Original paper

Influence of exercise order on maximum strength in untrained young men

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Abstract

It is generally recommended that exercises involving large muscle groups be placed at the beginning of a training session. However, methodological training studies manipulating exercise order and the investigation of its influence on strength have not been conducted. Therefore, the purpose of this study was to examine the influence of exercise order on strength in untrained young men after 8 weeks of training. Prior to the training program, participants were randomly assigned to three groups. One group began with large and progressed toward small muscle group exercises (G1) while another performed the opposite order (G2). The third group did not exercise and served as a control (CG). Training frequency was three sessions per week with at least 48 h of rest between sessions for a total of 24 sessions in the 8-week period. One repetition maximum (1RM) was assessed for all exercises at baseline and after 8 weeks of training. Both G1 and G2 resulted in significant increases of 16.3–77.8% in 1RM compared to baseline (\(p<0.05\)). However, only the small muscle group exercises revealed significant differences between groups (\(p<0.05\)). The results demonstrated exercise order of small muscle group exercises might be particularly important during the initial stages of strength training in untrained young men.

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Keywords: Muscle strength; Weight lifting; Exercise test; Physical fitness; Physical education and training

1. Introduction

It is generally recommended that exercises involving large muscle groups be placed at the beginning of a training session because this exercise sequence would result in the ability to resist higher loads.\textsuperscript{1–3} The rationale for performing large muscle group exercises in the beginning of a training session is that total work (repetitions \(\times\) resistance) is greater when compared to performing small muscle group exercises or single-joint exercises first, and may result in greater long-term strength gains.\textsuperscript{2,3} However, Kraemer and Ratamess\textsuperscript{4} suggested the general recommendation for exercise order of performing large muscle group exercises first can be changed depending on the goals of the training program.

Sforzo and Touey\textsuperscript{3} suggested if the goal is to maximise the strength gains for a particular muscle group, then the exercises for that muscle group should be completed first. Similarly, Simão et al.\textsuperscript{5,6} observed that performing either large or small muscle group exercises at the end of an exercise sequence resulted in significantly fewer repetitions compared to when the same exercises were performed early in an exercise sequence. In contrast, Spreuwenberg et al.\textsuperscript{7} showed exercise order can facilitate the power developed during an exercise placed at the end of a training session despite reductions in total work and number of repetitions performed in a set. Finally, Gentil et al.\textsuperscript{8} recommended if the strength and conditioning professional wants to maximise the
athlete’s performance in one specific resistance exercise, this exercise should be placed at the beginning of the training session. To our knowledge, methodological training studies manipulating exercise order and the investigation of the influence on strength have not been conducted. Therefore, the purpose of the present study was to examine the influence of exercise order of a training session on strength during 8 weeks of training in untrained young men.

2. Methods

Forty-eight young men from the Brazilian Navy Academy were randomly assigned to three groups. One group (18.7 \(\pm\) 1.5 years, 68.5 \(\pm\) 4.0 kg, 167.1 \(\pm\) 2.0 cm, 24.4 \(\pm\) 1.5 kg m\(^{-2}\)) trained with large muscle group exercises progressing toward small muscle group exercises (G1) \((n = 16)\). The second group (19.4 \(\pm\) 1.4 years, 72.7 \(\pm\) 4.4 kg, 170.2 \(\pm\) 4.5 cm, 25.2 \(\pm\) 1.9 kg m\(^{-2}\)) trained using the exact opposite exercise order beginning with small muscle group exercises progressing toward large muscle group exercises (G2) \((n = 17)\). The third group (18.8 \(\pm\) 1.6 years, 73.9 \(\pm\) 4.4 kg, 171.3 \(\pm\) 3.0 cm, 25.2 \(\pm\) 1.9 kg m\(^{-2}\)) served as a control group (CG) \((n = 15)\) and continued performing the regular military physical activity component during the 8-week period, but not the resistance training program. There were no significant differences between groups in anthropometric parameters or one repetition maximum (1RM) prior to training. In addition, the military diet was the same for all participants throughout the course of the study. Inclusion criteria were the following characteristics for all participants: (a) were physically active, but had not taken part in resistance training for at least 6 months prior to the start of the study; (b) not performing any type of regular physical activity for the duration of the study other than the prescribed resistance training and the regular military physical activity; (c) did not have any functional limitations for the resistance training program or the 1RM tests; (d) not presenting any medical condition that could influence the training program; and (e) did not use any nutritional supplements. All participants read and signed an informed consent document after being informed of the testing and training procedures to be performed during the study. The experimental procedures were approved by the Ethics Committee of the Castelo Branco University.

The 1RM tests were performed on two nonconsecutive days for all exercises as described previously.\(^5,6\) Two weeks of familiarisation took place prior to the 1RM tests (four sessions). The 1RM tests were performed following the anthropometric measurements on the first day. After 48 h, the 1RM tests were repeated to determine test–retest reliability. The heaviest load achieved on either of the test days was considered the pre-training 1RM. No exercise was allowed in the 48 h between 1RM tests, so as not to interfere with the reliability results. The 1RM was determined in fewer than five attempts with a rest interval of 5 min between 1RM attempts and 10 min were allowed before the start of the test for the next exercise. Following the 8 weeks of training, the 1RM test was performed similarly to the pre-training test in order to compare the strength changes in those exercises. Again, the highest load achieved in both days was considered as the 1RM.

