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Original Article

Acute effect of a complex training protocol of back squats on 30-m sprint times of elite male military athletes

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Abstract. [Purpose] The aim of this study was to determine the acute effect temporal of a complex training protocol on 30 meter sprint times. A secondary objective was to evaluate the fatigue indexes of military athletes. [Subjects and Methods] Seven military athletes were the subjects of this study. The variables measured were times in 30-meter sprint, and average power and peak power of squats. The intervention session with complex training consisted of 4 sets of 5 repetitions at 30% 1RM + 4 repetitions at 60% 1RM + 3 repetitions of 30 meters with 120-second rests. For the statistical analysis repeated measures of ANOVA was used, and for the post hoc analysis, student's t-test was used. [Results] Times in 30 meter sprints showed a significant reduction between the control set and the four experimental sets, but the average power and peak power of squats did not show significant changes. [Conclusion] The results of the study show the acute positive effect of complex training, over time, in 30-meter sprint by military athletes. This effect is due to the post activation potentiation of the lower limbs' muscles in the 30 meters sprint.
Key words: Complex training, Post activation potentiation, 30-meter sprint

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INTRODUCTION

Post Activation Potentiation (PAP) is a method used to increase the explosive strength of a contractile activity in order to naturally increase physical capabilities in the acute phase[1]. The stimulus results in two opposing outcomes: on the one hand, there is ATP level depletion post-workout; and, on the other hand, there is an activation of the central nervous system that lasts a few seconds in the motor endplate (this time has not been defined nor standardized). The presence of both of these factors leads to a PAP of the stimulated musculature[1–4], provided that the recovery is faster than the dissipation of the neuronal transmission.

There are a number of researchers who have tried to increase the explosive strength and velocity by generating PAP through different activation methods[5–8]. For example, Maio Alves et al.[6] obtained a significant velocity increase with 8 weeks of training. It is worth mentioning that all the studies consulted for this article are based on the principle explained by Sale[1] for the generation of PAP. All of these studies used constant resistance as activation; therefore, there is not enough evidence to support the notion that the basic principles of PAP can be obtained with a complex training protocol.

Several of the authors mentioned in this article researched the PAP effect with constant resistance[9, 10], but there is no conclusive evidence about the changes in explosive strength due to PAP when the activation is induced by complex training.

It seems that a valid alternative in sports training is to know the behavior of the reflex elastic explosive strength in power zones (from 0.6 to 0.9 m/s of velocity in bar squats), and how this strength increases due to PAP in the muscles involved in 30-m sprints. Simultaneously, it is fundamental to determine how the power levels are modified during Squats by extra load applied in order to meet the aim of the study, since diminishing the power would decrease the PAP effect.

The main aim of the study was to determine the acute temporal effect of complex training with squats on 30-m sprint times. As a secondary aim, fatigue indexes of military athletes were analyzed. These indicators show the variation of the average power and the maximum power of the squat during complex training.

SUBJECTS AND METHODS

Developing exercises with elite athletes is a privilege only a few researchers have; however, doing so presents a few methodological issues. It is common for elite athletes to be a very small sample; fortunately, there are experimental designs that facilitate such work with reduced and specific samples. Using the same subjects in a controlled condition and the experimental condition is one of the most widely-used strategies in research involving people. Seven male subjects participated in this study. A quasi-experimental intra subject design was used together with a control condition and an experimental condition; both of the latter two conditions were conducted 48 hours apart. Before any intervention, all the subjects were measured for their weight, and size and thickness of their skinfold. All the subjects of the study were requested to restrain from ingesting caffeine, drugs, or any substance that could increase their metabolism during the course of the experiment.

Seven male military athletes of the Chilean Navy (age: 25.0 ± 2.6 years; weight: 67.1 ± 2.0 kg; height 172.7 ± 3.6 cm, Body Mass Index: 22.5 ± 1.0 kg/m2; body fat percentage: 12.0 ± 2.6%) (Table 1) were enrolled in the study. Each athlete and their coach was informed about the aim of the study and the possible risks of the experiment, and they all signed a consent form before participating in the study. The signed consent form and the study were approved by the Research Ethics Committee of Universidad de Granada, Spain (register nº 933).

