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The acute effects of post-activation potentiation on sport-climbing specific power exercises

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ABSTRACT

The effect of performing biomechanically similar exercises in such order that resistance exercise was followed by plyometric, power or speed exercise is a temporal increase in power and force production. The physiological rationale for complex training effectiveness is a phenomenon known as post-activation potentiation (PAP). Only a few studies were dedicated to various aspects of sport climbers' training and to our knowledge, no study has examined the effects of post-activation potentiation and/or complex training in climbing.

The purpose of this study was to determine if there was a performance-enhancing response of power and power endurance exercises on the campus board that were performed after a high-load resistance exercise (weighted pull-ups). 12 climbers participated in the study. During the first testing condition, climbers were asked to hang on the lowest rung and perform three maximal reaches with their dominant arm, separated with 10 s rest periods. The second test involved touches to the rung just below climbers' maximal reach, then coming back down to the bottom rung, and performing the same exercise with the second hand. The climbers were required to repeat this cycle as many times as possible in the 20 s period. After 10 min rest, climbers repeated both tests after preloading. The time interval between resistance exercise (weighted pull ups) and campus power or power endurance exercise was 4 minutes.

On average during the test of maximal reach after weighted pull-ups, climbers improved their performance on the campus board by 3.11 cm. The difference between PRE and POST loading was statistically significant. The best of the reaches performed in the set was 2.23 cm higher after preloading. In the power endurance („Touches") test, only a tendency toward difference between the number of reaches in baseline and after heavy resistance exercise was observed, although the effect size suggests moderate strength of the relationship between both conditions.

The results indicate positive effect of weighted pull-up exercise on subsequent power exercises on the campus board. It should be noted, however, that results of the preload on campus board exercise varied between individuals and more studies are needed in order to determine the most effective protocol of pairs of exercises in sport climbers' training.

Key words: post-activation potentiation, sport climbers' training, comlex training

Rock- and sport-climbing are still increasing in popularity and following a recent decision of the International Olympic Committee, sport climbing will appear in the program of the 2020 Summer Olympics. The popularity of climbing is also reflected by an increasing number of scientific studies on this kind of activity. Their subject matter in most cases relates to physiological, kinematical and biomechanical demands of climbing, anthropometrical and physiological characteristics of climbers as well as potential medical problems resulting from this type of activity.[1-8] Only a few studies were dedicated to various aspects of sport climbers' training and to our knowledge,[9-12] no study has examined the effects of post-activation potentiation and/or complex training in climbing, although this method of training has been mentioned in some books on climbing training methodology.[13]

The term of complex training was introduced by Verkhoshansky who defined it as "concurrent use of different training means in the same workout",[14] usually alternating biomechanically similar exercises in such order that resistance exercise was followed by plyometric, power or speed exercise. Examples of such pairs of exercises include squats and jumps, the bench press and clap push-ups, the shoulder press and overhead medicine ball throws, to name but a few. The effect of performing such exercise sequences is a temporal increase in power and force production, thus allowing greater training stimuli and/or enhancing acute performance effect.[15] The physiological rationale for complex training effectiveness is a phenomenon known as post-activation potentiation (PAP). Although exact nature of PAP is still debatable, two mechanisms are proposed to explain its effect on performance: increasing neural excitability (better motor-unit recruitment and synchronization, decreased presynaptic inhibition) and an increased amount of Ca^{2+} in the sarcoplasmic reticulum and greater sensitivity of the myofilaments to Ca^{2+}.[15,16] Independently of the true nature of PAP, it seems to induce acute and long term effects on performance in various lower- and upper body activities such as jumps and sprints, as well as selected upper-body exercises like the bench press throw.[15,17-19]

Sport climbers' training belongs to the range of athletic activities that could also benefit from PAP. Power and power endurance development are of crucial importance especially for climbers going in for speed climbing and bouldering, but also extreme rock climbing. In all these activities movements like jumping from hold to hold or performing series of movements that require high velocities are common. One of the most popular forms of climbing specific power training are campus board exercises.[11] A campus board is a training tool designed for developing finger contact strength and upper body power. It consists of a slightly overhanged plywood panel with series of regularly spaced wooden rungs screwed on it. Most exercises are variations of moving up the board from rung to rung (usually called "laddering"), reaching explosively upward as far as possible, lowering back down and reaching upward again (usually called Reaches or Touches) and jumping with both hands from rung to rung temporarily losing contact with them (usually called Doubles or Dynos). Campus exercises are considered an "extraordinary tool for developing explosive
strength, improving force gradient, intramuscular and intermuscular coordination".[11] It would be worth investigating whether performing a heavy weight exercise before power campus board exercises would induce greater performance response of the latter.

Therefore, the purpose of this study was to determine if there was a performance-enhancing response of power and power endurance exercises on the campus board that were performed after a high-load resistance exercise (weighted pull-ups).

