Postactivation Potentiation Improves Performance in a Resistance Training Session in Trained Men

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Postactivation Potentiation Improves Performance in a Resistance Training Session in Trained Men

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Abstract

Alves, RR, Viana, RB, Silva, MH, Guimarães, TC, Vieira, CA, Santos, DdAT, and Gentil, PRV. Postactivation potentiation improves performance in a resistance training session in trained men. *J Strength Cond Res* XX(X): 000–000, 2019—This study aims to analyze the influence of postactivation potentiation (PAP) on performance during a resistance training (RT) session in trained individuals. Fourteen trained men (25.0 ± 3.5 years; 89.9 ± 16.3 kg; 1.77 ± 0:08 m; 28.0 ± 4.0 kg·m^{-2}; and 5 ± 4 years of RT experience) were tested in 2 situations: with PAP and without PAP (CON). Both situations involved 3 sets of the bench press exercise performed to muscle failure at 75% of the 1 repetition maximum load and with 1.5-minute interval between sets. Total work was greater ($p <$ 0.001) for PAP (1,601 ± 504 kg) than for CON (1,379 ± 364 kg). The number of repetitions performed in the first and second sets of PAP (11.5 ± 3.1 and 6.5 ± 1.9, respectively) were greater ($p < 0.05$) than those performed in CON (10.4 ± 2.7, 5.5 ± 1.8, respectively). No significant difference was found in the number of repetitions in the last set between the situations. The present study suggests that PAP might be beneficial to improve total work and performance during multiple sets of RT in trained men. Therefore, PAP might be used during RT to promote higher total work and potentially increase results over long term. Thus, the protocol can use in sports centers, fitness centers, and gyms per coaches and athletes to increase performance and total work in trained individuals.

Key Words: muscle strength, total work, muscle failure

Introduction

Postactivation potentiation (PAP) is a phenomenon characterized by an increase in muscular contractile capacity following a high-intensity voluntary contraction (40). The PAP protocols include exercises commonly used in resistance training (RT), such as the bench press and squat (2,3). Usually, such exercises are performed with 1–5 repetitions at 80–90% of the 1 repetition maximum (1RM) (19). After this, rest intervals from a few seconds to 20 minutes are given before the performance of power or strength tests are carried out (10,22).

Several studies have shown the positive effects of PAP protocols on increasing the performance of activities such as rowing (17), running (5), swimming (15), soccer (18), handball (16), weightlifting (28), and sprinting (31); however, we are not aware of any study that analyzed the effects of PAP in multiple sets of RT.

Many different strategies, like nutritional supplementation and self-hypnosis, have been used to improve performance during an RT session (11,25). However, these strategies usually show controversial results, have a high cost, or have limited practical applications (1,38). In this context, PAP can be an interesting strategy because it has a low cost and is relatively easy to implement. Total work performed during RT has been associated with the results obtained from RT (27,32). In this regard, it has been shown that protocols with higher work volume promote higher increases in anabolic signaling (20), and previous studies showed that when using the same load, performing a higher number of repetitions promoted higher increase in protein synthesis (9) and higher increases in muscle cross-sectional area (21). Therefore, if PAP could increase the total work done during RT, it is possible that it could lead to higher long-term strength and hypertrophy improvements. Thus, knowledge about the influence of PAP in performance during an RT session can potentially help to maximize morphofunctional changes in trained individuals. In this way, the purpose of this study was to analyze the effects of PAP on performance during an RT session in trained individuals. Based on previous studies in different modalities, such as rugby (22), volleyball (30), weightlifting (28), and sprinting (31), we expect that PAP will increase total work.

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Methods

Experimental Approach to the Problem

Subjects visited the laboratory on 3 occasions. During the first visit, the subjects underwent a 1RM test on the bench press. After 72 hours, the subjects were randomized into 1 of 2 experimental conditions: with PAP (PAP) or without PAP (CON) (Figure 1). During the CON protocol, the subjects performed 3 sets on the bench press to concentric failure, as previously defined (36), with 75% of 1RM and a 1.5-minute rest interval between the sets. During PAP, the subjects performed one set of 3 repetitions with 90% of 1RM, and after a 10-minute recovery, they performed 3 sets to concentric failure, similarly to the CON protocol. All sessions were performed at the same time of day, and all subjects were instructed not to perform any other exercise during the study period. Both situations were separated by 72 hours, and the researchers provided verbal encouragement during all sets.

