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original article

Effect of the manipulation of exercise order in the tri-set training system

Efeito da manipulação da ordem dos exercícios de força utilizando o sistema tri-set

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Abstract – The aim of this study was to analyze the effect of the manipulation of two different exercise orders using the tri-set system on the motor performance in exercises for the chest. Ten male (25.6 ± 5.7 years, 77.0 ± 5.8 kg, 172.9 ± 5.0 cm, 25.7 ± 1.4 kg/m^2) with experience in resistance training underwent two experimental sessions, in which the subjects performed two sequences of exercises for the chest: SEQA (bench press, incline bench press, and peck deck) and SEQB (peck deck, incline bench press, and bench press). The load used allowed 8 to 12 repetitions (80% of 1RM) in each exercise. A higher number of repetitions (29 ± 2 reps vs. 26 ± 3 reps, $P < 0.001$) and a greater total overload (resistance used x repetitions performed = 1,942 ± 172 kg vs. 1,728 ± 234 kg, $P < 0.001$) were observed in SEQB. The results suggest that in the tri-set system the higher number of repetitions and a greater training volume occur when the single-joint exercise is included before multiple-joint exercises.

Key words: Evaluation; Motor performance; Muscular fatigue; Resistance training; Weight training.

Resumo – *O objetivo do presente estudo foi analisar o efeito da manipulação de duas diferentes ordens de exercícios com pesos, utilizando o sistema tri-set sobre o desempenho motor em exercícios para o peitoral. Dez homens (25,6 ± 5,7 anos; 77,0 ± 5,8 kg; 172,9 ± 5,0 cm; 25,7 ± 1,4 kg/m^2) com experiência em treinamento com pesos foram submetidos a duas sessões experimentais, nas quais os sujeitos realizaram duas sequências de exercícios para o peitoral: SEQA (supino horizontal, supino inclinado e voador) e SEQB (voador, supino Inclinado e supino horizontal). A carga utilizada permitiu a realização de 8 a 12 repetições (80% de 1-RM) em cada exercício. Verificou-se um maior número de repetições na SEQB (29 ± 2 reps vs. 26 ± 3 reps; P < 0,001) e maior sobrecarga total (carga utilizada x repetições executadas = 1.942 ± 172 kg vs. 1.728 ± 234 kg; P < 0,001). Os resultados sugerem que, no sistema de tri-set, o maior número de repetições e o maior volume de treinamento é alcançado quando o exercício monoarticular é inserido antes dos exercícios multiarticulares.*

Palavras-chave: *Avaliação; Desempenho motor; Exercício resistido; Fadiga muscular; Treinamento com pesos.*

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INTRODUCTION

Adaptive responses induced by resistance training (RT) on muscular strength are associated with the combination of neural factors and muscle hypertrophy. Neural factors make a great contribution during the initial phases of a RT program[1], whereas the hypertrophic process becomes determinant for the development of muscular strength lately[2]. However, these adaptations tend to occur to a lesser extent as training time progresses, which may induce a process of stabilization (plateau) if strategies of training progression are not applied[3].

In this sense, the adoption of different RT systems (pyramid, superset, drop set, pre-exhaustion, among others) has been a strategy widely used by individuals with experience in RT and athletes, in an attempt to produce a gradual increase in stress that could lead to important adaptive responses. Among the different RT systems reported in the literature, the so-called tri-set training system (three different exercises for the same muscle group should be performed in sequence, with a minimum recovery interval between them) is one of the most frequently used, especially by individuals engaged in advanced RT programs, since this system can produce a high degree of muscle fatigue and metabolic stress[4], which are stimuli very favorable to neuromuscular adaptations[5].

Although the tri-set system is widely known, so far there is no information available on the literature regarding the impact of exercise order selected to be included in this training system. Thus, the aim of the present study was to analyze the effect of the manipulation of two different exercise orders using the tri-set system on the motor performance in exercises for the chest.

