Acute effects of pre-activation method with single and multiple joint exercises on muscular activity and training volume during the bench press exercise | Effetti acuti del metodo della pre-attivazione con esercizi monoarticolari e multiarticolari sull'attività muscolare e sul volume di allenamento durante l'esercizio di

Effects of pre-activation method with single and multiple joint exercises on muscular activity and training volume during the bench press exercise

Running head: Different pre-activation methods on EMG and volume during the bench press exercise

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Abstract

The pre-activation method (PA) has been shown to enhance muscle activation due to its characteristics of low intensity and not being performed until muscle failure, however it is not clear whether exercise selection may interfere in results. This study aimed to test two different protocols of PA on muscle activation and the volume of repetitions during the bench press (BP). Eleven resistance-trained males underwent anthropometric measures and (24.45 ± 3.93 years; 80.27 ± 7.74 kg; 1.74 ± 0.05 m) completed 3 different experimental conditions in a randomized-crossover design: traditional method (BP at 70% of 1RM), PA single-joint (dumbbell fly at 30% 1RM + BP AT 70% 1RM), and PA multi-joint (BP at 30% 1RM + BP at 70% 1RM). PA was performed with a fixed number of 10 repetitions and BP was performed until muscle failure. The activity of the pectoralis major was measured via surface electromyography (EMG), and normalized units were used for inter-individual analysis. A one-way ANOVA was used to compare EMG data and training volume (number of repetitions) across the experimental conditions. EMG data showed similar muscle activation of the pectoralis major for all conditions (PA-SJ = 58.87 ± 12.74; PA-MJ = 56.18 ± 12.29; traditional method = 57.44 ± 13.14). The number of repetitions performed during BP was reduced after PA single-joint and PA multi-joint ($P = 0.036$). Regardless of exercise selection, PA did not promote greater muscle activation either an improved number of repetitions during the BP, therefore PA may not be an effective method for exercise performance in BP.

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1. INTROUDCTION

In resistance training (RT) different outcomes can be achieved by manipulation of program variables, such as volume (1), intensity (2), rest intervals (3), movement velocity (4), exercise selection and order (5). Another common strategy in RT consists of applying different systems of training for greater mechanical and metabolic stress which can contribute to hypertrophy and strength adaptations (6).

Particularly about exercise order, a very popular training system used by those seeking to enhance muscle hypertrophy is the pre-exhaustion (PE), which involves the performance of a single-joint exercise until or close to momentary muscle failure, followed immediately by a multi-joint exercise, for the same muscle group (e.g dumbbell fly prior bench press) (7). The hypothetical underlying reason is that in multi-joint exercises the maximal level of activation is not achieved by the main agonist muscle, due to the early fatigue at the synergists muscles (7).

Most of the research investigating the PE system has analyzed the neuromuscular activity, by electromyography (EMG), as the primary outcome (AUGUSTSSON et al., 2003; BRENNECKE et al., 2009; GENTIL et al., 2007; GOŁAŚ et al., 2017; SOARES et al., 2016). In addition, as a secondary outcome, studies have looked into the number of repetitions (AUGUSTSSON et al., 2003; BRENNECKE et al., 2009; GENTIL et al., 2007; GOŁAŚ et al., 2017; SOARES et al., 2016), as research has shown a dose-response for volume leading to muscle hypertrophy (15).

However, there is no evidence supporting that PE increased muscle activation on the primary muscle group, either that increased the volume/number of repetitions at the multi-joint exercise. In contrast, there is the pre-activation (PA) method, which can be defined as a prior exercise for the same muscle group performed at low intensity immediately followed by a multi-joint exercise (16) (e.g similar to a specific warm-up) (11,14). This method might be a useful strategy showing increased EMG activity at the main muscle groups involved (11,14). Specifically, PA differs from PE in the intensity

applied at the prior exercise, which varied between 30-60% of 1RM and was not performed until muscle failure (11,14). Thus, it is possible to suggest that the intensity of the exercise may be a key factor for the greater neuromuscular activation seen at the multi-joint exercise.

It can be speculated that, instead of the exercise selection (single-joint before multi-joint), exercise intensity (light load without muscle failure prior main exercise) enhances activation of target muscles as a function of the post-activation potentiation mechanism (7). Thus, the aim of the present study was to analyze the neuromuscular activity (pectoralis major), and the number of repetitions performed (volume) during the bench press (BP) exercise, at three different conditions: traditional method (only BP), PA-SJ (single-joint prior BP) and PA-MJ (multi-joint prior BP). We hypothesized the PE system would promote the greater muscular activity and volume on the main lift (BP).

