Lecture Notes in Bioengineering

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The Acute Effects of Exercises Order During Upper-Lower Body Alternated Supersets Among Trained Men

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Abstract. The aim of this study was to determine and compare the acute effects of exercise order during upper-lower body alternated supersets. This study was conducted by using quantitative time series experimental design. Twenty resistance-trained men performed different exercises order of upper body (bench press) and lower body (squat) exercises; (i) upper body to lower body (order A) and (ii) lower body to upper body (order B) in random arrangement for three sets with 120 s rest inter-set. All participants performed both exercises at 75% of their one repetition-maximum (1RM) value. Muscles activation and repetitions completed were recorded during both exercises order. Repeated measure analysis of variance (ANOVA) was used to analyse the different of all variables. Results showed order A produced higher upper body muscles activation (pectoralis major: $\rho < .05$, triceps brachii: $\rho < .05$) and number of repetitions completed ($\rho < .05$) in bench press for all three sets compared to order B. In contrast, order B showed higher lower body muscles activation (rectus femoris: $\rho < .05$, biceps femoris: $\rho < .05$) in squat compared to order A. Number of repetitions completed during squat were higher during order B compared to order A in the first set, $\rho < .05$. In conclusion, the results of this study suggested that the order of exercises performed in a resistance training session will determine the benefits gained. The findings of this study could be used as guideline for individuals involved in strength and conditioning to plan a better resistance training program for achieving their own specific goals.

Keywords: Exercises order · Bench press · Squat · Muscle activation · Repetition completed

1 Introduction

Resistance training has been proven to be effective in improving physical fitness especially muscular strength [1, 2]. In order to enhance the effectiveness of resistance training, manipulation of training variables is deemed to be important. Previous researches has shown the different responses and adaptations when manipulating training program variables [3, 4].

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One of the variables in resistance training is exercise order. Exercise order refers to the sequences of how the exercises been perform during training. Large muscle groups exercises had been recommended to be performed at the beginning of the training session followed by small muscle groups exercise because this exercise sequence will result in the ability to use the heaviest resistances possible when performing the exercises of the large-muscle group and may result in great long term strength gains [5, 6].

For a total body workout, bench press is among the recommended exercises to be performed for upper body while squat for the lower body. Finishing bench press for three sets followed by three sets of squats may take some times as there are other exercises to be performed too. Thus, implementing an alternated supersets might be a better way to reduce time of training. The question arise now, if the alternated supersets want to be implemented, which exercise need to be performed first? Is there any different of effects if the order of exercises is been manipulated?

Until now, as to the author's knowledge, lack of studies have been conducted on investigating the muscle and number of repetitions that can be completed during the alternated supersets, in which, the value of all variables are important as it will provide possible future adaptations such as hypertrophy and strength adaptations of the trained muscles. Thus, this study attempted to examine the acute effects of exercises order during upper-lower body alternated supersets among trained men.

2 Methodology

2.1 Participants

Twenty recreationally resistance-trained men were recruited for this study based on volunteerism. All participants must had at least six months experience involving in resistance training. All participants were from 20 to 25 years old. Besides that, all participants were in good health and do not have any injuries in the past 12 months. Participants were divided into two groups of exercises order by using counter-balance grouping technique, to avoid order effects. After finished their first session of exercises order, the crossover technique were done for second session to perform the different exercises order, Order A (n = 20) and Order B (n = 20). All participants were recruited after fulfilling the requirement in the inclusion and exclusion criteria. Then, both group were randomly selected through ticket draw to decide which type of exercises order they will perform first.

Physical Activity Readiness Questionnaire (PAR-Q) and inform consent form were given to the participant to understand the purpose, procedure, and the risk involving in the study. The importance of the study was explained to the participants before starting the data collection. Before the data collection, all participants underwent one familiarization session to make sure the technique of squat and bench press were correct.

2.2 Squat and Bench Press Procedure

As participants need to lift 80% load of their maximal ability, one repetition maximum test was conducted for both the squat and bench press. The 1RM test was conducted by

referring to the protocols provided by [7]. After obtaining the 1RM value, each participants' 80% value for both exercises were calculated so that each participant will lift the correct amount of load.

Squat was performed in a power rack to improve safety. Participants put the barbell on their mid portion of trapezius and at the back of deltoid. Participants were needed to grasped the barbell at their own preferred and comfortable point (Fig. 1). Participants were needed to flex their knee to lower the barbell until the bottom of the thighs were parallel to the floor (Fig. 2). Next, participants need to extend their knee to ascend back to the starting position (Fig. 1). This full movement was regarded as one repetition.

