Combination of General and Specific Warm-Ups Improves Leg-Press One Repetition Maximum Compared With Specific Warm-Up in Trained Individuals

Cesar C.C. Abad,[1] Marcos L. Prado,[1] Carlos Ugrinowitsch,[2] Valmor Tricoli,[2] and Renato Barroso[2]

[1]Bandeirantes University of São Paulo (UNIBAN), São Paulo, Brazil; and [2]Laboratory of Neuromuscular Adaptations to Strength Training, School of Physical Education and Sport, University of São Paulo, São Paulo, Brazil

Abstract

Abad, CCC, Prado, ML, Ugrinowitsch, C, Tricoli, V, and Barroso, R. Combination of general and specific warm-ups improves leg-press one repetition maximum compared with specific warm-up in trained individuals. *J Strength Cond Res* 25(8): 2242–2245, 2011—Accurate assessment of muscular strength is critical for exercise prescription and functional evaluation. The warm-up protocol may affect the precision of the 1 repetition maximum (1RM) test. Testing guidelines recommend performing both general and specific warm-ups before strength tests. The general warm-up intends to raise muscle temperature, whereas the specific warm-up aims to increase neuromuscular activation. Although there is scientific evidence for performing the specific warm-up, the effects of general warm-up on strength tests are still unclear. The purpose of this study was to investigate whether the combination of a general with a specific warm-up (G + SWU) protocol would improve leg press 1RM values compared with a specific warm-up (SWU) protocol. Thirteen participants were tested for leg-press 1RM under 2 warm-up conditions. In the first condition, participants performed the SWU only, which was composed of 1 set of 8 repetitions at approximately 50% of the estimated 1RM followed by another set of 3 repetitions at 70% of the estimated 1RM. In the second condition (G + SWU), participants performed the 1RM test after a 20-minute general warm-up on a stationary bicycle at 60% of HRmax and the same specific warm-up as in the SWU. Values of 1RM in SWU and in G + SWU were compared by a paired *t*-test, and significance level was set at $p \leq 0.05$. Strength values were on average 8.4% ($p = 0.002$) higher in the G + SWU compared with the SWU. These results suggest that the G + SWU induced temperature-dependent neuromuscular adjustments that increased muscle force production capacity. Therefore, these results support the recommendations of the testing guidelines to perform a moderate intensity general warm-up in addition to the specific warm-up before maximum strength assessments.

Key Words maximal dynamic strength, evaluation, performance, exercise

Introduction

Accurate assessment of an individual's muscular strength is important for functional capacity evaluation and exercise prescription (6). One repetition maximum (1RM), the maximal amount of weight that can be lifted in 1 repetition, is a common and reliable measure of muscle strength. However, several factors are known to affect the precision of 1RM assessments. One of these factors is the warm-up procedure (6). Accordingly, testing guidelines (2,6) recommend warming up before 1RM tests to improve the precision of the assessments.

A warm-up routine consists of preparatory exercises before any physical activity and aims to reduce the risk of injury and to enhance performance (5,15,17,21). The aforementioned guidelines (2,6) advocate that the warm-up should include both general and specific activities. The general warm-up should consist of a low to moderate intensity aerobic activity (e.g., jogging or cycling) designed to raise muscle temperature. Stretching exercises can also be performed as part of a typical warm-up routine. Finally, it is recommended to perform a specific warm-up (SWU) including exercises that mimic the main activity at progressively higher intensities in an attempt to increase neuromuscular activation. In fact, there is good scientific evidence supporting the execution of an SWU (17,22), but the effects of general warm-up on strength tests are still unclear.

Despite the lack of evidence supporting the inclusion of general activities on warm-up protocols, it is conceivable that

Address correspondence to Renato Barroso, barroso@usp.br.

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increased muscle temperature enhances motor performance because many warm-up benefits are related to higher body temperature (e.g., faster nerve conduction velocity, higher enzymatic activity) (9). However, the effects of a general warm-up on performance of different strength and power tests seem to be dependent on the activity. For instance, jumping performance improves after warm-up (7,11,20), whereas the isometric torque is not affected (10,18).

Considering that an SWU routine may enhance performance but the effects of general warm-up on strength performance remains to be elucidated, this study aimed to investigate if performing both a general and an SWU would affect leg-press 1RM values. According to previous suggestions (9,11,12,20), we hypothesized that a general and SWU protocol would improve 1RM test results compared with an SWU only protocol.

