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THE EFFECTS OF POST-ACTIVATION POTENTIATION ON UPPER-BODY POWER PERFORMANCE IN RECREATIONALLY TRAINED MEN

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Abstract
The aim of this study was to determine the optimal rest period between PAP and medicine ball throwing, and to verify that the performance of the explosive strength of upper limbs was improved when it was preceded by 3x3 90% of 1RM on the incline bench press. Fifteen male respondents (age = 21 ± 1.53; body mass = 73.75 ± 5.18) students of Faculty of Sport and Physical Education, University of Sarajevo, participated in this research. Respondents throw the ball from sitting position, and 3, 5, 7, 10 minutes after the activation stimulus - incline bench press 3x3 90% 1RM. Analyzing the obtained results, an acute increase in the distance of the medicine ball throw was detected. The highest statistically significant pre and post-AP changes occurred in the seventh minute and amounted to 17 cm and 2.89% ($p = 0.033$). 3x3-90% 1RM IBP results in statistically significant PAP effects and optimal recovery time is 7 minutes.

Key words: **strength, students, PAP, medicine ball, 1RM**

Introduction

Improving new training strategies, in the focus as a primary aim sets the promotion of the strong performance of athletes. One of the most widely used and most applicable methods of improving these performances is PAP (Post-activation Potentiation) and implies an acute increase in the effectiveness of muscular contraction after previous muscular activity (Ebben, W. P., 2006; do Carmo et al. 2018). Just increasing this efficiency accompanied by neuromuscular changes can contribute improving performance in exercises that require strength, speed or power (Borba et al. 2017; MacIntosh et al. 2012). However, various studies revealed that PAP does not appear equally in all athletes, and that there are different parameters influencing the size of its effect, eg gender (Jensen and Ebben 2003; Rixon et al. 2007), training level (Wilson et al. 2013; Chiu et al. 2003, Pääsuke et al. 2007), muscular fiber (Hamada et al. 2000; Seitz et al. 2016), duration of contraction (Baudry and Duchateau 2004; Shima et al. 2006) etc. Also, the individual characteristics of athletes such as level of training, distribution and the ratio of different types of muscle fibers affect the size of the PAP effect (Evetovich et al., 2015).

In today's research it is not clearly defined stacking size that influences the strength of the occurrence and size of the PAP effect but the correlation, which is confirmed in many studies (Duthie et al. 2002; Kilduff et al. 2007; Xenofondos et al. 2018; Lockie et al. 2018). The study Bellar et al. (2012) noticed a positive correlation between absolute power and the distance of throwing the ball after activating stimulus by throwing balls of bigger weight. Jo et al. (2010) state that absolute strength has an impact on time course of PAP effect, and that stronger people need less time to complete recovery. Also, Seitz et al. (2014) noticed the greatest PAP effect occurs 3 minutes after activating stimulus for stronger (1RM squat ≥ 2x body mass) and 6 minutes for weaker subjects. However, study shows that there is no precise optimum time of PAP effect, especially when it comes to the power of the upper extremities.
There are indicators that the best effects are achieved between 7 minutes (de Assis Ferreira et al., 2012; Bevan et al. 2009) and 12 minutes (Kilduff et al. 2007). To be more precise, when it comes to acute improvements in ballistic movement performance, some authors report the statis-

tically significant improvements (Markovic et al., 2008; French et al., 2003; Smilios et al., 2005), while other authors have not noticed any improvement (Scott and Docherty, 2004; Jones and Lee, 2003; Koch et al., 2003).
Therefore, the general aim of this study was to verify that the performance of the explosive strength of the upper limbs was improved when it was preceded by 3x3 90% of the 1RM on incline bench press. The second purpose was to determine the optimal rest period between PAP and medicine ball throwing.

Methods

Participants

The sample subjects of this study consisted of 15 healthy, physically active male students of Faculty of Sport and Physical Education of the University of Sarajevo, without any reported upper extremity injuries in the past two years. The subjects had experience with strength training and were all physically active and had 3 to 5 trainings per week. The characteristics of subjects (mean±SD) were: age (21 ± 1.53), body mass (73.75 ± 5.18), maximum incline bench press 1RM strength - (66 ± 10.38). All subjects were previously informed in detail about the reasons and procedures of research and they signed a written consent, voluntarily.

Experimental Approach to the Problem

The subjects were asked not to do heavy training at least 24 hours before participating in this study. The research was conducted in two working days in the morning, between with one-day break. The first morning measured the weight of the examinees (BC-420MA, TANITA Europe GmbH, Sindelfingen, Germany), after which they performed a standard warm-up of 5 minutes of easy running (8 km · h-1) followed by 5 minutes of dynamic stretching (Tsoukos et al. 2016) after which 1RM was determined.

