and sequence [19-21]. One minute interval is commonly used in fitness centers, and Simão *et al*. suggested that different rest interval lengths must be tested in

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studies to verify the influence of some sequences of exercises in training [7].

Therefore, this study aimed to investigate the effect of manipulation of the upper body exercise order on the number of repetitions performed by trained men with one minute rest interval between sets.

MATERIALS AND METHODOLOGY

Subjects

Sixteen recreationally trained men (25 ± 4.16 years; 175 ± 5 cm; 77.37 ± 4.96 kg; 9.86 ± 2.34 % body fat) volunteered for this study. Before initiation of the study, subjects had a previous resistance training experience (6.36 ± 2.47 years) with a mean frequency of four sessions per week with durations of approximately one hour, utilizing one to two minutes rest intervals between sets and exercises. In addition, no volunteer made use of ergogenic or stimulants substances during the experimental design. All subjects answered the Physical Activity Readiness Questionnaire, PAR-Q [22], and signed an informed consent form before participation in the study in accordance with the Declaration of Helsinki.

Experimental Design

Data were collected on five nonconsecutive days that were separated by 48-72 hours. The eight repetitions maximum loads (8RM) of all subjects for all exercises was determined on the first day. On days two and three, the 8RM was retested for all exercises. A counterbalanced cross-over design was used to determine the exercise sequence session performed on days four and five for each subject. The two sessions were comprised with the same exercises performed in the exactly opposite order. One sequence began with large-muscle group exercises and progressed toward small-muscle group exercises (SEQA). The exercise order for SEQA was lat pull-down with a wide grip (LPD-WG), lat pull-down with a close grip (LPD-CG), machine seated row (SR-M), barbell row lying on a bench (BR-B), dumbbell seated arm curl (SAC-DB) and machine seated arm curl (SAC-M). Other sequence began with small-muscle group exercises and progressed toward large-muscle group exercises (SEQB). The exercise order for SEQB was SAC-M, SAC-DB, BR-B, SR-M, LPD-CG, and LPD–WG. The performance of SEQA and SEQB were separated by 48-72 hours. The total number of repetitions performed was determined after each set of each exercise for both sequences. Sets and exercises in both sequences were separated by one minute rest intervals of passive recovery. Three sets to voluntary exhaustion using the predetermined 8RM loads were performed for all exercises in each sequence. The total number of repetitions completed was recorded after each set of each exercise. The highest load achieved in both days was considered as the 8RM.

Strength Assessment

The mass of all weight plates and bars was determined with a precision scale and was used to calculate the 8RM load of each exercise. The 8RM tests were assessed during three nonconsecutive days in the following order: LPD-WG, LPD-CG, SR-M, BR-B, SAC-DB, SAC-M. All machine exercises were performed on Life Fitness equipment (Franklin Park, IL). To minimize possible errors in the 8RM tests, the following strategies were adopted: (a) standard instructions were given on the general routine of data assessment and exercise technique, (b) exercise technique was monitored and corrected as needed, (c) verbal encouragement was given. During the 8RM testing, each subject performed a maximum of three 8RM attempts for each exercise, with five minutes rest between attempts. After the 8RM load for a specific exercise was determined, an interval not shorter than 10 minutes was allowed before the 8RM determination for the next exercise. Standard exercise techniques were followed for each exercise. No pause was allowed between the eccentric and concentric phase of a repetition or between repetitions. For a repetition to be successful, a complete range of motion as normally defined for the exercise had to be completed [23].

Exercise Sessions

Forty-eight to 72 hours after completing the third day of 8RM testing, subjects performed SEQA or SEQB in a counterbalanced crossover design. Warm-up before each exercise sequence consisted of two sets of 12 repetitions in the first exercise of the session at 40% of the 8RM load. A two minutes rest interval was allowed after the warm-up set before subjects performed the assigned exercise sequence. Subjects were verbally encouraged to perform all sets to voluntary exhaustion. No attempt was made to control the repetition velocity; however, subjects were required to utilize a smooth and controlled motion. The total number of repetitions for each set of each exercise was recorded and later compared between sequences. Both exercise sequences consisted of three sets of each exercise to failure using the predetermined 8RM of each subject for each exercise. Sets and exercises in both sequences were separated by one minute rest intervals in passive recovery. During the exercise sessions, subjects were verbally encouraged to perform all sets to concentric failure, and the same definitions of a complete range of motion used during the 8RM testing were used to define completion of a successful repetition. No attempt was made to control the velocity with which repetitions were performed. The total number of repetitions for each set of each exercise was recorded.

Statistical Analysis

The statistical analysis was initially done by the Shapiro-Wilk normality test and by the homoscedasticity test (Bartlett criterion). All variables presented normal distribution and homoscedasticity. The descriptive analyses were presented as the means and standard-deviations. ANOVA two-way was used to verify if there were differences in the number of repetitions between sets of each exercise in the same sequence and between the two sequences (SEQA and SEQB), and when the difference presented was significant, the Tukey's post hoc test was applied for multiple comparisons. The paired Student's t-test was also applied to compare the total work (total number of repetitions in all sets of all exercises) between the two exercise sequences. An alpha level of $p < 0.05$ was used to determine the significance of comparisons. The statistical analysis was conducted using the software SPSS 13.0 for Windows.

