Original Article

The effect of high-intensity half-squat to the jump performance in recreationally active men.

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Abstract:

It was previously reported that the performance of the ballistic movements is positively affected when a maximal stimulus is preceded and this phenomenon was caused from Post Activation Potentiation (PAP). The effect of PAP on ballistic movements has not been extensively investigated between the intervals of the resistance trials during a training session. Aim of the present research was to evaluate the effect of 10 high-resistance half-squats (90% of 1 RM) on squat jump (SJ) which was performed after two different intervals between resistance trials. Fifteen recreationally active adults (aged: 20.73 ± 2.12 y) participated in the study. Resistance Maximal (RM) and maximal SJ of each participant were evaluated the same day with the test. The 10 Half-Squats trials were performed within a 5 minute rest interval between one another. On the 1st and on the 4th minute of the rest interval, the participants performed a SJ. This procedure was repeated 10 times. Afterwards, 7 minutes after the last set, participants performed a squat jump every 3 minutes for 22 minutes. For the statistical analysis, an Anova with repeated measurements (2x10) was used for jump scores between sets and an one- way Anova with repeated measurements for the jump scores after the sets. The level of significance was defined in $p < 0.05$. The statistical analysis revealed no statistically significant effect of the interval on jump height as no difference was observed between maximum SJ and the SJs performed in the first and the fourth minute of the interval. Thus, in the present research no PAP effect was found in recreationally active men on SJs performed between high-intensity resistance sets, independently of the applied interval, and also after the end of the training session. The obtained results indicate that the enhancement of performance due to PAP in ballistic movements does not always occur and fatigue does not play any role. It could be possibly attributed to the fact that subjects were not systematically active in resistance training. So this issue needs further investigation. However, from practical point of view, it seems that ballistic movements can be performed between resistance sets without interval limitation during power training.

Key words: post activation potentiation, complex training, squat jump, resistance sets

Introduction

PAP is a mechanism causing enhanced muscle performance following high-intensity stimulation. According to previous findings (Sale, 2002), after a maximum intensity stimulus such as an electrical stimulation or a maximum isometric contraction or high resistance training (1-10 RM), an improvement was observed in twitch torque and rate of force development (RFD). As a consequence, it causes, in many cases, an enhancement in the performance of explosive tasks such as jumping (Mitchell & Sale, 2011) and sprinting (Chatzopoulos et al., 2007). PAP depends on many factors (Xenofondos et al., 2010; Tillin & Bishop, 2009) such as the training level, muscle fiber type, the type and the intensity of the contraction and the fatigue. However, it is important to notice that PAP effect does not always appear in jump performance (Chiu et al., 2003).

The PAP phenomenon constitutes the basis of concept of combined training introduced by Verkhoshanski & Tatyana (1973) and includes high-intensity resistance training in combination with ballistic movements in the same training session (Kotzamanidis et al., 2005; Tsimahidis et al., 2010; Kubo et al., 2007) and especially in the untrained population (Gourgoulis, Aggelousis, Kasimatis, Mavromatis, & Garas, 2003)

The presence of post activation potentiation has been studied mainly in ballistic movements, such as sprint (Chatzopoulos et al., 2007) and jumping (Smilios, Pilianidis, Sotiripoulos, Antonakis, & Tokmakidis, 2005) when they are performed immediately after a high resistance training session. In these studies the potentiation of ballistic movements was evaluated immediately after a resistance training session. Relevant studies have shown both for jumping (Tillin & Bishop, 2009) and sprinting (Chatzopoulos et al., 2007) that the PAP effect usually appears approximately 5 min after the end of the resistance session. This phenomenon was attributed to the recovery of fatigue which was caused by the preceding resistance session. It is also important to notice that in some cases this potentiation was appeared immediately after the end of the training session (Gourgoulis, et al 2003). However, there are not many studies which examined the PAP effect on explosive movements when they are performed between resistance sets. Hamada, Sale, MacDougall, & Tarnopolsky (2000) reported a net PAP effect as twitch torque increased between consecutive isometric 5 sec contractions having 5 sec interval between them. Regarding PAP effect on ballistic movements when they are performed between resistance sets, Smilios et al. (2005) reported that jumping performance was increased after the first set and then gradually decreased in the rest sets and for a certain period after the end of the resistance session. In this point it is important to commend that jumping was evaluated approximately 1 min after the preceding resistance trial. This interval is considered that is not adequate for full recovery (Nevill, Jones, McIntyre, Bogdanis, & Nevill, 1997) which may explain the observed decrease after the first set. Consequently, it would be interesting to see the effect of PAP on ballistic movements performed in different interval periods between resistance sets.

The purpose of the present paper was to evaluate PAP effect on the Squat Jump performed in two different rest intervals between 10 high intensity Half-Squats, but also every 3 minutes after the training session for 22 minutes.

Material & methods

Fifteen recreationally active subjects with no background of systematic resistance or plyometric training volunteered to participate in this study (Table I). The procedure was conducted in accordance with the guidelines on ethics of the Aristotle University of Thessaloniki. All participants were informed about the experiment and all the potential risks associated to their participation. Before the test, they filled out a medical history questionnaire and signed the document. No medical history was reported for any of the participants.

Table I: Participants' Characteristics

Age (y)	Body Mass (kg)	Height (cm)
20.73 ± 2.12	84.25 ± 13.77	180 ± 3.1

Instruments

SJs height were recorded with a ground mounted, 40×60 cm force plate (Bertec Type 4060, Bertec Corporation, Columbus, USA). The sampling frequency was set at 100 Hz.