MATERIALS AND METHODS

Experimental approach to the problem

This is an experimental study with a crossover-counterbalanced design. The measurements were taken in the laboratory. Session 1 included anthropometric assessments as well as familiarization with 1RM tests and exercise execution. Session 1 and 2 were used to establish 1RM in the BP and dumbbell fly exercises. Finally, session 3 consisted of participants performing 1 set of one of the 3 experimental conditions in a randomized order.

Subjects

Eleven healthy males who were experienced in RT for at least 2 years and had been training for the last 6 months participated in the experiment (24.45 ± 3,93 years; 80.27 ± 7.74 kg; 1.74 ± 0.05 m). Participants were excluded if they had practiced any type of exercise 48 hours before an experimental or testing session and/or had not completed any phase of the study. The study received the approval of the ethical board and was conducted following the recognized national and

international ethical standards (CAAE-0158.0.097.000-10/CEP-UPE: 159/10). Subjects were informed of the benefits and risks of the investigation before signing a written informed consent form.

Procedures

Session 1

During the first visit, body mass (kg) and height (m) were collected in all subjects participating in this study following recommendations from the *International Society for the Advancement of Kinanthropometry* (ISAK) (MARFELL-JONES et al., 2006).

Session 1 and 2

Sessions 1 and 2 were used to determine the 1 RM of all subjects. The first visit was designated to familiarize the participants with the test (17). The second session followed the protocol proposed by Brown e Weir, (2001), the 1RM test started with a specific warm-up, which included one set of eight repetitions at 50% of the maximal load (estimated by the subject). After a 3 minutes rest, they completed one set of five repetitions at 80% of the maximal load (estimated by the subject). Then, after the two first sets, the load was adjusted by the research staff aiming to find the 1 RM. Verbal encouragement was provided for each attempt. After the first attempt, the loads were adjusted with increments ranging from 2 to 10 kg. For correct execution, subjects were in a supine position with the feet parallel and placed on the ground. Subjects had three to five trials with a five-minute interval to establish the maximal load.

Session 3

The experimental protocol was completed during three visits to the laboratory, separated by a minimum of two and a maximum of seven days. In the third visit, participants completed one of the experimental in a randomized order, with each participant drawing a piece of paper from an opaque

envelope which contained the description of one of the 3 methods, the order of execution followed the same order the paper was withdrawal.

The three resistance training protocols consisted of 1) traditional: only BP at 70% of 1RM performed until momentary muscle failure; 2) PA-SJ: dumbbell fly at 30% of 1RM with a fixed number of 10 repetitions immediately followed by BP at 70% completed until momentary muscle failure; 3) PA-MJ: BP at 30% of 1RM with a fixed number of 10 repetitions immediately followed by BP at 70% of 1RM completed until momentary muscle failure.

For BP exercise the subjects were instructed that repetitions would be counted only if the barbell touched his trunk during the eccentric phase of the movement, as it is illustrated in Figure 1. Similarly, in the dumbbell fly exercise subjects received the instruction that for a repetition be counted his hands should be forming a parallel line with shoulders, as it is shown in Figure 2. A metronome was set with a cadence of 2:1 seconds for the eccentric and concentric phases of movement, respectively. Research staff assisting experimental sessions assure that only 10 repetitions were performed in the PA-SJ and PA-MJ, as well verbal encouragement was given during the execution of BP until momentary muscle failure. A 10 minutes rest was allowed between the experimental conditions.

***** Please insert Figure 1*****

***** Please insert Figure 2*****

EMG

For muscle activity of the pectoralis major a channel system program EMG800C-1632 (EMG System do Brasil Ltda® São José dos Campos, Brasil) was used for data collection and acquisition. EMG signal was registered using surface differential and simple electrodes with a gain of 20 times, consisting of two parallel rectangular pure silver bars (10 x 2 x 1mm, with a 10 mm interelectrode

distance) (EMG System do Brasil Ltda® (São José dos Campos – Brasil). The electrodes were placed parallel to the direction of the underlying muscle fibers according to the recommendations by SENIAM (19). The grounding electrode was placed in the tuberosity of the tibia. Before electrode placement skin was shaved at the electrode sites, gently abraded and cleaned with alcohol to reduce skin impedance.

