Electromyographic and Performance Analysis during Three Sets of Resistance Exercises among Untrained Women


Abstract: The number of sets need to be performed in a resistance training session has been debated for decades. As more recent studies showed the superiority of performing multiple sets in resistance training, the aim of this study was to determine and compare the muscle activation and performance during three sets of resistance exercises among untrained women. Thirty-two recreationally active, untrained women were recruited as participants. Muscle activation was obtained from the pectoralis major during bench press and vastus lateralis during squat using electromyography method. Performance was measured by the number of repetitions performed in the three sets during both exercises. Results showed that the number of repetitions decreased significantly as early in the second set and continued to reduce in the third set. No significant changes were found for muscular activation. As the conclusion, among untrained women, it seems that performance in resistance training tend to decrease as early as during the second set. It is recommended for untrained women to perform more than a single set for each exercise in a resistance training to enhance their muscular strength and endurance.

Index Terms: Multiple set, Muscle activation, Number of repetitions, Acute responses, Training volumes

I. INTRODUCTION

For any individuals involved in resistance training, it is important to design a proper training program. Multiple sources are now available to be referred such as original research articles, review articles, books and any strength and conditioning blog/website. One of the resistance training variables that need to be well planned is volume. Volume is the amount of work performed. Volume in resistance training is affected by the number of sets, number of repetitions and the amount of loads lifted. Among these, the number of sets has been debated for decades. Several studies showed the superiority of multiple sets [1, 2] while some other studies showed the similar effectiveness of performing single set and multiple sets [3-6]. More recent studies showed the superiority of performing multiple sets [7, 8]. Despite of this, looking at the studies been conducted previously, it seems that less studies been conducted among untrained women.

Besides that, based on the authors’ knowledge, less study had been conducted on comparing the muscle activation and performance changes during a number of sets during major upper and lower body exercises. The knowledge on this is indeed important as we will be able to look whether there are any changes of performance and muscle activation when performing multiple sets in resistance training.

As not much studies had been conducted among untrained women, it is the aim of this study to determine and compare the muscle activation and performance changes of major upper and lower body exercises among untrained women.

II. METHODOLOGY

A. Participants

Thirty-two recreationally active, resistance-untrained women were recruited as participants. Participants were unfamiliar with systematic resistance training, but do have knowledge on how to perform a proper bench press and squat exercises. All participants were screened using Physical Activity Readiness Questionnaire (PAR-Q) and had filled in the informed consent. All participants were free from any injuries.

B. Procedures

1 Repetition Maximum

One repetition maximum tests were performed in the week prior to the main data collection. After ten minutes of warm up session, all participants were evaluated of their one repetition maximum (1RM) test in bench press and squat as indicated by a formerly depicted incremental protocol [9]. As a safety precautions, both squat and bench press exercises tests were conducted in a power rack.

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 elbows were fully extended again. This complete movement was considered as one full repetition.

Squat

The participants positioned themselves under the bar with the bar aligned across the middle portion of the trapezius and posterior to the deltoid. The hands grasped the bar at a comfortable point. Upon setting the feet the subject lifted the bar from the rack and began...
Electromyographic and Performance Analysis during Three Sets of Resistance Exercises among Untrained Women

III. RESULTS

Physical characteristics of participants involved in this study were shown in Table 1.

Table 1. Physical characteristics of participants

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>21.43±4 1.03</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>50.34 ± 3.51</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>157.83 ± 5.83</td>
</tr>
</tbody>
</table>

Table 2 showed the number of repetitions completed in Set 1, Set 2 and Set 3 during both bench press and squat exercises. Referring to the pairwise comparison in the repeated measure ANOVA, it was showed that number of repetitions during bench press was higher in Set 1 compared to Set 2 \( (p = 0.000) \) and Set 3 \( (p = 0.000) \). Set 2 showed greater number of repetition than Set 3 \( (p = 0.000) \). For squat, the number of repetitions was higher in Set 1 compared to Set 2 \( (p = 0.000) \) and Set 3 \( (p = 0.000) \). Number of repetitions in Set 2 was higher than Set 3 \( (p = 0.000) \).

Table 2. Number of repetitions completed

<table>
<thead>
<tr>
<th></th>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench press</td>
<td>8.67 ± 0.76</td>
<td>8.00 ± 0.74</td>
<td>7.27 ± 0.58</td>
</tr>
<tr>
<td>Squat</td>
<td>9.67 ± 0.80</td>
<td>9.43 ± 0.73</td>
<td>9.03 ± 0.77</td>
</tr>
</tbody>
</table>

Table 3 showed the muscle activation of pectoralis major during bench press and vastus lateralis during squat in Set 1, Set 2 and Set 3. Results showed that the EMG during bench press and squat were not significantly different between sets \( (p > 0.05) \).