The exercise order for G1 was barbell bench press (BP), machine lat pulldown (LPD), seated machine shoulder press (SP), free weight standing biceps curl with a straight bar (BC), and machine triceps extension (TE). The exercise order for G2 was TE, BC, SP, LPD, and BP. All exercises for both groups were performed for three sets. In addition, an experienced strength and conditioning professional supervised all training sessions. Frequency of the training program was three sessions per week with at least 48 h of rest between sessions and 2 min between sets and exercises. Twenty-four sessions were performed during the 8 weeks training period. The resistance for a given exercise was increased whenever an individual could perform more than the prescribed number of repetitions (8–12RM) of a particular exercise. Prior to each training session, the participants performed a specific warm up, consisting of 20 repetitions with approximately 50% of the resistance used in the first exercise of the training session. During the exercise sessions, participants were verbally encouraged to perform all sets to concentric failure and the same definitions of a complete range of motion used during the 1RM testing were used to define completion of a successful repetition. There was no attempt to control the velocity of the repetitions performed. Adherence to the program was 100% for all groups.

The total work performed by G1 and G2 were calculated by multiplying the number of sessions by the number of sets and resistance load (session \(\times\) sets \(\times\) load). Intra-class correlation coefficients (ICC) were used to determine 1RM test–retest reliability. The ICC method was used based on a repeat measurement of maximal strength. Coefficient of variation (CV) was used to calculate within-subject variation (CV\% = [standard deviation/mean] \(\times\) 100).\(^9\) The statistical analysis was initially done by the Shapiro–Wilks normality test and by the homocedasticity test (Bartlett criterion). All variables presented normal distribution and homocedasticity. Following two-way (time) by three-way (groups) ANOVAs (time [baseline vs. 8-week training] \(\times\) group [G1 vs. G2 vs. CG]) were used to analyse for differences among the groups in the 1RM and kilogram of body mass (1RM load/body mass). When appropriate, follow-up analyses were performed using Fisher post hoc tests. T-tests were used to analyse for differences between 1RM test and retest, pre- and post-training, and between the total work in both training programs. An alpha level of \(p \leq 0.05\) was considered statistically significant for all comparisons. Statistica version 7.0 (Statsoft, Inc., Tulsa, OK) statistical software was used for all statistical analyses.
Table 1
Intra-class correlation coefficients (ICC) and range values in kg for each exercise, between 1RM tests and retests at baseline and after 8 weeks.

<table>
<thead>
<tr>
<th>Group</th>
<th>Bench press</th>
<th>Lat pulldown</th>
<th>Shoulder press</th>
<th>Biceps curl</th>
<th>Triceps extension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>8 week</td>
<td>Baseline</td>
<td>8 week</td>
<td>Baseline</td>
</tr>
<tr>
<td>G1 (n = 16)</td>
<td>59.7–61.9</td>
<td>83.1–83.3</td>
<td>48.8–50.0</td>
<td>33.8–34.6</td>
<td>50.7–51.8</td>
</tr>
<tr>
<td></td>
<td>r = 0.99,</td>
<td>r = 0.99,</td>
<td>r = 0.94,</td>
<td>r = 0.98,</td>
<td>r = 0.99,</td>
</tr>
<tr>
<td>G2 (n = 17)</td>
<td>61.7–62.0</td>
<td>73.2–73.7</td>
<td>54.3–55.5</td>
<td>65.5–67.2</td>
<td>35.0–37.1</td>
</tr>
<tr>
<td></td>
<td>r = 0.99,</td>
<td>r = 0.99,</td>
<td>r = 0.96,</td>
<td>r = 0.98,</td>
<td>r = 0.97,</td>
</tr>
<tr>
<td>CG (n = 15)</td>
<td>56.5–57.0</td>
<td>57.7–58.0</td>
<td>46.6–47.0</td>
<td>46.8–48.0</td>
<td>32.1–32.8</td>
</tr>
<tr>
<td></td>
<td>r = 0.98,</td>
<td>r = 0.99,</td>
<td>r = 0.99,</td>
<td>r = 0.97,</td>
<td>r = 0.98,</td>
</tr>
</tbody>
</table>

3. Results

Table 1 presents ICC, in addition to ranges, for 1RM test and retest of each exercise at baseline and after 8 weeks. Table 2 shows 1RM loads and the kilogram of body mass, along with CVs, at baseline and after 8 weeks of resistance training. Fig. 1 presents 1RM progression in G1 and G2 after 8 weeks.

After the normalisation per kilogram of body mass, with the exception of the TE that did not present differences between trained groups, all of the other results remained the same. There were no differences ($p = 0.725$) between total work performed by G1 (36682.612.0 ± 3819.151.4 kg) and G2 (35040.160.0 ± 9916.373.5 kg).

