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Influence of exercise order on upper body maximum and submaximal strength gains in trained men

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Summary

The purpose of this study was to investigate the influence of exercise order on one-repetition maximum (1-RM) and ten-repetition maximum (10-RM) strength gains after 6 weeks of resistance training (RT) in trained men. Sixteen men were randomly assigned into two groups based on the order of exercises performed during training sessions: a group that performed large muscle group exercises first and progressed to small muscle group exercises (LG-SM); while a second group performed the opposite sequence and started with small muscle group exercises and progressed to large muscle group exercises (SM-LG). Four sessions of RT were conducted per week; all exercises were performed for three sets of 8–12 repetitions with 1-min rest intervals between sets. Maximal and submaximal strength were assessed at baseline and after 6 weeks of RT with 1-RM and 10-RM testing for the bench press (BP), lat pulldown (LPD), triceps pulley extension (TE) and biceps curl (BC), respectively. Two-way ANOVA for the 1-RM and 10-RM tests indicated a significant group x time interaction. The 1-RM values significantly increased for all exercises in both groups ($P<0.05$), but were not significantly different between groups. However, effect size (ES) data indicated that the LG-SM group exhibited a greater magnitude of gains (1-RM and 10-RM) for the BP and LPD exercises. Conversely, ES indicated that the SM-LG group exhibited a greater magnitude of gains (1-RM and 10-RM) for the TE and BC exercises. In conclusion, the results suggest that upper body movements should be prioritized and performed according to individual needs to maximize maximal and submaximal strength.

Introduction

Resistance training (RT) is an effective modality that stimulates adaptational processes that are expressed through increases in strength, power, hypertrophy and muscular endurance (American College of Sports Medicine, 2009). These characteristics are emphasized through manipulation of prescriptive variables such as the modality, load, volume, exercise order and rest interval between sets and exercises (Fleck & Kraemer, 2004). While previous research has examined the effects of different RT loads and volumes on various strength and performance measures; few studies have focused on the longitudinal effects of varying the order of exercises.

In this sense, RT exercises, which involve large muscle groups or multi-joint movements, are usually performed before smaller muscle groups or single-joint movements (Sforzo & Touey, 1996; American College of Sports Medicine, 2002). The rationale for performing large muscle group exercises in the beginning of a training session is that total volume (load × repetitions) is greater when compared with performing small muscle group exercises or single-joint exercises first and may result in greater long-term strength gains. Conversely, it has been demonstrated that independent of exercise order, fewer repetitions are completed for exercises performed at the end of a RT session (Simão *et al.*, 2005, 2007). Furthermore, previous studies have indicated that training induced neuromuscular adaptations for exercises performed at the end of a RT session are reduced versus exercises performed at the beginning of a RT session (Dias *et al.*, 2010; Simão *et al.*, 2010; Spineti *et al.*, 2010).

Although previous research has utilized untrained subjects (Dias *et al.*, 2010; Simão *et al.*, 2010), whether longitudinal variations in RT exercise order effects maximal and submaximal strength gains in trained men have not been addressed. Therefore, the purpose of this study was to investigate the influence of exercise order on one-repetition maximum (1-RM) and ten-repetition maximum (10-RM) strength gains after 6 weeks of resistance training (RT) in trained men. We hypothesized that 1-RM and 10-RM strength gains would be greater for exercises that were consistently performed at the beginning of a session.

Methods

Subjects

Twenty men volunteered to participate in the present study. Four volunteers were excluded due to the use of supplements. Sixteen men were randomly assigned into two groups based on the order of exercises performed during training sessions: a group that performed large muscle group exercises first and progressed to small muscle group exercises (LG-SM, *n* = 8) (25.4 ± 3.7 year; 81.8 ± 7.1 kg; 179.9 ± 6.4 cm; ~4.4 year of training); while a second group performed the opposite sequence and started with small muscle group exercises and progressed to large muscle group exercises (SM-LG, *n* = 8) (27.5 ± 2.9 year; 80.2 ± 9.5 kg; 173.9 ± 7.5 cm; ~6.3 year of training). The inclusion criteria for participation included being at least 18 years of age, consistent resistance training for more than 2 years, following the recommendations of the American College of Sports Medicine (2009). Potential subjects were excluded from participating in the case of clinical problems that could interfere in the protocol and testing procedures or consuming nutritional supplements or hormones that could confound the results. All subjects were notified of the research procedures, requirements, benefits and risks before providing their informed consent. The study protocol was approved by the Euro-American University Center (UNIEURO) Research Ethics Committee for Human Use (protocol nº 030/09).