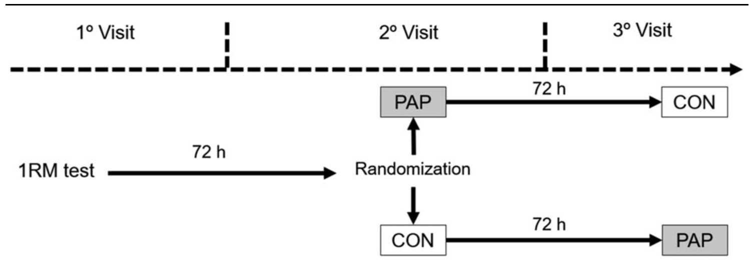

Figure 1. Study design. 1RM = 1 maximal repetition; CON = protocol without postactivation potentiation; PAP = protocol with postactivation potentiation.

Subjects

Table 1 shows the characteristics of the subjects. The volunteers were recruited through social media, word of mouth, and banners placed around the Federal University of Goiás, Goiânia, Brazil. To be included in the study, the volunteers must have had at least 1 year of uninterrupted RT practice and have been performing bench press for the past 6 months. The exclusion criteria were as follows: (a) history of neuromuscular, metabolic, hormonal, or cardiovascular disease, (b) use of any medication that could influence hormonal or neuromuscular function, and (c) any orthopedic limitation that could interfere in the performance of the test. The subjects had been training each muscle group for 3–5 days, with 6–12 repetition to volitional failure, with 6–12 sets per muscle group per week. All subjects were informed about the experimental procedures, possible risks and discomforts related to the study, and were asked to sign an informed consent form. The study protocol was approved by the Federal University of Goiás (approval number: 56907716.5.0000.5083).

Procedures

The CON protocol involved a warm-up with 8 repetitions with 50% of the 1RM, followed by an interval of 4 minutes. Then, 3 sets were performed with 75% of the 1RM until concentric failure. The PAP warm-up was the same with the addition of 3 repetitions performed with 90% of the 1RM (19). After an interval of 10 minutes (19), the subjects performed 3 sets with 75% of the 1RM until concentric failure. The concentric and eccentric phase of each repetition was controlled by a metronome and lasted 2 seconds and 1 second, respectively. In the final repetitions, the subjects were not able to maintain the predetermined velocity; however, the sets were continued until momentary muscle failure, as previously defined (36). The feet had to remain in contact with the ground, the subject's head and torso also had to remain in contact with the bench to avoid any undesired change in motor pattern, like raising the hips from the bench. The subjects were instructed to slightly touch the bar to the chest and not bounce in the transition between the eccentric and concentric phases. A rest interval between sets of 1.5 minutes was adopted for both protocols. The exercise was performed in a bench press using a barbell and free weights. Subjects self-selected the position of the hands, which was kept the same over the study using marks in the bar.

The performance was evaluated by the number of repetitions performed, and the total work was measured by multiplying the number of repetitions performed by the workload in kilograms. Verbal stimulus was provided in all sets by the same researcher to maximize the performance of the subjects.

One-Repetition Maximum Test. The 1RM test was performed on the bench press with a guided bar and consisted of carrying out a previous warm-up of 10 repetitions with an estimated load of 50% of the 10RM according to the subjects report, followed by a 2-minute interval. The initial load was estimated using the Lombardi (24) equation from the training load reported by the subject. The subject had up to 5 attempts to perform the test, adopting 3-minute intervals between the attempts. Each subject was tested for the 1RM test by increasing the resistance on subsequent attempts until the subject was unable to complete an attempt. The 1RM load was defined as the highest load in a complete repetition performed by the subjects with a proper technique, without compensatory movements, like lifting the hips from the bench, and they were instructed to touch the bar slightly in the chest in the end of the eccentric phase, without bouncing the bar in the beginning of the concentric phase (7). All subjects achieved 1RM load in less than 5 attempts. The position of the hands and velocity of movement were self-selected during the tests.