METHODOLOGICAL PROCEDURES

Subjects

This study was part of a broader research project entitled "Influence of exercise order during resistance training on body composition", conducted during the school year of 2009. Subjects were recruited to participate in the project through poster advertisements and oral presentations at classrooms of the university where the investigation was carried out, as well as through a private database of emails from the involved researchers. Of the 35 subjects that concluded the project, a sample comprising 10 male (25.6 ± 5.7 years) were randomly selected for this study, according to the following inclusion criteria: having been performing a standardized RT program uninterruptedly for the 12 weeks prior to the beginning of the experiment, not being an athlete, and not being engaged in any sports activity for at least six months. After being instructed on the purpose of the study and on the procedures they would undergo, all participants signed a free and informed consent form. The research project was approved by the Ethics Committee of Universidade Estadual de Londrina (Process 8002/09), in

accordance with regulations of Resolution 196/96 of the National Health Council on research involving human subjects.

Experimental design

Participants underwent seven testing sessions, performed on non-consecutive days. The first two sessions were designed for participants to familiarize themselves with the one repetition maximum test (1RM). Anthropometric measurements were taken on the third visit, previously to the application of the 1RM tests, in which each exercise was performed separately (bench press, incline bench press, and peck deck, respectively), with a 48-h interval, on sessions three, four and five. Subsequently, the subjects participated in two experimental sessions (sessions six and seven) separated by an interval from 48 to 72 h, in which the three exercises were combined adopting the tri-set training system. Each session followed a certain sequence (SEQ) of exercises: the exercise order for SEQA was bench press, incline bench press and peck deck, while SEQB followed the opposite order. All subjects were tested for the two sequences, in a balanced (five to five) and randomized (SEQA and SEQB or SEQB and SEQA) design.

Anthropometry

The variables body mass, height and BMI were used to characterize the sample. Body mass was measured on a Urano digital scale model PS 180A, accurate to 0.1 kg, and height was determined by a wooden stadiometer accurate to 0.1 cm. Based on these measures, body mass index (BMI) was calculated as the ratio between body mass (in kilograms) and height squared (in meters). All participants were measured barefoot.

1RM tests

In order to determine exercise workloads, maximum strength was estimated by 1RM tests. Before the experimental protocol was carried out, all participants had two sessions to familiarize themselves with the procedure, in an attempt to attenuate the learning effect[6].

The exercise order of the 1RM tests was the following: bench press (BP), incline bench press (IBP), and peck deck (PD). A specific warm-up set (6 to 10 repetitions) with approximately 50% of the load to be used in the first attempt of the 1RM test was performed two minutes before each exercise. The subjects were instructed to try to accomplish two repetitions. In case two repetitions were accomplished at the first attempt, or even if no repetition was accomplished at all, a second attempt was performed after a 3-5 minute interval[7] with load above (first possibility) or below (second possibility) that employed in the previous attempt. Such procedure was repeated again in a third attempt in case the load corresponding to a single maximum repetition had not yet been established. Therefore, the load recorded as 1RM was that in which it was possible for the individual to accomplish only one repetition. The transition interval between the exercises was of three to five minutes. The technique and execution form

of each exercise was standardized and continuously monitored in the attempt of assuring the quality of information.

Experimental sessions

Previously to the experimental sessions, the subjects were instructed not to perform any other type of physical activity in the 24 h prior to the experimental sessions, as well as to avoid the consumption of foods or drinks with caffeine during this period. A specific warm-up was adopted only for the first exercise of the tri-set, in which the subjects performed between 6-10 repetitions with approximately 50% of maximum load. Two minutes after the warm-up, the exercise protocol was carried out according to the sequences SEQA (BP, IBP and PD) or SEQB (PD, IBP and BP).

Both sequences (SEQA and SEQB) used loads that allowed participants to perform between 8 and 12 repetitions (80% of 1RM). The subjects were instructed to perform as many repetitions as possible in each exercise until being functionally unable to overcome the resistance provided. In the two experimental protocols, verbal encouragement was provided during all exercises.

Total overload (TO) was determined by the sum of the number of repetitions performed multiplied by the load lifted in each exercise of the tri-set (BP + IBP + DP).

Statistical treatment

The Shapiro Wilk´s test was preliminarily used to analyze data distribution. After the normality of distribution was confirmed, the Student's t test for paired samples was used to compare SEQA and SEQB with regard to the variables maximum number of repetitions and TO. Results are shown as mean and standard deviation. Data were analyzed on the SPSS 17.0 statistical package, considering a significance level of $P < 0.05$.

RESULTS

The sample of young adult male investigated in this study (n = 10) had body mass = 77.0 ± 5.8 kg; height = 172.9 ± 5.0 cm; and BMI = 25.7 ± 1.4 kg/m^2. Figure 1 shows the number of repetitions performed in the two experimental sequences. A higher number of repetitions was observed in SEQB compared to SEQA (29 ± 2 reps vs. 26 ± 3 reps; $P < 0.001$).