Resistance training program

The 6 weeks RT program consisted of four sessions per week; all exercises were performed for three sets of 8–12 repetitions with 1 min rest intervals between sets. All training sessions were carefully supervised by a certified strength and conditioning professional, and the adherence to the training program was 100% for both groups. The upper body RT program was divided into sessions A (Monday and Thursday) and B (Tuesday and Friday), so that each movements were trained twice per week in conjunction with the opposing sequences. Lower body training was not specifically controlled for either group, but took place on other days of the week so as not to interfere with the experimental sessions.

The exercise order for LG-SM group was as follows: session A: barbell bench press, inclined dumbbell press, peck-deck, machine triceps extension and triceps pulley extension; session B: front lat pulldown, close grip lat pulldown, seated row back, machine biceps curl and free weight standing biceps curl. Conversely, SM-LG was as follows: session A: machine triceps extension, triceps pulley extension, barbell bench press, inclined dumbbell press and peck-deck; session B: machine biceps curl and free weight standing biceps curl, front lat pulldown, close grip lat pulldown and seated row back. Each exercise session lasted ~35 min.

1-RM testing

One-repetition maximum test and retest sessions were performed on different days with 72 h between tests. The tested exercises included the bench press, front lat pulldown, triceps pulley extension and free weight standing biceps curl (JOHNSON, USA). The protocol consisted of 5 min low intensity walking on a treadmill followed by eight repetitions with 50% of an estimated 1-RM (according to the subjects' perceived capacity) as described previously (Tibana *et al.*, 2012). After a rest of 1 min, three repetitions were performed with 70% of an estimated 1-RM. Following 3 min of rest, subjects completed three to five 1-RM attempts with progressively heavier weights (~5%), interspersed with 3–5-min rest intervals until a 1-RM was determined. The range of motion and exercise technique was standardized according Brown & Weir (2001). High intraclass correlation coefficients (ICCs) were found, $R = 0.98$, $R = 0.99$, $R = 0.98$, $R = 0.99$, for the bench press, front lat pulldown, free weight standing biceps curl and triceps pulley extension, respectively.

10-RM testing

Similarly, ten-repetition maximum test and retest sessions were performed on different days with 72 h between tests. Prior to testing, subjects performed 5 min of low intensity walking on a treadmill followed by the 10-RM testing procedures as follows: (i) warm-up on each resistance exercise with five submaximal repetitions using 60% of the 1-RM, (ii) load increments were then employed by 5–10% until the 10-RM was found within two attempts with a 10-min rest interval prior to a second attempt if necessary.

Additionally, all subjects participated in a familiarization period prior to testing during which they were given standardized instructions regarding proper exercise technique and body position. Verbal encouragement was used during the testing procedures for all subjects. High intraclass correlation coefficients (ICCs) were found, $R = 0.99$, $R = 0.97$, $R = 0.96$, $R = 0.97$, for the bench press, front lat pulldown, free weight standing biceps curl and triceps pulley, respectively.

Statistical analyses

The normal distribution of the data was assessed via the Shapiro–Wilk test and homoscedasticity was tested via the Levene's test. Baseline differences between groups were assessed via an unpaired Student's t-test (no differences were found - $P>0.05$).

The effects of training on the experimental groups were assessed via a two-way ANOVA [time (baseline versus 6-week training) × group (LG-SM versus SM-LG)]. When appropriate, follow-up analyses were conducted using Bonferroni *post hoc* tests.