Statistical Analyses

Data were presented as the mean ± *SD*. All variables presented a normal distribution according to the Shapiro-Wilk test. A 2-way repeated-measures analysis of variance (ANOVA) 2 × 3 (situations × sets) was used with mean confidence interval at 95% (IC). When necessary, post hoc testing was performed by multiple comparisons using the Bonferroni's correction. Total work was compared by a paired *T* test. The sample size resulted in a power of 0.98 to detect an effect size (ES) of 0.4 at an alpha level of 0.05. Cohen's conventions for ES (*d*) were used for interpretation for no effect (ES < 0.2), small effect (ES = 0.2–0.49), moderate effect (ES = 0.5–0.79), and large effect (ES > 0.8) (12). All statistical analyses were performed with the Statistical Package for the Social Sciences version 20.0 (University of Chicago, Chicago, IL). A significance level of 0.05 was adopted for all statistical tests.

Table 1

Characteristics of subjects.

Variables	Mean ± *SD*
Age (y)	25.0 ± 3.5
Body mass (kg)	89.9 ± 16.3
Height (m)	1.77 ± 0.08
Body mass index ($kg \cdot m^{-2}$)	28.0 ± 4.0
Resistance training experience (y)	5 ± 4
Relative strength	1.14 ± 0.1

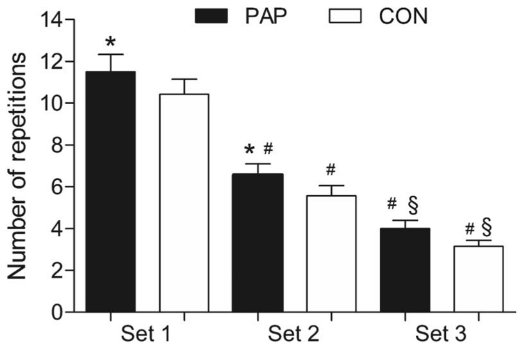

Figure 2. Comparison between the numbers of repetitions in each set between the groups. CON = protocol without postactivation potentiation; PAP = protocol with postactivation potentiation. *$p < 0.05$ from same set without PAP. #$p < 0.05$ from set 1. §$p < 0.05$ from set 2.

Results

The 1RM load was 99.4 ± 20.2 kg and relative strength was 1.14 ± 0.1. The total work performed during PAP and CON were 1,600.9 ± 504.4 kg and 1,379.2 ± 364.4 kg, respectively. Postactivation potentiation resulted in a greater total work than CON ($p < 0.001$, $d = 0.50$, moderate). The total number of repetitions performed during PAP (22.1 ± 6.0 repetitions) was significantly higher than that performed during CON (19.1 ± 4.7 repetitions) ($p < 0.001$). The 2-way ANOVA showed that the average number of repetitions performed during PAP in the first ($d = 0.38$, small, confidence interval = 0.37–1.76) and second ($d = 0.54$, moderate, confidence interval = 0.36–1.64) sets (11.5 ± 3.1 and 6.5 ± 1.9, respectively) sets were higher than those performed during CON ($p < 0.05$) (10.4 ± 2.7 and 5.5 ± 1.8, respectively) (Figure 2). There was no difference in the number of repetitions performed in the third set between PAP (4 ± 1.5) and CON (3.1 ± 1.1) ($p = 0.06$). The number of repetitions during PAP and CON reduced significantly from set 1 to set 2 and set 2 to set 3.

Discussion

The purpose of this study was to analyze the effects of PAP on the number of repetitions and total work performed during an RT session with concentric failure in trained men. Our findings that PAP increases performance, as total measured by work and the number of repetitions performed, during RT are in agreement with the literature, (3,28,33). In many sports, especially those that require higher levels of muscle strength, PAP protocols consisting of few repetitions and high loads are used by athletes and trained subjects as a warm-up to improve the performance, such as countermovement jumps (18), 100-m race (23), weightlifting (28), rowing (17), and swimming (15).