Methods

After providing written informed consent, a total of 12 climbers voluntarily participated in the study. All participants were required to be advanced climbers with at least one year experience in campus board training. Sport climbing experience of the participants ranged from 6 to 30 years (M=12 years, SD=6.3), and their climbing performance level determined on the basis of self-reported best red-point (RP) climbs (routes climbed in one push, without falling, although being previously familiarized with their character, ie. knowing the holds, the movements required to move from hold to hold, etc.) ranged from 8a to 8c acoording to the French system.

Prior to testing, subjects were instructed to perform a warm-up up to their individual preferences in order to prepare to intense campus exercises. Participants had at their disposal a set of hangboards, a campus board with four kinds of rungs and wooden hemisphere-shaped slopers, a boulder wall, a system wall, and a bar with movable holds. The test of 5 RM weighted pull-ups was performed on a Witchholds fingerboard using two 4 cm deep jugs placed just below slopers (see figure 1). Power and power-endurance campus exercises were performed on 3 cm deep rungs. During the first testing condition, climbers were asked to hang on the lowest rung and perform three maximal reaches with their dominant arm, separated with 10 s rest periods. The distance was measured to the highest mark left by magnesium covering their fingers with accuracy of 0.5 cm. After 5 min rest, the second test was performed. It involved touches to the rung just below climbers' maximal reach, then coming back down to the bottom rung, and performing the same exercise with the second hand (fsee figure 2). The climbers were required to repeat this cycle as many times as possible in the 20 s period. After 10 min rest, climbers repeated both tests after preloading. The time interval between resistance exercise (weighted pull ups) and campus power or power endurance exercise was 4 minutes.

Statistical analyses

Assumptions of normality and homogeneity of variance were determined with the Shapiro–Wilk and Levene's tests, respectively. The resistance exercise-related effects on power and power endurance were analyzed using a Student's paired *t*-test. To quantify the true size of the difference between both conditions, effect size was calculated with the use of Hedges' *g* measure, which is considered more appropriate for small sample sizes than commonly used Cohen's *d*. All statistical analyses were conducted using Statistica 12.0 (Statsoft, PL).

Fig. 1 Fingerboard used in the survey

A B

Fig. 2 Execution of campus board test A – starting position, B – final position

Results

Descriptive statistics of study results are presented in Table 1. On average during the test of maximal reach after weighted pull-ups, climbers improved their performance on the campus board by 3.11 cm. The difference between PRE and POST loading was statistically significant and the size of the difference was weak-to-moderate: $t_{(df=11)}$= -2.64, *p*=0.023, Hedge's g=-0.29. The best of the reaches performed in the set was 2.23 cm higher after preloading: $t_{(df=11)}$= -2.23, *p*=0.047, Hedge's g=-0.29.

Table 1. Results of campus board power and power endurance exercises before (PRE) and after (POST) the preload stimulus

	Mean	Std Dev	Min	Max	Skewness	Kurtosis
Mean of 3 reaches PRE (cm)	83.61	10.94	68.00	103.3	0.134	-1.01
Mean of 3 reaches after (cm) POST	86.72	9.40	72.00	103.0	0.430	-0.25
Max reach PRE (cm)	86.58	12.16	68.00	108.0	0.106	-0.80
Max reach after (cm) POST	88.83	10.29	72.00	108.0	0.465	-0.14
Power endurance (no of reaches per 20 s) PRE	14.00	3.25	8.00	20.0	-0.153	0.28
Power endurance (no of reaches per 20 s) POST	15.08	2.94	11.00	22.0	0.832	2.07

Taking into consideration scores obtained by each athlete, 8 climbers improved their performance, one climber remained at the same performance level, and in three cases regression of results was observed (see figure 3).

In the power endurance („Touches") test, only a tendency toward difference between the number of reaches in baseline and after heavy resistance exercise was observed: $t_{(df=11)}$= -1.95, *p*=0.078, although the effect size suggests moderate strength of the relationship between both conditions, Hedges' g=-0.34. Nine climbers improved, , while two of the subjects decreased their performance; the remaining two subjects performed the same number of "Touches" in both conditions (see figure 3).