Bench press test was also conducted in a power rack. Participants lie down on the bench and position themselves so that their eyes is parallel with the barbell. Participants were needed to grasped the barbell at their own preferred and comfortable point (Fig. 3). Participants need to lower the barbell through elbow flexion until the barbell was approximately touched the chest (Fig. 4). Then, the barbell need to be raised back to the starting position (Fig. 3). This full movement was regarded as one full repetition.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

2.3 EMG Procedure

Electromyography (EMG) method was used to obtain the muscle activation data. EMG electrodes (Trigno, Delsys, USA) were placed at the dominant side triceps brachii and pectoralis major during bench press, while during squat, electrodes were placed at rectus femoris and biceps femoris. Muscle determination and electrode placement procedure were based on the surface EMG for non-invasive assessment of muscles (SENIAM) [8]. A qualified physiotherapist was presented to help in determining the right location of muscles that was involved in this research. The EMG setting was based on the previous study been conducted [9, 10]. EMG reading was obtained from the movement start until finish. EMG value was presented in mean of muscle activation from the MVC value.

2.4 Data Analysis

Descriptive statistics were used to analyze mean and standard deviation of participants' data. To compare the number of repetitions and EMG data, repeated measure analysis of variances (ANOVA) was conducted. α-level of $\rho < 0.05$ was set as the significant value. All statistical analysis was performed using Statistical Package for the Social Science (SPSS) version 23 for Windows software.

3 Results

Table 1 showed the physical characteristic profile of participants involved in this study.

Table 1. Physical characteristic profile of participants involved

Variables	(N)	Minimum	Maximum	Mean ± SD
Age (yrs)	20	20.00	25.00	21.30 ± 1.42
Body mass (kg)	20	47.00	74.00	61.50 ± 7.06
Height (m)	20	1.58	1.88	1.70 ± 6.10
BMI ($kg \cdot m^{-2}$)	20	18.07	24.80	21.37 ± 1.99
Bench press 1RM (kg)	20	75.00	90.00	84.25 ± 4.06
Squat 1RM (kg)	20	90.00	100.00	97.00 ± 3.40

3.1 Comparison of Muscles Activation Between the Exercises Order

Table 2 showed the EMG data of both exercises order during set 1. Analysis of the dominant upper and lower body showed that the significant differences were found in all the following muscles activity variables between the exercises order: (i) pectoralis major, $F(1,19) = 39.14$; $\rho < 0.000$, (ii) triceps brachii, $F(1,19) = 27.70$; $\rho < 0.000$, (iii) rectus femoris, $F(1,19) = 692.99$; $\rho < 0.000$, (iv) biceps femoris, $F(1,19) = 526.85$; $\rho < 0.000$.

Table 2. Comparison of muscles activation between the exercises order for set 1

Muscles	Order A	Order B	Sig (ρ)
Pectoralis Major Mean EMG (%)	58.72 ± 7.79	53.81 ± 8.86	0.000*
Triceps Brachii Mean EMG (%)	34.98 ± 5.38	30.99 ± 7.34	0.000*
Rectus Femoris Mean EMG (%)	47.46 ± 15.08	51.01 ± 14.91	0.000*
Biceps Femoris Mean EMG (%)	29.11 ± 7.49	32.57 ± 7.59	0.000*

*Result is significant when **ρ < 0.05**

Table 3 showed the EMG data of both exercises order during set 2. Analysis of the dominant upper and lower body showed that the significant differences were found in all following muscles activity variables between the exercises order: (i) pectoralis major, $F(1,19) = 42.12$; $\rho < 0.000$, (ii) triceps brachii, $F(1,19) = 40.46$; $\rho < 0.000$, (iii) rectus femoris, $F(1,19) = 292.92$; $\rho < 0.000$, (iv) biceps femoris, $F(1,19) = 132.04$; $\rho < 0.000$.

Table 3. Comparison of muscles activation between the exercises order for set 2

Muscles	Order A	Order B	Sig (ρ)
Pectoralis Major Mean EMG (%)	56.09 ± 7.87	51.40 ± 8.43	0.000*
Triceps Brachii Mean EMG (%)	32.61 ± 5.19	28.46 ± 6.61	0.000*
Rectus Femoris Mean EMG (%)	44.54 ± 14.62	48.13 ± 14.73	0.000*
Biceps Femoris Mean EMG (%)	26.36 ± 7.54	29.54 ± 7.62	0.000*

*Result is significant when **ρ < 0.05**

Table 4 showed the EMG data of both exercises order during set 3. Analysis of the dominant upper and lower body showed that the significant differences were found in all following muscles activity variables between the exercises order: (i) pectoralis major, $F(1,19) = 44.66$; $\rho < 0.000$, (ii) triceps brachii, $F(1,19) = 38.66$; $\rho < 0.000$, (iii) rectus femoris, $F(1,19) = 120.65$; $\rho < 0.001$, (iv) biceps femoris, $F(1,19) = 122.544$; $\rho < 0.000$.

