The effects of exercise order during resistance training on muscular strength

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Abstract. The objective of this study was to compare the muscular strength adaptation during resistance training performed through two methods of exercise order. Thirty recreationally active, resistance untrained men were recruited as research participants and were divided into three groups based on their specific tasks to be performed during six weeks training intervention; i) order A (multi-joint followed by single-joint exercises) ii) order B (single-joint followed by multi-joint exercises) and iii) control group. Bench press was performed as multi-joint while chest fly was performed as single-joint exercises. 1RM value for bench press and chest fly exercises were measured pre and post training intervention as an indicator for muscular strength adaptation. Repeated measure analysis of variances (ANOVA) was conducted to determine the effects of training intervention in each groups. The percentages of 1RM score changes during the post test was compared between all groups using one way ANOVA. Results showed that both order A and order B groups improved their 1RM value for both exercises. Bench press 1RM was found to be greater in order A group. Findings of this study suggested that performing a multi-joint exercise first promote greater gain for the multi-joint exercise while performing single-joint exercise first lead to no differences in single joint exercise strength gain.

Keywords: multi-joint, single-joint, strength adaptation, untrained men, chest exercise

1. Introduction

Resistance training is a kind of training that performed involving any kind of resistance as the loading. The resistance can be the performer own bodyweight, dumbbell, barbell and many more. Resistance training has been proven to induce many benefits such as increasing muscular strength, muscular endurance and power [1-4]. A lot of resources can be referred to design resistance training program. The process of designing resistance training program is important as it has been shown that the manipulation of variables will effect on the acute responses [5, 6] and chronic adaptation [7]. Several variables need to be carefully considered during the program design includes needs analysis, exercise selection, training frequency, exercise order, training set and repetition, volume and rest interval [8].

There are many ways of conducting resistance training session. A resistance training session can be a total body session, or split body part routine. A total body routine consisted of exercises that targeted each parts of body while split routine can be either splitting upper and lower body, or even splitting to more specific body parts such as chest, back, shoulder, legs etc.
During split body routine, usually the performer will tend to perform more than one exercises for each body part. The exercise could be multi-joint and single-joint. A multi-joint exercise is any exercise that involve more than one joint during a movement while a single-joint exercise is any exercise that only involved one joint. Taking chest (i.e. pectoralis major) training for example, a multi-joint exercise could be the bench press that involve shoulder and elbow joint while single-joint exercise could be chest fly that only involved the movement of shoulder joint.

One question exist, for a training session that consist a multi-joint and single-joint exercises, will there be any differences between performing multiple joint exercise first or single joint exercise first? Lack of study has been conducted on comparing the effects of exercise order on muscular strength adaptation. The objective of this study is to determine and compare the effects of performing single- to multiple-joint and multiple- to single-joint exercises on muscular strength adaptation among untrained men.

2. Methodology

2.1. Participants
Thirty untrained men were recruited as study participants. All of them were healthy, and had never been involved in systematic resistance training. However, all participants need to have basic knowledge and able to perform both bench press and chest fly exercises with correct technique. All participants were also free of any injury, and had filled in the Physical Activity Readiness Questionnaire (PAR-Q) and informed consent.

2.2. 1-RM test
One repetition maximum tests were performed pre and post training intervention as the indicator for muscular strength. The procedures followed a formerly depicted incremental protocol [9].

2.3. Bench Press
The participants positioned themselves supine on the bench and gripped the bar approximately 20-30 cm greater than shoulder width with arms extended. The elbows were positioned out and wrists straight. With the assistance of spotters, the bar was slowly lowered through flexion at the elbow joint until the bar touched the chest in line with the nipples. From this position the bar was raised until the arms were fully extended again and was considered as one full repetition.

2.4. Chest Fly
Participants lie with their head and shoulders supported by the bench and feet flat on the floor. The dumbbells were hold directly above chest, palms facing each other. Participants then lower the weights in an arc out to the sides as far as comfortable. When the dumbbell reach the level of their chest, participant reverse the movement back to the start. The elbows were slightly bent throughout the movement.

2.5. Procedures
Participants were first involved in familiarization session, which in this session they were required to demonstrate their ability to perform bench press and chest fly exercises. Major failure in performing correct technique that is thought to be risky in terms of injury will cause participants dropped from being a research participant. During the familiarization session, participants were encouraged to try to perform bench press and chest fly with some weights so that they will be familiar with the 1RM test that will be conducted during and after training intervention. 48 hours after familiarization session, participants were tested for their 1RM in both bench press and chest fly exercises. The test was conducted in randomized order, to prevent order effects on the score for each exercises. Participants were given one hour rest between both exercises tests. After 1RM testing session, participants were
divided into three groups; i) order A (multi-joint followed by single-joint exercises), ii) order B (single-joint followed by multi-joint exercises) and iii) control group. The groups were divided by considering the 1RM score of both exercises to prevent unbalanced of strength between all groups. Participants were asked to train for six weeks, twice a week in a well-equipped strength and conditioning laboratory. During the six weeks, participants in Group A and B need to lift 70% of their 1RM score in each exercises. The exercises that need to be done was the same as the exercises that were tested; bench press and chest fly. Group A performed bench press first followed by chest fly while Group B performed chest fly first followed by bench press. Each exercises were performed for three sets, with 2 minutes rest interest rest interval and 5 minutes rest between exercises. Control group just asked to perform their normal daily routine for the six weeks. The training intervention started in the range of 48-72 hours after pre-test while post-test was conducted 48=72 hours after the last training session.