Figure 2 presents the number of repetitions performed in each exercise separately. Significant statistical differences were found between the two sequences analyzed in exercises BP (SEQA = 16 ± 1 reps vs. SEQB = 5 ± 1 reps; $P < 0.001$), IBP (SEQA = 6 ± 2 reps vs. SEQB = 10 ± 1 reps; $P < 0.001$) and PD (SEQA = 5 ± 1 reps vs. SEQB = 15 ± 1 reps; $P < 0.001$).

Figure 3 shows TO in both experimental conditions. Significant statistical differences were observed in the comparison between sequences, with SEQB showing the highest values (SEQA = 1728.0 ± 233.5 kg vs. SEQB = 1941.9 ± 171.8 kg; $P < 0.001$).

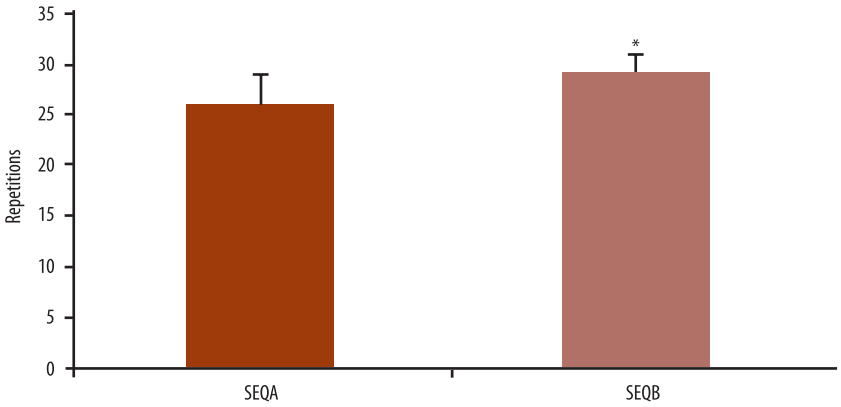

Figure 1. Number of repetitions in sequences A (SEQA) and B (SEQB) (n = 10). Values are expressed as mean and standard deviation. *$P < 0.001$ vs. SEQA. SEQA = bench press, incline bench press and peck deck, and SEQB = peck deck, incline bench press and bench press.

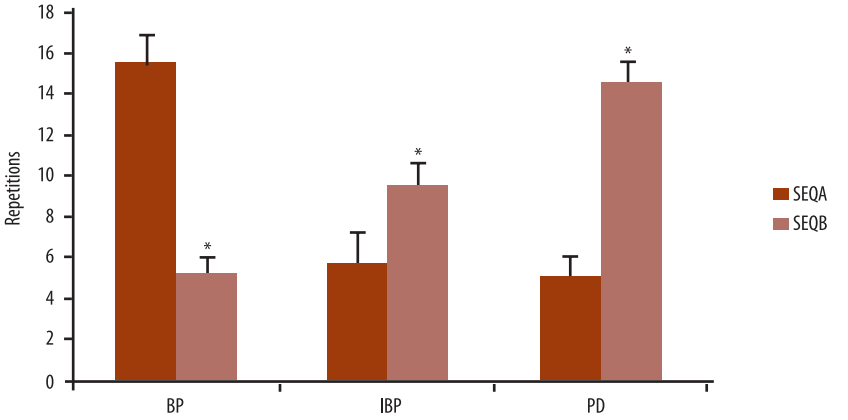

Figure 2. Number of repetitions in exercises bench press (BP), incline bench press (IBP) and peck deck (PD) in sequences A (SEQA) and B (SEQB) (n = 10). Values are expressed as mean and standard deviation. *P < 0.001 vs. SEQA. SEQA = BP, IBP and PD, and SEQB = PD, IBP and BP.