For the characterization of the sample, weight and height were measured with a HEALTH O METER PROFESSIONAL® Scale and Stadiometer. Skinfolds were measured with a F.A.G.A.® caliper. Using the Durnin & Womersley[11] method, the skinfolds of the biceps, triceps, subscapularis, and supraspinatus were measured to determine the fat percentage.

Standard warm-up: For the evaluation of one repetition maximum (1RM), the control set, and the treatment based on complex training, the standard warm-up consisted of a 10-minute jog. During the first 5 minutes, subjects performed a low-intensity run and in the next 5 minutes they added some ballistic movements to the lower limbs (hip adductions, abductions, flexion and extension, and knee and ankle flexion and extension).

Base Line: For the evaluation of 1RM, Encoder Lineal CHRONO JUMP® and CHRONOJUMP Version 1.4.6.0® software were used. The 1RM evaluation was performed indirectly through the formula proposed by Sanchez-Medina et al[12]. Twenty-four hours after the 1RM evaluation, a control set was performed that consisted of 4 sets of 1RM 60% squats. The aim of this was to verify the vertical speed of the bar of each subject[13] by determining the peak power and average power of squats. Furthermore, three 30-m sprint sets were evaluated using a CHRONO JUMP PHOTOCELL® and the CHRONOJUMP Version 1.4.6.0® software. The times were measured at the starting point, and 10 m, 20 m, and 30 m.

Protocol: The intervention session with complex training consisted of: 4 sets of 5 repetitions of 30% 1RM + 4 repetitions of 30% 1RM + 3 repetitions of 30-meter sprint with two-minute resets between repetitions of 30-meter sprint (Fig. 1a and 1b).

During the protocol of complex training with squats, the vertical velocity of the bar in the low intensity (30% 1RM) and high intensity (60% 1RM) tasks in each set was monitored. This analysis verified the presence of fatigue over the course of the intervention. Also, all 30-meter sprint repetitions were evaluated (3 repetitions per set) in order to determine the appearance of PAP (Fig. 2).

The minimum times of the 30-meter sprints (10 m, 20 m and 30 m), and average power and peak power were submitted to the Kolmogorov-Smirnov (K-S) test. Repeated measures ANOVA test was used to analyze the differences among the control sets and the four complex training sets. The effect size for this analysis was calculated using the partial Eta-squared test.

For Post hoc analysis, student's t-test was conducted on those variables that showed significant differences in the repeated measures ANOVA test. The following comparisons were carried out using student's t-test: control sets vs. experimental set 1

Table 1. Characteristics of the sample (means ± SD)

	Experimental group (n=7)
Age (years)	25.0 ± 2.6
Height (cm)	172.7 ± 3.6
Weight (kg)	67.1 ± 2.0
BMI (kg/m^2)	22.5 ± 1.0
Fat percentage	12.0 ± 2.6

BMI: body mass index; SD: standard deviation

(Pair 1), control set vs. experimental set 2 (Pair 2), control set vs. experimental set 3 (Pair 3), and control set vs. experimental set 4 (Pair 4). The size of the effect for this analysis was calculated using Cohen's d test with the following effect scale: insignificant (d < 0.2), small (d = 0.2 − 0.6), moderate (d = 0. − 1.2), large (d = 1.2 − 2.0), and very large (d > 2.0). The level of significance for all statistical analysis was p < 0.05. Data analysis was carried out with the GRAPHPAD INSTAT Versión 3.05® software.

RESULTS

According to ANOVA, the partial times of the 10-meter and 20-meter sprints did not show any significant differences between the control set and the 4 experimental sets (p = 0.46 and p = 8.80). However, was there a significant decrease in the 30-meter time between the control set and the 4 experimental sets (p = 0.0001).