2.6 Data Analysis
The data collected from this study were analyzed by using Statistical Package for the Social Science (SPSS) version 23 for Windows software. The descriptive analysis were used to report and measure demographic data such as the means and standard deviation of physical characteristics. Repeated measure analysis of variance (ANOVA) was used to analyse the muscular strength changes within groups. Next, for comparison of muscular strength adaptation between groups, separate One Way ANOVA was conducted on the percentage changes in each exercises 1RM during the post test (formula 1). The statistical significant α-level of this research were accepted at $p < 0.05$.

Formula 1:

$\% \text{ changes} = \frac{\text{Post-test} - \text{Pre-test}}{\text{Pre-test}} \times 100$

3. Results

3.1 Physical characteristics

| Table 1. Physical Characteristics of Research Participants |
|----------------------------------------------------------|
| Mean                | SD       |
| Age (years old)    | 20.19    | 0.92 |
| Mass (kg)          | 65.48    | 5.35 |
| Height (cm)        | 170.48   | 4.82 |

Table 1 showed the descriptive analysis of participants involved in this study.

3.2 1RM score

| Table 2. 1RM score of bench press and chest fly |
|-----------------------------------------------|
| Group | Exercises | Tests | Mean ± SD | p-value |
|-------|-----------|-------|-----------|---------|
| A     | Bench press | Pre  | 50.25 ± 3.62 | 0.000 |
|       |           | Post | 60.00 ± 4.08 |         |
|       | Chest fly  | Pre  | 20.90 ± 4.89 | 0.000 |
|       |           | Post | 26.50 ± 5.30 |         |
| B     | Bench press | Pre  | 50.75 ± 3.13 | 0.000 |
|       |           | Post | 57.25 ± 2.75 |         |
|       | Chest fly  | Pre  | 21.40 ± 4.45 | 0.000 |
|       |           | Post | 27.60 ± 4.65 |         |
| C     | Bench press | Pre  | 50.75 ± 2.90 | 0.169 |
|       |           | Post | 51.25 ± 2.95 |         |
Table 2 showed the mean and standard deviation of 1RM value for bench press and chest fly exercises pre and post-test in each groups. Repeated measure ANOVA was conducted to look into the differences between pre and post data in each groups. Pairwise comparison showed that the 1RM value for bench press and chest fly exercises were greater during post-test compared to pre-test in Group A and Group B. No significant differences found in Control group during the post-test when compared to the pre-test.

3.3 Percentage changes

| Exercises   | Groups | % changes (Mean ± SD) |
|-------------|--------|-----------------------|
| Bench press | A      | 19.47 ± 2.95          |
|             | B      | 12.92 ± 3.03          |
|             | C      | 1.00 ± 2.12           |
| Chest fly   | A      | 27.80 ± 6.07          |
|             | B      | 29.97 ± 6.62          |
|             | C      | 0.29 ± 4.39           |

Table 3 showed the mean and standard deviation of percentage changes of 1RM value during post-test when compared to the pre-test. Results showed Group A got significantly greater percentage changes of bench press compared to both Group B and Control. Group B on the other hand got greater percentage changes than the Control group.

For chest fly exercise, it was found that both Group A and Group B managed to obtain greater percentage changes compared to Control Group. However, no significant differences were found between both Group A and Group B.

4. Discussions

This study was conducted to compare the effects exercise order (multi-joint first or single-joint first) during resistance training on muscular strength adaptation. Bench press was chosen as the multi-joint exercise while chest fly was chosen as the exercise for single-joint. Performing multi-joint first followed by single-joint has been described as Order A while performing single-joint first then followed by multi-joint was named as Order B. Bench press and chest fly 1RM tests were performed prior and after six weeks training intervention. Results showed that both exercise order (Order A and Order B) improve muscular strength in both bench press and chest fly. Control group did not managed to have improvement in both exercises.

Looking specifically at the bench press performance, it was found that order A which started with multiple joint exercise training first managed to give more improvement in bench press 1RM compared to order B. This showed that for individuals that want to optimize the strength gains for a particular multi-joint exercise, multi-joint exercise should be perform first during the training session. Generally understood, multi-joint movements require more skill and energy to perform. Thus, performing multi-joint exercise first during training session might enhance the muscular adaptation to the exercise. Performing multi-joint exercise after single-joint might be more taxing as single-joint exercise in this study (chest fly) is an isolation exercise that targets only one joint that is the shoulder. Thus, the pectoralis major need to work more during the chest fly exercise and might have been fatigued before proceed to the chest fly exercise.
Looking at the chest fly, the finding was not similar to the bench press exercise. It was found that performing single-joint exercise first during training session (order B) did not have any advantages for the group to have more improvement in the single-joint exercise. Thus, it can be said that single-joint exercise could be performed as the later after multi-joint exercise. In contrast to multi-joint exercise, single-joint exercise basically require less skill to perform and hence do not give much taxing on the body. Thus performing single joint-exercise after multi-joint might not reduce the performance and adaptation during the training session. The findings of this study were in line with several previous recommendations/findings of previous study that showed the more effective training if multi-joint exercise being performed first

5. Conclusion
Taking into consideration of both multi and single joint exercise muscular strength adaptation, performing multi-joint exercise first during training session seem to be more beneficial as participants able to have more improvement in the muscular strength adaptation in the multi-joint exercise without being similar effective in single-joint exercise. Future studies should look into what really happed during the training session (acute study) of different exercise orders.

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