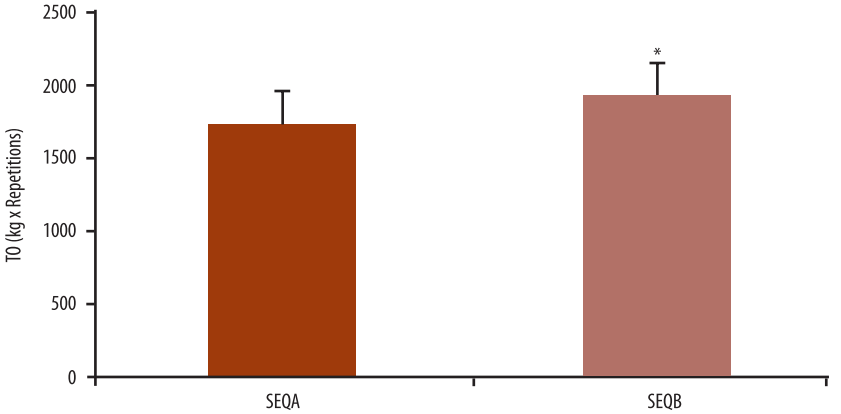

Figure 3. Total overload (TO) in both conditions (SEQA and SEQB) (n = 10). Values are expressed as mean and standard deviation. *P < 0.001 vs. SEQA. SEQA = bench press, incline bench press and peck deck, and SEQB = peck deck, incline bench press and bench press.

DISCUSSION

The results found in the present study indicate that starting the tri-set system with a single-joint exercise rather than with a multiple-joint exercise

may promote a better motor performance, according to the number of repetitions performed and to the TO obtained.

Although RT is one of the most currently practiced training modality, consistent information on the importance of exercise order in a RT program or even in a training system that combines two or more exercises performed in sequence and in sets with little or no interval between them, such as super-set, compound set, tri-set, pre-exhaustion or giant-set are relatively scarce in the literature[3]. As far as we know, this is the first study aiming to investigate the influence of exercise order on a tri-set system applied to the chest muscle group.

Previous studies that investigated the influence of exercise order on a training program rather than on a specific RT system, like our study did, indicated that there were no differences in the number of repetitions performed when the session begins with single or multiple-joint exercises[8,9]. However, in these investigations the exercises were performed with wide intervals (1-3 min) among them, a characteristic that differ very much from the tri-set system, which, due to the short recovery intervals between the exercises (only the time necessary to make the transition between the exercises), induces hyperemia, lead to increased metabolite accumulation, and thus causes high metabolic acidosis[10].

The analysis stratified by exercises revealed that exercises included at the end of the tri-set (BP and PD) showed a lower number of repetitions, which was already expected, since when the exercises are included at the end of the training session they tend to show a reduction in subject's performance compared to when they are performed at the beginning of the session[8,9,11-19]. It is hypothesized that this reduction observed in motor performance is associated with fatigue in type-II motor units during exercises[12], decreasing the capacity to generate strength.

An interesting aspect of the present study was the use of an odd number of exercises, which allowed for the analysis of the impact of single and multiple-joint exercises on the exercise included in the middle of the two sequences. Thus, our results indicated that this specific exercise seems to have its performance most negatively affected when included after a multiple-joint exercise. In this study, it should be taken into account that the localized muscle fatigue produced during BP performance may have compromised the performance of the following exercise (IBP), since both exercises require the activation of similar muscle groups. On the other hand, because PD does not request for a significant participation of the muscles involved in the movement of the elbow joint, this muscle group may have been spared in SEQB, favoring the performance in IBP.

The last American College of Sports Medicine position stand[3] on RT for healthy subjects suggested that RT sessions should begin with multiple-joint exercises. This recommendation is mostly based on a study conducted by Sforzo and Touey[11], which found a lower workload when the session started with single-joint exercises. More recently, Gil et al.[9] also observed that TO seems to be optimized when multiple-joint exercises are included

at the beginning of the session. Nevertheless, these findings should not be generalized, as shown in the study. We believe, based on information available in the literature and especially on the results found in this study, that the responses associated with exercise order in a RT program may be system-dependent.

Although adopting an important methodological control, the present study has some limitations. Only a single tri-set for the chest was analyzed, which makes it difficult to extrapolate the results to multiple sets or to other exercises or different muscle groups. However, our findings provide important information on the influence of exercise order in this training system. It is worth stressing that biochemical markers of fatigue were not collected, making thus impossible to understand the possible metabolic mechanisms involved in the responses found in the present investigation.

CONCLUSION

The results of this study suggest that the exercise order for the chest influence the number of repetitions performed in the tri-set system. Therefore, it is important to include a single-joint exercise at the beginning of the sequence to improve motor performance.

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