RESULTS

Significant differences between sequences were observed in all exercises for the number of repetitions completed, with exception of the SR-M (Fig. **1**). As shown in Fig. (**1**) small number of repetitions were observed when the exercises were performed last in the sequence. Comparison between sequences showed no significant differences for total work (mean of total number of repetitions in all sets of all of the exercises) in SEQA (80 ± 4.87 repetitions) and SEQB (75 ± 3.82 repetitions) (Fig. **2**).

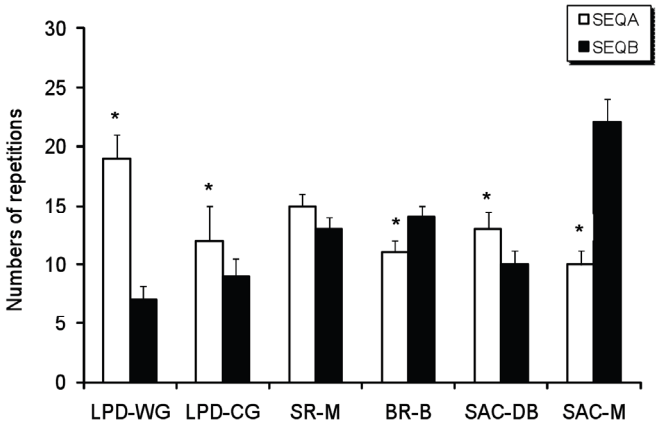

Fig. (1). Number of repetitions for each exercise sequence. *Significant difference between SEQA and SEQB. Legend: SEQA: sequence A; SEQB: sequence B. LPD-WG: lat pull-down with a wide grip; LPD-CG: lat pull-down with a close grip; SR-M: machine seated row; BR-B: barbell row lying on a bench; SAC-DB: dumbell seated arm curl; SAC-M: machine seated arm curl.

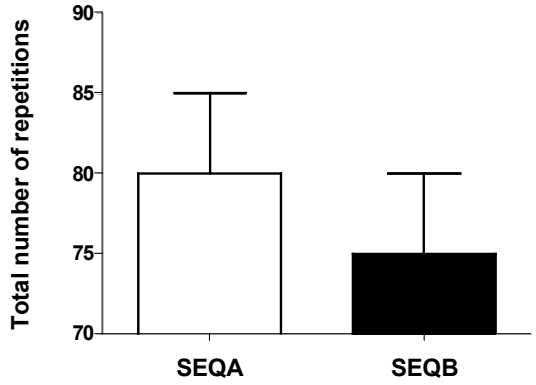

Fig. (2). Mean of total number of repetitions in all sets of all of the exercises. No significant differences for total work was noted ($p>0.05$). Legend: SEQA: sequence A; SEQB: sequence B.

DISCUSSION

The purpose of this study was to examine the effects of exercise order on the number of repetitions performed by trained men with one minute rest interval between sets. The key finding from the current study was that in a sequence of upper body strength training exercises the exercises for large muscle groups (i.e. latissimus dorsal) and for small muscle groups (i.e. biceps brachii), suffer reductions in the number of repetitions when were positioned at the end of the sequence.

Traditional exercise order dictates large muscle group or multijoint exercises should be performed before small muscle group or single joint exercises, because this exercise sequence may result in the greatest long-term strength gains [24-25]. However, methodological training studies manipulating exercise order and the investigation of its influence on strength gains are still lacking in the literature.

The sequences order used in the present study were the same adopted in previous study [26]. Similarly, it was showed that upper-body exercises involving similar muscle groups and neural recruitment patterns are negatively affected in terms of repetition performance when performed at the end *vs* the beginning of a session. In addition, others studies also demonstrated that performing either large or small group exercises at the end of an exercise sequence resulted in significantly fewer repetitions compared to when the same exercises were performed early [5-10]. Simão *et al*. investigated in twenty-three trained women the influence of different exercise orders on the number of repetitions [8]. Were performed three sets with 80% of 1RM to voluntary exhaustion, with two minutes between the sets. The sequences were composed of six exercises for upper and lower body alternately (leg-press, bench press, leg extension, seated machine shoulder press, leg curl and seated machine triceps extension), but one sequence started with the large groups and ended with the small groups and another sequence followed exactly the opposite order. There were significant differences in all exercises when the number of repetitions performed was compared between sequences. It was observed that exercises performed at the beginning of the training sequences completed higher numbers of repetitions. In the present study, all the exercises, except SAC-DB, showed a better performance following which it was performed first, including the SR-M, the only exercise that showed no significant differences between the sequences. Spreuwenberg *et al*. showed the effects of a whole body workout on squat performance [6]. Were performed three sets with 8-10RM for each exercise, and for squat exercise, four sets were performed with 85% of 1RM to concentric failure in both sequences. In one of the sequences, the squat was executed before the entire sequence and in another sequence he was run after the entire sequence. Significant differences were observed in number of repetitions completed at squat, with a better performance when it started the sequence, as well as in our findings for upper body exercises. As in our study, the exercise that started the sequence always had a best performance, while the exercise performed latter always had the worst performance in the sequences. Gentil *et al*. observed the influence of two methods of training, pre-exhaustion and priority system on pectoral muscle exercises (bench press and pec-deck) executed by thirteen trained men [9]. After 10RM load tests for each exercise, two training sessions were accomplishment to verify the methods influences, in wich one started with bench press, and the other started with pec-deck. In our study, even with short intervals and the involvement of the same groups in all exercises the performance of the exercises positioned at the end of the session presented a decrease.