One-Repetition Maximum Bench Press

Determining maximum dynamic strength (1RM) was made according to the recommendation of Brown and Weir (2001) with the help of barbell and free weights. The subjects were asked to lie down on the incline press (28 ° incline) with head, shoulder blades, and buttocks constantly contacting the bench. The bar is lowered to the chest parallel to the nipple line, after which one pushes upward until the elbows aren't fully corrected. The 1RM was determined by using the standard procedure (Brown and Weir, 2001; Dohoney et al., 2002). After determining 90% of 1RM, the loads are gradually increased with the dumbbells of 1.25; 2.5 and 5 kg until 1RM is reached. For all subjects 90% of 1RM corresponded to their 3RM.

Seated Medicine Ball Throw

The second day included warm- up and throwing the medicine ball (4kg). The medicine ball throwing test used is recommended by the authors Harasin et al. 2006, which was performed by the subject sitting on a chair with a medicine ball (4 kg, medical volume 76 cm) in both hands on the chest. The subject was asked to throw the medicine as far as possible in a certain direction and after then the distance of the throw have been measured. There were two throws in 10 second intervals in order to avoid the acute effects of the first throwing on the second. This test is used because it is very simple and highly reproducible test of upper-body explosive performance (int. Corell = 0.97) (Harasin et al. 2006), and very often used in the training of athletes in many sports. Activation stimulus meant 3x3 with 90% 1RM after which they threw the medicine ball at certain time points of 3, 5, 7 and 10 minutes. Results of throwing distance medicine ball are marked and rounded to the lower whole number.

Statistical Analysis

The results were processed using SPSS. 23 for Windows (IBM Corp. Chicago). Arithmetic mean values and standard deviations were calculated, for all variables, followed by paired samples T-test to determine possible differences in time points. Statistical significance deemed at $p<0.05$.

Results

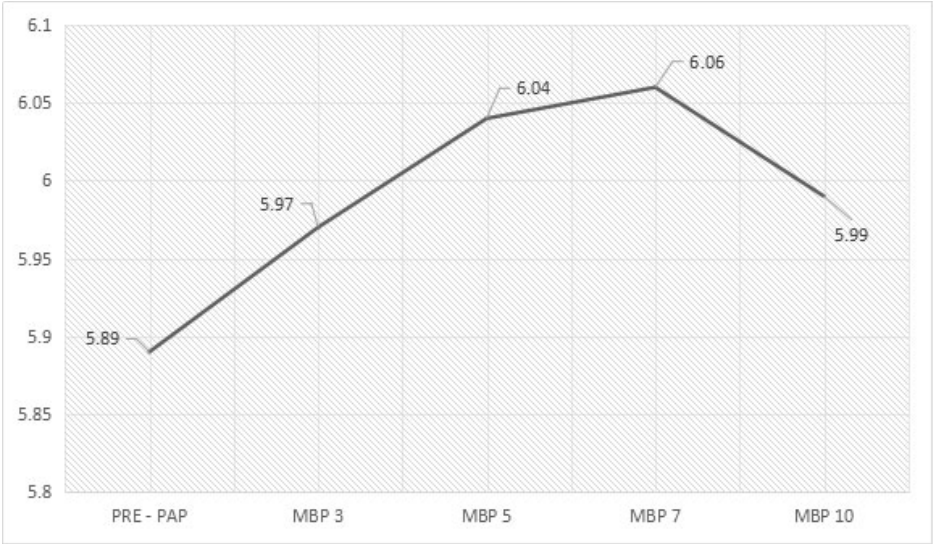
Table 1 shows the results of arithmetic means and standard deviations of treated variables. It is noticeable that the results of the pair sample T-test show statistically significant difference in the power output by throwing medicine ball only in the seventh minute ($p = .033$). Figure 1. shows the average means of the distance of medical ball throwing at certain points that were analyzed in this study.

Table 1 Descriptive values of the achieved results (n = 15)

Variables	Mean	Std. Deviation	T - test
Weight	73.75	5.188	/
IBP	66.00	10.385	/
PRE - PAP	5.89	.4760	/
MBP 3	5.97	.376	.380
MBP 5	6.04	.353	.109
MBP 7	6.06	.444	.033*
MBP 10	5.99	.452	.182

** significant at p<0.05; IBP = Incline bench press; PRE - PAP = medice ball distance before PAP; MBP3 = distance after 3 minutes; MBP5 = distance after 5 minute; MBP7 = distance after 7 minute; MBP10 = distance after 10 minute;*

Figure 1 Mean values of the distance of medical ball throwing (3,5,7,10min)



Discussion

The aim of this study was to evaluate PAP effects during upper limb power exercise after a 3x3-90%1RM IBP. Two evaluated factors were (1) PAP magnitude and (2) optimal recovery time.