Using a similar protocol to ours (3 repetitions), however, with different intensity (40–60% of perceived subject 3RM), Crewther et al. (14) reported that PAP enhanced countermovement jumping height in rugby players. Additionally, despite the differences in exercise used (back squat), and the type of training (2 repetitions at 90% 1RM with 5 minutes of recovery), Conrado de Freitas et al. (13) found that PAP increased the number of repetitions performed in 4 sets of squat at 70% of 1RM when compared with control (56.20 ± 17.3 vs. 48.80 ± 14.5).

Interestingly, although we have not found equal to our studies, the use of PAP provided a 15% increase in total work performed in the present study, demonstrating better results than other studies with PAP such as 2.1% in vertical jumping (14), 6.5% in sprinting (31), 4.9% in reaction force (33), and 9.9% at peak power (28). Despite the differences in the results obtained from different tests, Seitz and Haff (34) also showed that the results obtained from PAP might be modulated by factors like the type of activity used to promote PAP (better results for plyometrics than other forms of exercise), rest interval (higher results for longer intervals), number of sets used for PAP (greater results for multiple sets), and intensity of effort (better results for higher effort). Although the present study observed some of this modulators (high effort and longer intervals), we opted to perform single sets in the bench press to provide a time efficient and more practical approach.

Previous findings suggest that increased performance can be related to phosphorylation of the myosin regulatory light chain, increased sensitivity and concentration of Ca^{2+} (37), and changes in muscle architecture, such as increases in fascicle length and pennation angle, (6,8). According to Baker (3), PAP can also be associated with an increased recruitment of motor units, synchronization firing of electrical impulses, and decreased central (Cell Renshaw) and peripherals inhibitory mechanisms (Golgi tendon organ). Considering that the observed results involved the production of the same force over a longer period, the changes in recruitment pattern and decreased inhibitory mechanism might be more relevant because of changes in efficiency. However, it is important to note that the aforementioned mechanisms would be evident for a period ranging from a few seconds to minutes (39), which may explain the fact that there are positive effects only in the first and second sets because the aforementioned mechanisms can reduce their influence as the exercise extends.

The previous experience of RT may have been a contributing factor to the results. Seitz et al. (35) and Chiu et al. (10) demonstrated that PAP increased performance in trained individuals when compared with physically active individuals. This was confirmed in a systematic review and meta-analysis by Seitiz and Haff (34); according to the results, individuals with more than 2 years of RT experience showed higher benefits in performance after PAP than those with less than 2 years of training (ES = 0.53 vs. 0.44). Additionally, some researches (4,29) did not find any significant differences in the performance of individuals without experience in RT after PAP protocols. Therefore, we recommend this protocol for trained individuals. Moreover, it would be interesting if future studies adopt strategies to minimize fatigue, like prolonging rest intervals and using cluster sets (26), to see if PAP would provide higher benefits.

The present findings may suggest that PAP could be beneficial in increasing the number of repetitions and total work performed in RT. Regarding the study limitations, it is important to consider that the present design only allowed the researchers to bring observations that generate hypotheses for further studies on long-term training programs. Therefore, the possible implications of the long-term effects of PAP should be verified in other studies. In addition, the RT protocol was performed only in one exercise with healthy men; therefore, the results might not be extrapolated to other exercises and populations.

Practical Applications

Based on the results of the present study, the use of PAP may be recommended to acutely improve RT performance in trained men. The easy application of the protocol allows for its use in sports centers, fitness centers, and gyms, therefore, coaches and athletes can apply PAP to increase performance and total work in trained individuals. However, it is important to note that the use of PAP might increase the duration of the training session, especially if it is used when training multiple muscle groups in a session. Moreover, the fact that the effects were significant only in the first 2 sets suggests that the benefits of PAP might be more evident when training with lower number of sets.

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