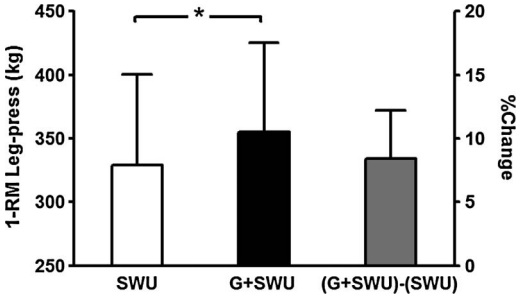

Figure 1. Mean (*SD*) leg-press 1 repetition maximum (1RM) values for both specific warm-up (SWU) and a combination of a general with a specific warm-up (G + SWU) sessions *$p = 0.002$–G + SWU greater than SWU. The right bar indicates relative improvements after G + SWU compared to SWU.

Methods

Experimental Approach to the Problem

This was a crossover design study in which participants were tested for their leg-press 1RM following 2 different warm-up protocols. In one of the protocols, participants performed the combination of a general and a specific warm-up (G + SWU), whereas in the other protocol, they performed only the SWU before the 1RM test. In the SWU protocol, participants performed a set of 8 repetitions at approximately 50% of the estimated leg-press 1RM followed by another set of 3 repetitions at 70% of the estimated 1RM (6). In the G + SWU protocol, participants cycled for 20 minutes and, then, performed the SWU protocol. Testing sessions were performed in a random order, at least 7 days apart at the same time of the day. Participants were asked to refrain from any physical activity for 48 hours before testing.

Subjects

Thirteen male individuals (age: 26.5 ± 6.1 years, body mass: 72.3 ± 8.3 kg, and height: 174.2 ± 6.3 cm) volunteered to participate in this study. Participants should have had at least 12 months of strength training experience (17.8 ± 7.1 months) and performed the leg-press exercise during their regular training routine at least twice a week. They were free from lower extremity injuries and neuromuscular disorders. The investigation was approved by an institutional review board for use of human subjects, and all participants signed an informed consent form before participation.

Procedures

One week before the beginning of the study, participants visited the laboratory for a familiarization session with the experimental procedures. During the familiarization session, the position of each participant on the leg-press machine was recorded to ensure reproducibility during subsequent sessions. Each repetition started with knees fully extended, participants flexed their knees up to a 90° angle (eccentric phase) and then returned to the initial position (concentric phase). After adjustments in the leg-press machine, participants warmed up on the stationary bicycle for 5 minutes and performed a simulated 1RM test to obtain an estimation of the load to be used during the experimental sessions. The 2 experimental sessions (i.e., SWU and G + SWU) were conducted in random order at least 7 days apart, at the same time of the day.

Specific Warm-Up Session. In the SWU protocol, participants performed only the SWU before being tested for 1RM in the inclined (45°) leg-press machine. The procedures for the SWU followed ASEP guidelines (6). The initial load was based on values obtained during familiarization session. In short, the participant should perform a specific set of 8 repetitions at approximately 50% of the estimated 1RM followed by another set of 3 repetitions at 70% of the estimated 1RM. Warm-up sets were separated by a 2-minute interval. After the completion of the second set, subjects rested for 3 minutes, and then they had up to 5 attempts to obtain the 1RM weight, with a 3-minute interval between attempts.

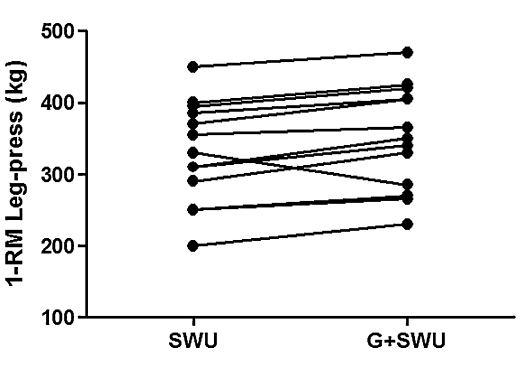

Figure 2. Individual 1 repetition maximum (1RM) values in both specific warm-up (SWU) and a combination of a general with a specific warm-up (G + SWU) sessions.

General and Specific Warm-Up Session. Participants were required to cycle on a stationary bicycle for 20 minutes, with a pedaling rate between 60 and 70 rpm, at approximately 60% of their maximal heart rate (HRmax = 208 − [0.7 × age]) (19). We chose this warm-up duration and intensity based on previous studies that showed that muscle temperature raises ~3° C and plateaus in approximately 15−20 minutes (4,9,16). Three minutes after the general warm-up, participants performed the same specific warm-up as in the SWU. After the completion of the SWU, subjects rested for 3 minutes. Participants had up to 5 attempts to obtain the 1RM weight, with a 3-minute interval between attempts.