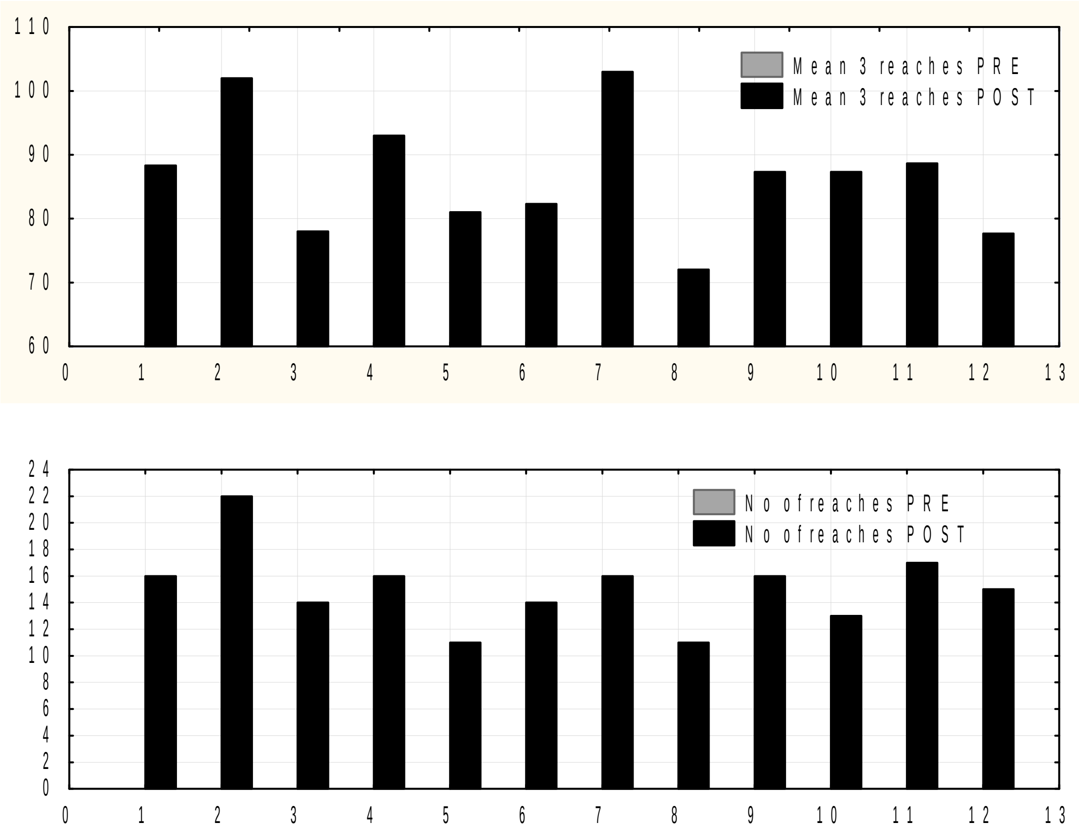

Fig. 3 Individual results of climbers in both campus board tests in PRE and POST conditions

Discussion

The purpose of this survey was to assess acute effects of post-activation potentiation (PAP) in climbing-specific power and power endurance exercises. Both exercises were performed using one of the most popular training devices, i.e. a campus board. The power exercise consisted of pulling up explosively from a hanging position, with both arms fully extended, as fast and as far as possible and reaching with one's preferred hand as high as climbers could touch. In the power endurance test, climbers performed similar movements, however at submaximal intensity and with the goal to complete as many reaches as possible in a 20 second time limit. Since proper exercise selection is of the utmost importance to induce PAP, we concluded that the criterion of biomechanical similarity was met by popular and most frequently performed resistance exercise consisting of pull-ups on a fingerboard with additional weight strapped to the climbing harness. The intensity of the pull-up was 5-RM which corresponded to ca. 85-87% of 1 RM i.e.[20] intensity within the range considered as most effective for producing PAP.[21]

Our findings suggest that climbing specific resistance exercise performed before power exercise may significantly improve the latter. Mean value of the three maximal reaches interspersed with ten second rest intervals improved by 3.11 cm, while the best result of these three reaches improved by 2.25 cm. However, not all climbers responded in a similar manner. While most of them improved their results, some athletes remained at the same level and some even decreased their performance. This is consistent with previous findings in which dependence of performance results on training status was observed.[17,22,23] However, contrary to previous findings indicating that stronger individuals presented better PAP response, in our study improvements in power exercise were observed in weakest climbers. It may, however, be related to the nature of the exercise as powerful climbers can reach so far from the starting rung that the pulling arm is fully flexed with the rung touching the edge of pectoralis major. In such condition, further movement could be possible with extending the arm in the elbow, which is extremely difficult (if possible) and, as a consequence, positive effect of the preload can hardly be expected. Considering inter-individual differences in response to a preload, one should also bear in mind that the potentiation window may be different for various athletes. Therefore, from a practical point of view, an optimal window of opportunity should be individually established for each athlete. In our study one time interval between the preload stimulus and the execution of a campus exercise was implemented. In such case for some climbers the interval might not be optimal.

In the power endurance test, eight climbers improved their performance, attaining from 1 to 3 reaches more after the preload. Two climbers decreased the performance and the remaining two presented no changes compared to baseline values. In this test, difference between two conditions reached only a trend toward significance, although the effect size was small-to-moderate. This may indicate that preloading could be also used to increase effectiveness of power endurance exercise. All in all, this problem is worth interest of sport climbing coaches from one hand, and researchers from the other hand. The latter should consider studies with more participants and different time intervals.

Conclusions

Although our study is not without limitations, it is the first in which the effectiveness of PAP on climbing specific power and power endurance exercise has been demonstrated. It is also one of the first studies dealing directly with the problem of sport climbers' training. The results indicate positive effect of weighted pull-up exercise on subsequent power exercises on the campus board. It should be noted, however, that results of the preload on campus board exercise varied between individuals and more studies are needed in order to determine the most effective protocol of pairs of exercises in sport climbers' training.

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