Data were collected with a 4.000Hz frequency. Raw EMG was rectified by mirroring the negative and positive values. The signal curve was analyzed to eliminate high frequencies in the EMG recordings, ultimately raw EMG data were digitally filtered at a frequency bandwidth between 15 and 500Hz, and the root mean square (RMS) value was calculated. A maximum voluntary isometric contraction (MVIC) of the pectoralis major was performed for the normalization of EMG data. Three MVIC were collected during 6 seconds with a 2-minutes interval between them, following the recommendations (20). EMG RMS was adjusted by the maximum value obtained in one of the 3 MVIC from the pectoralis major (20).

Data analysis

All data were processed and analyzed using the software *Statistical Package for the Social Sciences* (SPSS), version 16 (SPSS Inc., Chicago, IL, Estados Unidos da América, Release 16.0.2, 2008). First, homogeneity and normality were checked with Shapiro-Wilk and Levene teste, respectively.

For muscle activity analysis the EMG was normalized and the RMS value was considered. Thus it was used a one-way ANOVA for repeated measures to compare EMG data and the number of repetitions performed during the BP. When F was significant, a Tukey *post-hoc* was applied to identify the differences with significance set at $p \leq 0.05$.

RESULTS

The data presented in Figure 3 shows that EMG activity at the pectoralis major did not differ at the bench press exercise in any of the experimental conditions (PA-SJ = 58.87 ± 12.74; PA-MJ = 56.18 ± 12.29; traditional method = 57.44 ± 13.14; $P = 0.87$).

Please insert Figure 3

Regarding the volume of training Figure 4 shows that the number of repetitions performed was significantly different from the traditional method (9 ± 1.78; $P = 0.036$) compared to PA-SJ and PA-MJ.

Please insert Figure 4

DISCUSSION

The present study compared neuromuscular activity and the number of repetitions performed at the bench press exercise in three conditions: traditional method, PA-SJ, and PA-MJ. Our main results indicate that: i) there is no difference in the pectoralis major EMG activity between conditions; ii) traditional method resulted in significantly more repetitions compared to the other two methods.

Regarding muscle activation, our data is in agreement with previous studies investigating exercise order, which reported that a performance of a previous exercise does not negatively affect activation of the primary muscle when compared to the traditional method (5). The current results are similar to studies that applied PE and verified that EMG analysis does not differ from the traditional method, even when muscle failure is reached by the execution of a previous movement (21–24). Indeed, only the study by Augstsson et al., (2003) reported a decrease in EMG activity of rectus femoris and vastus lateralis on the leg press after 10 RM of knee extensions.

In opposite to the majority of the research two studies have demonstrated increased muscle activation in the main exercise (bench press and leg press) after the execution of single-joint exercise (11,14). Despite the different exercises used by those studies both applied intensity of 60% of 1 RM (11,14). On the other hand, the studies showing no increments in EMG activity have applied intensities ranging from 70-95% of 1 RM (24) and most a 10 RM protocol for the single and multi-joint exercise (8,12,21,23).

Volume in RT has been recognized as one of the most important variables to be monitored. Our results are in agreement with previous studies which showed that exercises for the pectoralis major performed until or close to muscle failure reduced the number of repetitions in the bench press (20-40%) (8,23,24). For investigations using knee extensions before the leg press, biceps curl, or lat pull-down the results are the same, volume (number of repetitions) decreases after the execution of a single-joint exercise, regardless the intensity applied in the prior exercise (25,26).

As observed, this study reinforces the idea that exercise order matters for the manipulation of RT, for the reason that when an exercise is placed at the beginning of an RT session a better performance can be accomplished and muscle activation is not increased after a pre-activation regardless of exercise selection. Also, if performance is not improved after PA there is no reason to hypothesize that post-activation potentiation occurs after performing PA as it is supposed by the previous study (7).

CONCLUSION

The PA system regardless of exercise selection does not promote greater EMG activity or improves the volume of the multi-joint exercise. As our results show using the traditional method is not inferior to the PA system to promote activation of the pectoralis major and it is superior to induce greater volumes during RT sessions.

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Figure legends

Figure 1: Side view of the movement's initial phase (A) and final phase (B) of the bench press exercise.

Figure 2: Side view of the movement's initial phase (A) and final phase (B) of the dumbbell fly exercise.

Figure 3. EMG activity of pectoralis major during PA-SJ, PA-MJ and traditional method.

Figure 4. Number of repetitions performed for PA-SJ, PA-MJ, and traditional methods.