Tests were conducted by 2 experienced researchers, and strong verbal encouragement was provided during the lifts.

Statistical Analyses

Results of 1RM test after the SWU and the G + SWU protocols are presented as mean (±*SD*). After normality assurance (i.e., Shapiro–Wilk test), 1RM values were compared using a paired *t*-test between warm-up protocols. Significance level was set at $p \leq 0.05$. To identify the magnitude of the changes and the practical significance of the differences between conditions, effect size (ES) and the 95% confidence interval (CI) were calculated. The ES was considered trivial if its value was below 0.2, small if between 0.2 and 0.6, moderate between 0.6 and 1.2, large between 1.2 and 2.0, and very large above 2.0 (13).

Results

In the G + SWU condition, 1RM values were significantly higher than in the SWU (Figure 1; $t = 3.76$; $p = 0.002$). The mean improvement in 1RM values was of 8.4%. Figure 2 shows individual 1RM values for both warm-up protocols. Only one subject decreased 1RM value following G + SWU, whereas the other 12 improved it (Figure 2). The ES of the 1RM values between the G + SWU and the SWU conditions was small (ES = 0.37); however, the 95% CI (20.62–31.69) suggests important increments in 1RM in the G + SWU compared with the SWU.

Discussion

The purpose of this study was to investigate if performing a G + SWU protocol would improve 1RM strength values in the leg-press exercise compared with an SWU protocol. Our results indicate that a 20-minute duration moderate intensity aerobic warm-up performed before a specific warm-up routine (G + SWU) improves performance in the leg-press 1RM compared with the condition in which only the SWU protocol was performed. Our results provide empirical support for American College of Sports Medicine (1), National Strength and Conditioning Association (3), American Society of Exercise Physiologists (6) recommendations of performing both a general and an SWU routine before strength tests.

The main purpose of the general warm-up is to increase body temperature through nonspecific activities to enhance performance (5,17). Testing guidelines (2,6) recommend a 5- to 10-minute general warm-up in the preparation for strength tests. However, previous studies showed that muscle temperature does not significantly change within the first few minutes of exercise, but increases ~3°C after a 15- to 20-minute moderate intensity activity, reaching a plateau afterward (4,9,14). Thus, we chose a longer (20 minute) than recommended (5 minute) warm-up duration to ensure increased muscle temperature. Despite the fact that we did not measure body temperature, it is conceivable that the G + SWU produced similar increments in body temperature as reported by others (4,9,14) (i.e., ~3°C) and that no significant changes were induced by the SWU because of its short duration. It seems reasonable to suggest that the increment in temperature was associated with the higher leg-press 1RM values (8.4%) in G + SWU compared with the SWU and that the G + SWU protocol produced a relative increment of ~2.8%·in 1RM values per 1°C.

To the best of our knowledge, no study has investigated the effects of a general warm-up on the performance of the 1RM test. Thus, it is not possible to directly compare our results with previous investigations. Nevertheless, the relative improvement in 1RM values reported in this study corroborates with previous findings (3,7,11,16,20). For instance, Sargeant (16), and Bergh and Ekblom (3) reported improvements between 2 and 10% in peak cycling power, maximal isokinetic strength, vertical jump, and sprinting performance per degree of increment in body temperature after a passive (no exercise) warm-up. Other researchers (7,11,20) have also reported similar increments in performance, after active warm-up (general and specific) routines. Thus, it seems that raising body temperature is a critical performance enhancing factor regardless of the warm-up procedures. On the other hand, Girard et al. (10) and Stewart et al. (18) did not report changes in maximum isometric strength after G + SWU protocol. These later findings are in agreement with those of animal in vitro preparations in which muscle force did not change after elevating muscle temperature above 35° C (8). Therefore, it is possible that increasing muscle temperature within physiological range improves performance only during dynamic tasks, probably through neuromuscular adjustments in the control of movement. Future studies should investigate whether increasing body temperature affects coordination (e.g., antagonist coactivation) and if this is related to improved performance.

In summary, in this study, the addition of a 20-minute moderate intensity general warm-up increased 1RM performance by 8.4% on average, thus providing a more accurate assessment of maximum strength. Therefore, our results present evidence to support ACSM (1), NSCA (2), and ASEP (6) recommendations of performing a G + SWU routine before maximum strength assessments.

Practical Applications

Our results suggest that moderate intensity general warm-up routines should be performed in association with specific warm-up before maximum strength assessments to improve performance, but more importantly to obtain accurate maximal strength assessments. However, this recommendation is still limited to maximum strength tests, and should not be applied to other strength tests (i.e., 10RM tests).

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