The most obvious acute effect of previous highly intensive or high-performing activities is the loss of the ability to generate force. However, it has been observed that contractile history can also result in improved performance.

High intensity and/or high-volume physical activities primarily reduces force generation ability (MacIntosh i Rassier, 2002). However, it is noticed that this type of contractile history can also enhance performance for a short time (Smith i Fry, 2007; Grange et all, 1993; Sweeney et all, 1993). Previous studies have shown positive PAP effects on nerve activation magnitude (Hamada i sur., 2000; Moore i Stull, 1984; Suzuki i sur., 1988) and contractile characteristics (Hamada i sur., 2000; Vandervoort et all, 1983).

If observed in percentages, if the contraction (or contractile parameters) after the activation stimulus is 100% of the initial means, PAP does not occur, while means bigger than 100% indicate the presence of PAP and less than 100% indicates "posterior activation depression" (Mola et al., 2014) or fatigue domination over PAP effects (Chiu et al., 2003). Further in the text, the changes in measurements after the activation stimuli will be represented in percentages, compared to the initial measurement.

According to the aim and based on the results presented in the previous chapter, it is noticed that 3x3 90% 1RM incline bench press increased upper-body ballistic performance. The highest statistically significant pre and post-AP changes observed were 17 cm (2.89%; $p = .033$) seven minutes after AP while other changes, although present, were also positive but not statistically significant. Thus, the increase in medicine ball throw distance after three minutes was 9 cm (1.36%), 15 cm (2.55%) after five minutes and 10cm (1.70%) after 10 minutes.

These results are in line with the review article in which author (Bishop, 2003) who stated that medium (and stronger) intensity activation stimuli may cause acute improvement in the performance of subsequent task performance until local muscular fatigue occurs. It is important to mention that Sale (2002) stated that PAP affects subsequent performance, but the optimal parameters are not fully determined.

In addition to review articles that point to the existence of PAP effects, Hrysomallis and Kidgell (2001) did not notice statistically significant difference in the scores recorded on the force plate during explosive push-ups after a 5RM bench press activation stimulus.

Liossis et all (2013) noted that strength output increases after 65% and 85% 1RM bench press, whereas at 65% 1RM changes occur after 4 minutes while at 85% 1RM the greatest PAP effects were observed 8 minutes after activation stimulation. These findings are consistent with the results of the study since, after 90% of 1RM, the biggest difference was observed 7 minutes after AS.

Considering that the factors affecting the level of PAP: 1) the age of the respondents (Baudry et al., 2005), 2) individual's training level (Chiu et al., 2003; Wilson et al., 2013), 3) the type of sport (Pääsuke i sur., 2007), 5) the ratio of fast and slow twitch muscle fibers (Hamada et al., 2000) and 6) contraction type (Ye et al. , 2015) it is likely that the results would be a little different if sample with different characteristics was included in the study, for example professional athletes, athletes which predominantly use their upper extremities or participate in training involving mostly explosive activities.

Many argued about possible PAP mechanisms and concluded that this type of contraction is primarily associated with myosin regulatory light chain phosphorylation (Grange et al., 1993; Sweeney et al., 1993; Metzger et al., 1989) and an increase in α-motoneuron excitability (Misiaszek, 2003, Zucker and Regehr, 2002), and, additionally, the increase in central nervous system stimulation (Rixon et al., 2007) which manifests itself by increasing nerve conduction and decreasing presynaptic inhibition thus resulting in better synchronization and activation of higher order motor units (Aaagard et al., 2002; Chiu et al., 2003; Güllich and Schmidtbleicher, 1996; Tillin & Bishop, 2009)

In addition to t myosin regulatory light chain phosphorylation, some of PAP mechanisms are increased moto-neuron excitability, better motor units synchronization (Hodgson et al., 2005, Rassier and Macintosh, 2000), acute changes in muscle fiber angle (Tillin and Bishop, 2009), increase in actin-myosin binding number and better interaction (Güllich and Schmidtbleicher, 1996), improved stimulation - contraction synchronization and increased motor units activation (Zhi et al., 2005, Szczena et al., 2002) Klein et al., 2001; de Luca et al., 1996).

Conclusion

In accordance to the set of aims, it can be concluded that 3x3-90% 1RM IBP results in a statistically significant increase in the distance of the medical ball throwing distance from the chest and the optimal recovery time after activation stimulus with the amateurs is 7 minutes.

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