Table 4. Comparison of muscles activation between the exercises order for set 3

Muscles	Order A	Order B	Sig (ρ)
Pectoralis Major Mean EMG (%)	52.48 ± 7.06	47.74 ± 8.06	0.000*
Triceps Brachii Mean EMG (%)	29.64 ± 4.84	25.57 ± 5.95	0.000*
Rectus Femoris Mean EMG (%)	42.15 ± 14.51	45.03 ± 14.49	0.001*
Biceps Femoris Mean EMG (%)	23.52 ± 7.84	26.54 ± 7.76	0.000*

*Result is significant when **ρ < 0.05**

3.2 Number of Repetitions Completed Between Exercises Order

Table 5 showed the comparison of the repetitions completed during bench press between the exercises order. The pairwise comparison analysis of the dominant upper

limb between order A and order B was showed the significant differences on the repetitions completed for bench press: (i) set 1, $F(1,19) = 103.26$; $\rho < 0.000$, (ii) set 2, $F(1,19) = 137.14$; $\rho < 0.000$ and (iii) set 3, $F(1,19) = 62.81$; $\rho < 0.000$.

Table 5. Comparison of repetitions completed between exercises order for bench press

Sets	Order A	Order B	Sig (ρ)
1	9.75 ± 1.92	7.25 ± 1.62	0.000*
2	9.00 ± 1.86	6.3 ± 1.34	0.000*
3	8.05 ± 2.01	5.3 ± 1.30	0.000*

*Result is significant when **ρ < 0.05**

Table 6 showed the comparison of the repetitions completed during squat exercises between the exercises order. The pairwise comparison analysis of the dominant lower limb between order A and order B were showed the significant differences on the repetitions completed for squat exercises during set 1, $F(1,19) = 13.57$; $\rho < 0.002$. However, there were no significant differences between the exercises order A and B during set 2 and set 3: (i) set 2, $F(1,19) = 4.13$; $\rho < 0.056$, and (ii) set 3, $F(1,19) = 4.13$; $\rho < 0.056$.

Table 6. Comparison of repetitions completed between exercises order for squat

Sets	Order A	Order B	Sig (ρ)
1	11.85 ± 1.66	12.35 ± 1.50	0.002*
2	11.20 ± 1.51	11.45 ± 1.39	0.056
3	10.30 ± 1.34	10.55 ± 1.47	0.056

*Result is significant when **ρ < 0.05**

4 Discussions

EMG is a method to detect the intentional or voluntary activation in the muscles. Voluntary activation is affected by both the motor unit frequency and the level of muscle recruitment and is almost related to the unfatigued muscle force production [11, 12].

In this study, the percentage of mean EMG data for pectoralis major, triceps brachii, rectus femoris, biceps femoris activities were determined and compared between exercises order and between sets. All of these conditions applied only to the dominant upper and lower limb. The comparison of muscles activation for all three sets showed the significant differences results between exercises order A and order B, $\rho < 0.001$ for all muscles. However, the pattern of the percentage for both part of muscles activation were different because the activation of pectoralis major and triceps brachii were higher during order A, but the activation of rectus femoris and biceps femoris were higher during order B. Even so, the percentage difference of lower body musles activation were not much as both the upper body muscles.

This outcome pattern may occur as each training sequence begins with different exercise. This will give an advantage for all participant to perform the best trial in every first type of exercise compared to the second type of exercise in both order. Based on both exercises order, the muscles activities during second exercise decreased in every sets.

Even though the analysis results showed significant differences for all muscles, the percentage difference of EMG results for lower body muscles were not as much as EMG results for upper body muscles. This showed that, exercise order starting with upper body had more effect to the muscles improvement during resistance training. The decrease in muscles activation on second exercises during opposite exercises order may occur due to neuromuscular fatigue of some muscles that compensated for increased some motor unit recruitment of other muscles in an attempt to maintain performance after doing the first exercise.

The number of repetitions completed was different between the two exercises during the training program. The results showed that, number of repetition for bench press exercise significantly decreased during exercise order B compared to exercises order A for all three sets. This pattern of a results between order A and order B in the total mean number of repetitions for bench press indicated that different multi-joint exercises were negatively impacted the performance. Performance refers to the ability to perform the allotted number of repetitions without stopping to rest [13].

The number of repetitions for squat exercise did not show significant different for set two and set three between both exercises order. Even though there were some improvement on the number of repetitions during squat exercise, but only small differences were found between both order A and B. The performance of participants were quite the same for squat exercise even it was done first or second in exercises order. This result was similar as other previous study that found no significant differences on number of repetitions for lower body exercise [14].

However, the analysis for number of repetitions completed on squat exercises in set one showed significant improvement during exercise order B compared to exercise order A. This was due to the squat exercise that was done first in order B and it gave some advantage for all participants that still not affected by other element such as fatigue before starting the exercises program and this allows them to do their best performance in producing more number of repetitions completed for squat exercise in the first sets of order B.

5 Conclusions

Based on the results, performing a an alternated upper-lower body superset starting with upper body exercise first was suggested to be more suitable to be adopted with greater number of repetitions completed along with more muscle activation, starting upper body exercise first would be more preferable to be associated with improvement in muscle development.

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