The relative percentage change was calculated for the 1-RM and 10-RM values using the following equation: [(Postvalues – Prevalues)/Prevalues × 100] and differences between groups were checked by the Wilcoxon signed-rank test. In all calculations, the alpha level was set at $P \leq 0.05$. Effect size (ES) statistics were calculated to determine the magnitude of results as proposed by Rhea (2004) (<0.50 = insignificant, 0.50–1.25 = small, 1.25–1.90 = moderate, >2.0 = high). The statistical software SPSS Inc., version 19.0 (SPSS Inc., Chicago, IL, USA) was used in all analyses.

Results

A paired Student's t-test indicated no significant differences in the test– retest 1-RM and 10-RM loads for each exercise, nor in any variable before training (unpaired Student's t-test). Thus, there were no differences among groups for the baseline values of 1-RM and 10-RM assessments

Two-way ANOVA for the 1-RM and 10-RM tests indicated a significant group x time interaction. The 1-RM values significantly increased for all exercises in both groups ($P<0.05$), but were not significantly different between groups (Figs 1 and 2). Fig. 3 presents the delta variation (%) for the 1-RM and 10-RM values in both groups after 6 weeks of training. Although the percentage values were different, there were no statistically significant differences between groups. However, effect size (ES) data indicated that the LG-SM group exhibited a greater magnitude of gains (1-RM and 10-RM) for the BP and LPD exercises. Conversely, ES indicated that the SM-LG group exhibited a greater magnitude of gains (1-RM and 10-RM) for the TE and BC exercises (Table 1).

Discussion

The purpose of this study was to investigate the influence of exercise order on one-repetition maximum (1-RM) and ten-repetitions maximum (10-RM) strength gains after 6 weeks of resistance training (RT) in trained men. The results indicated that 1-RM and 10-RM strength increased after 6 weeks of resistance training for both groups, but there were no statistically significant differences between groups. However, effect size (ES) data indicated that the LG-SM group exhibited a greater magnitude of gains (1-RM and 10-RM) for the BP and LPD exercises. Conversely, ES indicated that the SM-LG group exhibited a greater magnitude of gains (1-RM and 10-RM) for the TE and BC exercises. Therefore, there was some effect for exercises consistently performed first in the sessions for each group.

To the best of our knowledge, this is the first study to directly compare 1-RM and 10-RM strength gains under different exercise sequences in trained men. The results of the present study are similar to previous investigations that involved untrained populations (Dias *et al.*, 2010; Simão *et al.*, 2010; Spineti *et al.*, 2010). This reinforces the importance of individual training goals when choosing exercise order, whether or not it is a large or a small muscle group. The training protocols employed in the current study were different from previous studies that employed whole body sessions (Dias *et al.*, 2010; Simão *et al.*, 2010; Spineti *et al.*, 2010) and examined variables consequent to different exercise sequences. The current study was designed to be consistent with American College of Sports Medicine (2009) prescriptive guidelines for trained subjects, by training movements for different muscle groups on different days in a split routine.

Previous studies that compared different exercise sequences for maximal and submaximal strength gains are scarce. Specifically, Dias *et al.* (2010) examined the influence of exercise order on strength in young (18–20 year) untrained men after 8 weeks of RT. The authors reported that strength improved in all trained muscle groups. Similar to the present study, strength increased by a greater magnitude for those movements placed at the beginning of a training session. Subjects, who performed larger muscle mass movements first, experienced 47.44% greater increases in bench press strength, while subjects, who performed smaller muscle mass movements first, experienced 60.41% greater increases in triceps extension strength.