The decrease in the minimum time of the 30-meter sprint was attributed to PAP in the lower limb muscles activated by the complex training. The control set and the 4 experimental set results are shown in Table 2.

The average power and peak power of squats did not show any significant changes between the control set and the 4 experimental sets (p = 0.52 and p = 0.45). The progressions and changes are shown in Table 2.

In post hoc analysis, the control set and the 4 experimental sets were examined in pairs. There were significant differences in all categories. The results of Student's t-test for all 4 pairs of results are shown in Table 3.

DISCUSSION

Regarding the first aim of the study, the results of ANOVA showed a positive temporal acute effect of complex training in 30-meter sprints performed by military athletes. This positive effect was a consequence of PAP in the muscles used in the sprint, as a result of higher phosphorylation of the light chains of muscular miosine[1]. It is also important to mention that in the post hoc analysis, the size of the effect in the student's t-test was large in all the pairs evaluated. Similar to this study, Okuno et al.[7] researched PAP conducting complex training for the lower limbs, and found a significant increase in the sprint velocity in the repeated sprint ability (RSA) test (p = 0.01) (30 meters with a change of direction at 15 meters). However, Lim et al.[14] did not find any significant differences among the 10-m, 20-m, and 30-m sprint times. They tried to elicit acute PAP with Squats using constant resistance. Possibly, the weight increase (load) used in the present study elicited PAP in the 30-meter sprint muscles, since both this study and the study performed by Okuno et al.[7] used complex training with squats

Fig. 1a. Experimental protocol in complex training in squats
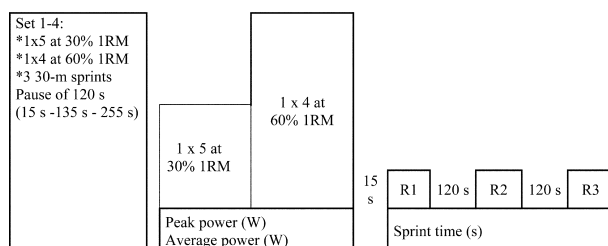1RM: 1 repetition maximum; 30-m: 30 meters sprints

Fig. 1b. Design of experimental protocol with complex training
1RM: 1 repetition maximum; 30-m: 30 meters Sprints; s:seconds;
R1: first repetition of 30-m; R2: second repetition of 30-m; R3:
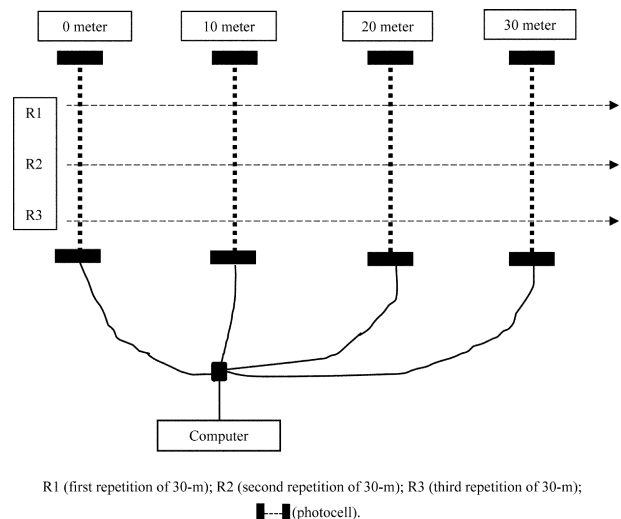third repetition of 30-m; W: Watts

R1 (first repetition of 30-m); R2 (second repetition of 30-m); R3 (third repetition of 30-m); ▐┅▌(photocell).

Fig. 2. Sequence of 30-m sprint repetition in experimental protocol

as an activation method.