It could be hypothesized that decrease on number of repetitions has been due to muscular fatigue which is certainly expected when weight training (*e.g*. when subjects performed SEQB, they likely failed to complete many repetitions in the lat pull down exercises due to fatigue in the

biceps and not due to fatigued lats or other larger muscle groups). In same way, a study conducted by Farinatti *et al*. showed the last exercise in a given sequence exhibited a higher VO_2 in the rest intervals between sets, which may reflect the accumulation of fatigue from previous exercises [27].

Using other technique of muscle fatigue analyze, Belleza *et al*. investigated the influence of two different orders of exercise in the blood lactate, number of repetitions and affective responses [10]. Twenty nine individuals (men and women's) performed two sets (80% to 10RM and 100% to 10RM) of each lift in sequences of nine exercises for the upper and lower body in exactly opposite orders. Their results suggest more benefits in the sequence the small to large exercise order with a greater number of repetitions and a lower concentration of blood lactate and may have a better influence exercise adherence. Instead, our results show that whether the exercise is for a large or small muscle group, if it is at the end of the training sequence it will suffer reductions in the number of repetitions. In addition, when starting with the small muscle groups the exercises for the large muscle groups suffer a ~75% reduction in repetitions performed, where as when starting with the large muscle groups the small muscle groups suffer a ~50% reduction in repetitions performed.

Unlike the expected and the results presented in the order of studies cited earlier, the SAC-DB presented a better performance when it was performed in the end of the sequence with mean of 12.64 ± 2.43. As this was executed at the beginning of the sequence, immediately after the SAC-M, had a worse performance, with mean of 10.28 ± 2.52. It seems that small groups and short recovery time are affected more effectively than larger groups. As the exercise (SAC-DB) was specific to the muscles of the biceps brachii and anterior exercise (SAC-M) also, a short time was not sufficient for the recovery of muscles, affecting their development in an effective. In larger groups, the amount of ancillary muscles is also higher, with the variation of movement; different group's assistants may act minimizing the fall of main performance of the muscle.

An interesting finding of our study was that only one exercise did not present significant difference between sequences (SR-M). This exercise was positioned as the third (SEQA) or fourth (SEQB) exercise, which is at the middle of the sequences, may be one of the possible reasons for the small difference between them. Similar data were found by Simão *et al*., who studied the effects of a sequence of five exercises (bench press, lat pull down, shoulder press, biceps curl and triceps extension) for upper body [7]. After verification of 10RM loads of these exercises, 18 individuals executed two different orders of the sequence of training. Were performed three sets of each exercise to the failure concentric, with two minutes between the sets and exercises. Agreeing with previous studies, the exercises that started the session, presented a higher number of repetitions, while those performed at the end of the sequences, and showed a decline in the number of repetitions. However, shoulder press exercise did not present difference between sequences. In this study, the shoulder press was positioned at the middle of both sequences investigated, getting a similar influence on volume of exercises. This confirms the importance the manipulation of the order of exercises in a training sequence, because the sequence position influences directly the number of repetitions performed.

In summary, our results permit to consider the following practical applications: the target exercises, involving whether large or small muscle groups, should start the sequence of training, because it will result in a better performance in relation to the exercises performed at the end of the sequence, principally if the exercises of the session are for the same muscle groups. Even with short intervals and the involvement of the same muscle groups in all exercises, the performance of the exercises positioned at the end of the sessions presented decreases. This negative effect on exercises performed in a training session needs to be considered when designing programs for both athletes and fitness enthusiasts. This is true for both large and small muscle group exercises. However when exercises for the same small group start the sequence, this may decrease performance.

In conclusion, the manipulation of the order of exercises directly influences the number of repetitions performed in each exercise and exercises for the same muscle group followed. The results demonstrate that target exercises, involving whether large or small muscle groups, should start the sequence of training, because it will result in a better performance in relation to the exercises performed at the end of the sequence. However, additional research would be needed for further evaluation of this variable.

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