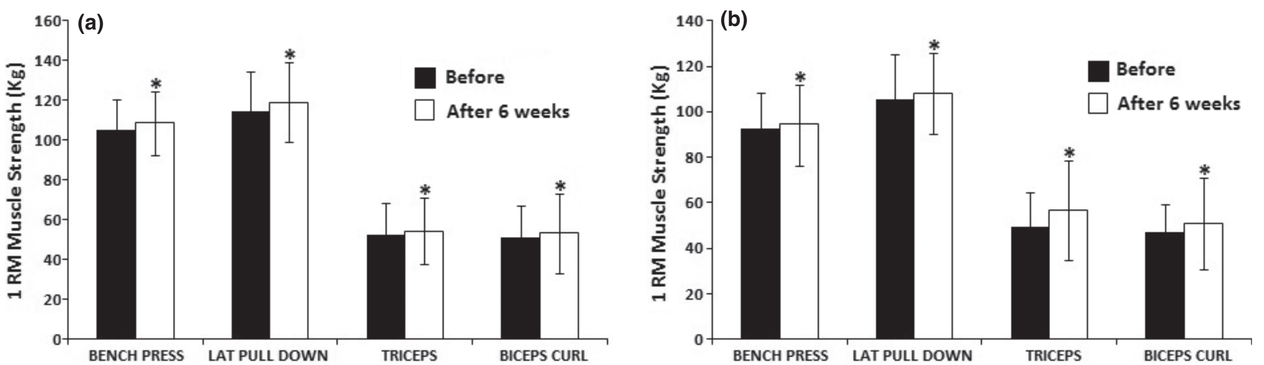

Figure 1 Changes in 1-RM after 6 weeks in groups LG-SM (a) and SM-LG (b); * $P<0.05$.

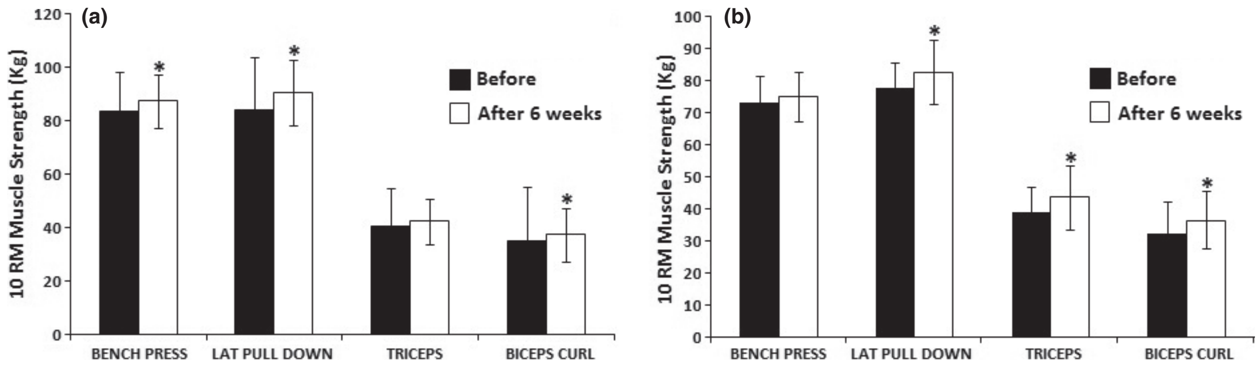

Figure 2 Changes in 10-RM after 6 weeks in groups LG-SM (a) and SM-LG (b); * $P<0.05$.

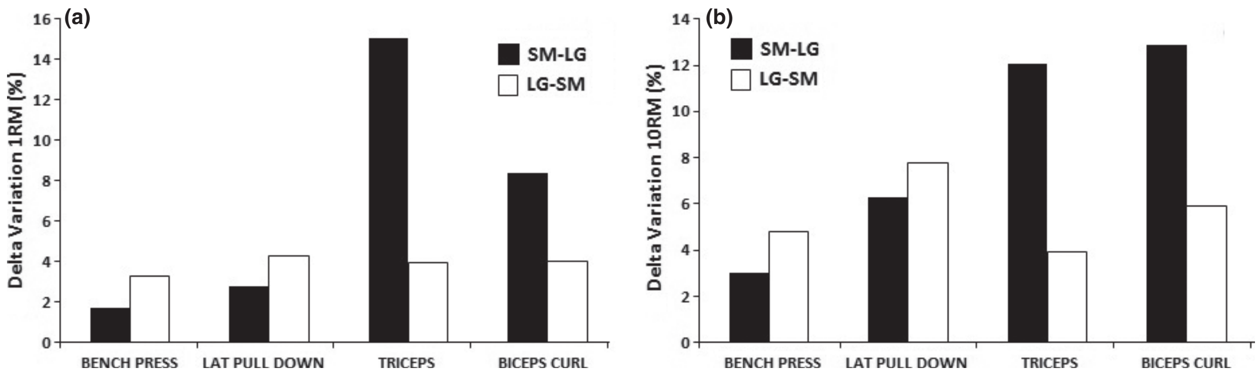

Figure 3 1-RM (a) and 10-RM (b) strength progression (%) in each exercise of LG-SM and SM-LG after 6 weeks of resistance training; there were no significant differences between groups.