Table 3. Muscle activation

<table>
<thead>
<tr>
<th></th>
<th>Set 1</th>
<th>Set 2</th>
<th>Set 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectoralis major ( (% \text{ of MVIC}) )</td>
<td>65.85 ± 3.94</td>
<td>64.48 ± 4.76</td>
<td>62.88 ± 5.23</td>
</tr>
<tr>
<td>Vastus lateralis ( (% \text{ of MVIC}) )</td>
<td>69.50 ± 2.46</td>
<td>68.05 ± 3.55</td>
<td>66.98 ± 4.52</td>
</tr>
</tbody>
</table>

Table 4 showed the percentage changes of muscle activation and number of repetitions in Set 2 and Set 3. Results on number of repetitions showed that the percentages of reduction in Set 2 and Set 3 was higher in bench press compared to squat, \( p = 0.000 \) and \( p = 0.001 \) respectively. In contrast, the reduction percentages of muscle activation in Set 2 and Set 3 were not different between both bench press and squat, \( p = 0.971 \) and \( p = 0.09 \) respectively. Pearson correlation showed no significant relationship between the percentages changes of EMG and percentage changes of number of repetitions performed.

Table 4. Percentage changes during Set 2 and Set 3

<table>
<thead>
<tr>
<th>Variables</th>
<th>Percentage changes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pectoralis major Set 2</td>
<td>-1.99 ± 3.42</td>
</tr>
<tr>
<td>Pectoralis major Set 3</td>
<td>-1.92 ± 2.45</td>
</tr>
<tr>
<td>Vastus lateralis Set 2</td>
<td>-1.78 ± 1.97</td>
</tr>
<tr>
<td>Vastus lateralis Set 3</td>
<td>-1.54 ± 2.01</td>
</tr>
<tr>
<td>Bench press number repetitions Set 2</td>
<td>-7.59 ± 5.52</td>
</tr>
<tr>
<td>Bench press number repetitions Set 3</td>
<td>-8.92 ± 5.53</td>
</tr>
<tr>
<td>Squat number repetitions Set 2</td>
<td>-2.28 ± 4.22</td>
</tr>
<tr>
<td>Squat number repetitions Set 3</td>
<td>-4.15 ± 5.18</td>
</tr>
</tbody>
</table>

IV. DISCUSSIONS

This study was conducted to determine and compare the muscle activation and performance during three sets of resistance exercises among untrained women. Electromyography method was used to obtain muscle activation of pectoralis major during bench press and vastus lateralis during squat. Number of repetitions performed during the three sets of exercises was obtained as indicator for performance.

The loading that was chosen to be lifted for both exercises in this study was 70% of participants’ 1RM. It has been suggested [13] that high-load resistance training (i.e., ≥60% 1RM) to maximize muscle
strength and hypertrophy is based on Henneman’s size principle [14], which states that the recruitment of high-threshold motor units is dependent on the intensity of the stimulus [14]. Thus, motor unit recruitment is suggested to be great enough during resistance exercise at 70% 1RM.

Looking at the performance, results showed that the number of repetitions performed decreased significantly during the second set compared to the first set. The third set also showed significantly lesser number of repetitions compared to the second set. Results next analysed the percentage changes of number of repetitions in Set 2 (compared to Set 1) and in Set 3 (compared to Set 2). Results showed that the percentages of reduction in Set 2 and Set 3 was higher in bench press compared to squat. The smaller pectoralis major muscle compared to the quadriceps might be the possible reason for the greater decrease of bench press performance compared to squat.

Unlike the number of repetitions, for muscle activation variable, it was found that both pectoralis major EMG and vastus lateralis EMG were not significantly changed during all sets. This findings was in line with what was found previously [15]. Results also showed the percentages of EMG reduction in Set 2 and Set 3 were not different between both bench press and squat. Thus, despite decrement of performance, muscle activation was found not to be significantly changed across the three sets. However, despite no changes were found, it should be noted that the number of repetitions performed during the earlier sets for both exercises were greater. Future studies are suggested to look deeper on these findings.

No correlation were found between percentage reduction in EMG and number of repetitions. Thus, it can be said that decrement of EMG value was not the reason of decrement of performance in this study.

V. CONCLUSIONS

As the conclusion, among untrained women, it seems that performance in resistance training tend to decrease as early as during the second set. It is recommended for untrained women to perform more than a single set for each exercises in a resistance training.

ACKNOWLEDGEMENT

The authors would like to extend their gratitude to the Research Management and Innovation Centre (RMIC), Sultan Idris Education University (UPSI) for the University Research Grants (code: 2018-0159-106-01) that helped fund the research.

REFERENCES