In the literature, there are several studies which investigated the chronic effect of complex training on PAP over different sprint distances[5, 15–17], but only a few studies have demonstrated significant changes in sprint time and velocity over 30 m[5], and/or demonstrated a positive correlation between explosive force tests (squat jump) versus sprints[17]. Similarly, PAP was only elicited acutely in those cases where complex training was conducted. In the studies where constant resistance was applied, the variables measured showed no significant changes[9, 16]. It seems that working with constant resistance causes the neuromuscular system to stabilize, limiting PAP and, in consequence, explosive strength events. In contrast, complex training activates the neural system, but does not trigger fatigue in athletes. The combination of both processes generates PAP and an increase in the explosive strength, and in this study, it generated a better performance in 30-m sprints.

Regarding the second aim of the study, the ANOVA results show there were no significant changes in the peak power and average power of squats (p = 0.45; p = 0.53). Similar to this study, Marques et al.[18] reported the bar velocity, peak power, and average power of throwing a handball; however, these researchers did not evaluate PAP as a study variable. Walker et al.[19] observed the chronic effects of complex training on PAP and the fatigue index, and found a substantial increase in the active strength (p<0.05), as well as a substantial increase in the muscular fatigue after the activation (p<0.05). The evidence shows that long-term workouts increase the fatigue index, but there is no conclusive evidence to support the generation of neuromuscular fatigue with complex training of 60% 1RM, since this study PAP in 30-meter sprints. If athletes had experienced fatigue, it is likely that they would not have shown potentiation[1, 2, 20, 21].

The present results shown indicate that complex training activation elicits PAP as evidenced by the 30-meter sprint of military athletes. This PAP is clearly seen in the significant decrease in the minimum times of the 30-meter sprints, and the lack of variation in the peak power and average power of the control set and the 4 experimental sets. Therefore, working with 4 sets of 5 repetitions of 30% 1RM + 4 repetitions of 60% 1RM + 3 repetitions of 30-meter sprints with a 120-second rest, seems to be a valid way of developing explosive strength in the lower limbs.

From a practical point of view, the application of complex training for physical capacity is a good method of increasing explosive strength levels in the lower limbs, since it stimulates two physical capacities simultaneously, increasing both muscular strength in the back squat series and explosive strength in 30-m sprints. It is our suggestion that complex training should be performed with load in power zones (from 0.6 to 0.9 m/s of velocity in bar squats) in the pre-competition and competition phases, since it stimulates the central nervous system without causing fatigue in the muscles used in the 30-m sprint. Finally, it is our suggestion that all movements, either back squats or 30-m sprints, should be executed at the fastest speed of movement possible.

Table 2. Results (means [SD]) of post activation potentiation (PAP) elicited by complex training with squats for the control set and the four experimental sets

Variables	Control set	Set 1	Set 2	Set 3	Set 4
	Means (SD)	Means (SD)	Means (SD)	Means (SD)	Means (SD)
Time in 10 m (s)	1.68±0.08	1.66±0.12	1.67±0.10	1.68±0.12	1.71±0.12
Time in 20 m (s)	3.00±0.14	2.97±0.16	3.01±0.16	2.99±0.17	3.01±0.16
Time in 30 m (s)**	4.57±0.23	4.22±0.20	4.27±0.20	4.23±0.23	4.23±0.21
Average power (W)	579.2±133.2	592.4±110.0	587.8±115.6	584.4±144.5	625.4±143.9
Peak power (W)	1,451.2±216.1	1,368.5±176.7	1,451.3±210.2	1,424.5±279.1	1,451.2±285.7

SD: standard deviation; **p<0.0001

Table 3. Post hoc analysis of 30-m sprint times after post activation potentiation (PAP) elicited by complex training: control set vs. the four experimental sets

Contrast among conditions (Control Set – Sets)	Control set	Sets
	Means (SD)	Means (SD)
Pair 1	Control set	Set 1
Time (s)*	4.57±0.23	4.22±0.20
Pair 2	Control set	Set 2
Time (s)*	4.57±0.23	4.27±0.20
Pair 3	Control set	Set 3
Time (s)*	4.57±0.23	4.23±0.23
Pair 4	Control set	Set 4
Time (s)*	4.57±0.23	4.23±0.21

s: seconds; SD: standard deviation; *p<0.01

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