Table 1 1-RM and 10-RM ES across 6 weeks of resistance training.

	LG-SM	SM-LG
1-RM		
Bench press	0.18 (trivial)	0.13 (trivial)
Lat pulldown	0.46 (small)	0.18 (trivial)
Triceps extension	0.29 (small)	1.03 (large)
Biceps curl	0.28 (small)	0.65 (moderate)
10-RM		
Bench press	0.26 (small)	0.22 (trivial)
Lat pulldown	0.92 (moderate)	0.48 (small)
Triceps extension	0.31 (small)	0.87 (moderate)
Biceps curl	0.38 (small)	0.94 (moderate)

Similarly Simão *et al.* (2010) examined the influence of exercise order on strength in untrained men after 12 weeks. The results showed no significant differences in 1-RM between the training groups in the selected exercises after 12 weeks of training. However, the normalized 1-RM loads for the triceps extension and biceps curl were significantly different only between the training group that had performed these exercises at the beginning of their workouts, versus the control group.

Spineti *et al.* (2010) examined the influence of exercise order on strength after 12 weeks of resistance training. Subjects were randomly assigned into 3 groups. Similar to the current study, one group performed workout sessions with the large muscle group exercises first and then progressed to the small muscle group exercises (LG-SM), whereas another group performed the opposite sequence (SM-LG). Both training groups demonstrated greater strength improvements than the control group, but only bench press strength increased to a greater magnitude in the LG-SM group versus the SM-LG. In all other strength measures (lat pulldown, triceps extension and biceps curl), the SM-LG group showed significantly greater strength increases. The present study was consistent in demonstrating greater effect sizes for the biceps curl and triceps extension exercises in the SM-LG group and for the bench press and lat pulldown for the LG-SM group.

The potential mechanisms which may explain the results of the present study remain to be determined. Previous research revealed that exercises placed at the beginning of a RT session will result in a higher training volume as compared with exercises performed at the end of a session (Simão *et al.*, 2005, 2007; Gentil & Oliveira, 2007). Additionally, it has been shown that training volume may influence longitudinal neuromuscular adaptations (Starkey *et al.*, 1996; Ronnestad *et al.*, 2007). To note, the initial strength gains (1–8 weeks) due to RT are primarily neural adaptations, while after this period, strength gains are also influenced by muscle hypertrophy (Fleck & Kraemer, 2004). Considering that in the present study, individuals trained for only 6 weeks, neural gains would be the most important.

In conclusion, the present results suggest that, in trained men using 8–12 RM loads over 6 weeks, the use of opposing exercise sequences (i.e. LG-SM and SM-LG) produced statistically similar gains in muscle strength. As the effect size data indicated some dependence on exercise order, the length of the study may have been a limiting factor, and a longer duration of training may have revealed statistically significant differences. However, it is important to note that the results are limited to upper body muscle strength, and the manipulation of exercise order has not been fully elucidated for other characteristics such muscle hypertrophy, power and endurance.

Practical applications

Practitioners can apply the results of the present study in designing upper body workout sessions for trained men. The results are consistent with the philosophy of prioritizing the sequence of exercises based on movements or muscle groups in greatest need of strength improvement. As demonstrated in the current study, the differences in strength gains between sequences were evident in greater effect sizes for those exercises performed at the beginning of each training session. A higher volume of training or greater neuromuscular activation in an unfatigued condition might account for greater strength increases for exercises prescribed at the beginning of a training session.

Conflict of interest

The authors have no conflict of interest.

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