4. Discussion

The purpose of this study was to examine the influence of exercise order of a training session on strength during 8 weeks of training in untrained young men. To our knowledge, this was the first study to investigate the chronic effects of different exercise orders of equal total work. The current results revealed no significant differences in strength gains in large muscle group exercises. In contrast, significant differences were found in small muscle group exercises between the different exercise sequences, suggesting exercise order may be particularly important during the initial stages of resistance training in untrained men, mainly in small muscle group exercises.

Hansen et al. compared two protocols; one using eight sets of 8–12 repetitions of arm exercises versus eight sets of 10RM of the leg press followed by the same arm training. The authors of the study reported large muscle group exercises for the lower body performed early in a training session have a stimulatory effect on small muscle group exercises for the upper-body performed later in the same session. In contrast to what was found by Hansen et al., our findings indicated arm exercises provided greater strength gains when performed early in the training session. This discrepancy can be associated to the fact that the sessions investigated in our study involved only exercises for the upper-body and had the same total work. This difference in total work might have influenced the results of the study by Hansen et al., as well as the fact the exercises used were for different parts of the body.

It is very difficult to compare our results with previous similar studies, since none of these studies investigated chronic effects of exercise order on strength. In addition, all previous studies used trained participants. However, the
current study investigated the influence of resistance training sessions in untrained men. The different exercise orders did increase strength differently in small muscle group exercises throughout the course of the study, but the same did not occur in the large muscle group exercises. Nevertheless, it should be noted both training groups revealed significant increases in strength over the course (8 weeks) of the training period in all exercises (Table 2). Another interesting point to observe was the strength progression in each exercise in both sequences (Fig. 1). The 1RM strength progression was higher for the exercises performed earlier in a training session for both training groups.

The current results are in agreement with previous studies\(^3\) and suggest whenever an exercise is performed last in an exercise sequence or training session, performance of that particular exercise may be negatively affected. This is true whether the exercise involves large or small muscle groups. This negative effect on exercises performed later in a training session needs to be considered when designing programs for both athletes and fitness enthusiasts. Simão et al.\(^5\) investigated the influence of different exercise sequences on the number of repetitions performed in a group composed of both men and women with at least 2 years of recreational resistance training experience. The exercise sessions, which were similar to our study, consisted of performing three sets of each exercise with a resistance of 10RM and 2-min rest periods between sets and exercises. The results demonstrated performing either large or small group exercises for the upper-body at the end of an exercise sequence resulted in significantly fewer repetitions compared to when the same exercises were performed early in an exercise sequence. A more recent study by Simão et al.\(^8\) suggested a similar phenomenon in trained women when both upper- and lower-body exercises are performed in the same exercise session. The previously mentioned studies\(^3\) demonstrated that an exercise performed last in a training session, is negatively affected in an acute manner whether the exercise involves large or small muscle groups. Our findings revealed those effects can influence the results also in a chronic manner. These results suggest the exercise most important for the training goals should be placed at the beginning of the training session for larger strength gains, independent of the size of the muscle groups involved.

Early muscular strength gains (during the first few weeks of training) are predominantly mediated by the increase in motor unit firing rate.\(^11\) Thus, an increase in muscular strength without hypertrophy is commonly observed in the initial stages of resistance training. However, we are unaware if our results are associated with neuromuscular adaptations only, given that muscle volume and hypertrophy were not assessed. Therefore, additional investigations with longer interventions and using procedures to assess muscle volume and hypertrophy are necessary to promote further understanding of the chronic effects from the exercise order.

### Table 2

<table>
<thead>
<tr>
<th>Group</th>
<th>1RM (kg)</th>
<th>kg/body mass</th>
<th>CV (%)</th>
<th>CV = coefficient of variation.</th>
</tr>
</thead>
<tbody>
<tr>
<td>G1 (n = 16)</td>
<td>59.7 ± 7.2</td>
<td>0.86 ± 0.17</td>
<td>0.30 ± 0.10</td>
<td>13.2</td>
</tr>
<tr>
<td>G2 (n = 17)</td>
<td>61.7 ± 9.1</td>
<td>0.75 ± 0.16</td>
<td>0.82 ± 0.09</td>
<td>14.8</td>
</tr>
<tr>
<td>CG (n = 15)</td>
<td>56.5 ± 7.5</td>
<td>0.86 ± 0.17</td>
<td>0.82 ± 0.09</td>
<td>14.8</td>
</tr>
</tbody>
</table>

- \(a\) Significant difference from baseline.
- \(b\) Significant difference from control group.
- \(c\) Significant difference from group 2.
5. Conclusion

The present study suggests exercise order during a resistance training session involving upper-body single- and multi-joint exercises may influence strength gains during 8 weeks of training in untrained young men. The results of the present study are relevant to the design of training sessions with the goal of maximising muscle strength in untrained young men during the initial 8 weeks of resistance training.

Practical implications

- The two resistance training programs utilised promote strength gains in untrained young men.
- Exercise order appears to be important to improve strength during 8 weeks of resistance training in young men.
- If an exercise is important for the training goals of a program, then it should be placed at the beginning of the training session, whether or not it is a large or a small muscle group exercise.

Conflict of interest

None declared.

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