A Smith Machine was used for the Half-Squats resistance sessions.

Procedure

Before testing, all participants familiarized in the laboratory conditions and performed a general warming up program for 5 minutes, cycling on an ergometer (MONARK™, Varberg, Sweden) in a self selected pace with warming up exercises. After that the maximal SJ was evaluated and then the 1RM one. 10 min after each participant performed the 10 trials of 90% of 1 RM resistance with a 5 minute rest interval between one another. On the 1st and on the 4th minute of the rest interval of all resistance trials, the participants performed a squat jump (SJ1 and SJ2, respectively). This procedure was repeated 10 times. Afterwards, 7 minutes after the last resistance set, participants performed a maximal RS jump every 3 minutes for 22 minutes (As seen in DiagI.)

-----DiagI.-----

Diag I. Illustration of the testing procedure. RM indicates the 90% of 1RM trial. While 1' and 4' the SJ which was performed in the 1st and 4th min respectively, in the interval between trials.

Testing

Half-Squat Resistance: The participants stepped under the bar of a Smith Machine, in upright position, looking forward, and grasping the bar firmly with both hands to support its load upon their shoulders. They were instructed to flex their knees at 90°, with the trunk slightly tilted forward and the heels on the ground. Afterwards they returned to the starting position. Then the estimation of 1 RM was performed as previously reported (Tsimahidis et al., 2010). A week before the experiment all subjects were familiarized with the testing procedure of 1 RM.

Squat Jump: For the SJ test, the participants were positioned on the force plate and from a standing position smoothly flexed their knees at 90° with their feet on the force plate. The knee flexion was evaluated with a manual goniometer. When they were stabilized at this position on their own for 2 sec to avoid any counter movement effect, then they executed 3 maximal vertical SJs under the instruction jump as high you can which were considered for further evaluation. Before this, a specific warm up was preceded, including submaximal and 3 maximal SJs for further familiarization. Besides, the subjects were familiarized to execute the SJ from 90° of knee flexion, as previously suggested (Bobbert, 2010).

As PAP effect was considered the differentiation of all SJ heights performed between resistance trial and after the training session compared to the average value of the the 3 maximal SJs performed before resistance session (reference value).

Statistical analysis

For the statistical analysis, we used an Anova with repeated measurements (2x10) for jump scores between sets and an one-way Anova with repeated measurements for the jump scores after the sets. The significance level was defined in $p < 0.05$.

Results

According to the statistical analysis, we found no effect of the rest interval on the jumping performance ($p > 0.05$) as no difference was observed between jump height SJ1 and SJ2 performed during the interval between resistance trials. We observed also no significant effect of the resistance trial on the jumping performance ($p > 0.05$) since the height of their maximum jump did not differ from the jumps between the resistance trials performed both on the 1st and the 4th minute of the given trial (Fig.1 and Fig.2, respectively). In addition, there was no interaction of interval x resistance trial ($p > 0.05$) on jump height.

We observed no effect of the time on jumping height after the completion of the strength sets ($p > 0.05$), as the height of the maximum jump values, performed before the session, was not statistically different from the jump values from the 7th to the 22nd minute after the training session (Fig.3).

Fig.1 Jump height alteration performed 1 min after the resistance trial.

Fig.2 Jump height alteration performed 4 min after the resistance trial.

Fig.3 Jump height alteration performed (every 3min) 7 min after the end of resistance session.

Discussion

In the present research no PAP effect was found on SJs performed between high-intensity half-squats in recreationally active subjects neither on the 1st nor on the 4th minute of the given interval. In addition, PAP did not occur for the next 22 minutes after the completion of high-intensity half-squat training.

The obtained results contradict the findings of Smilios et al. (2005) study in which a PAP effect on SJ was observed 1min after the first set but thereafter SJ height decreased. The different findings could be attributed to the different protocols used by Smilios et al. (2005) since the selected intensity was 60%RM while in the present study 90% RM was applied.

The non-appearance of PAP in the 1st minute could be also attributed to the fatigue caused by the high intensity task (Rassier, 2000) in a counter balance with PAP. However, PAP did not occur even after the 4th minute that is almost a complete rest interval for the restoration of phosphocreatine (Nevill et al., 1997). It seems that in the second case the non enhancement of SJ2 is not attributed to fatigue but to the absence of PAP

per se. This fact could lead to the conclusion that possibly in the first case the non enhancement of SJ1 could be attributed to the absence of PAP, as well. Thus, it can be concluded that there is no PAP effect on SJ performance between sets independently of the applied interval. As, there is only one study (Smilios et al., 2005) regarding this issue, the effect of the rest interval between resistance sets remains to be further investigated.

Relevant studies have showed an increase of the performance in ballistic movements 5 min after high-intensity resistance sets (Chatzopoulos et al., 2005; Tsimahidis et al., 2010) due to PAP while other studies did not found a relevant improvement in jumping performance (Chiu et al., 2003). In the current study no PAP effect was observed even 22min after the end of the training session. From this finding raises the question whether PAP effect really exists in ballistic movements. The most appropriate method to evaluate PAP is the twitch torque which is not influenced by technique or any volitional factors. Twitch torque was used by Hamada et al. (2000) who proved real PAP existence via twitch torque potentiation after repetitive bouts of 5sec Maximal Voluntary Contractions although applying a very short interval. Therefore, the enhanced performance in ballistic movements performed after high intensity resistance sets should not only be attributed to the PAP effect but also to the complexity of the movement.

Additionally, it has been found that the training level of the participants play an important role in the occurrence or not of the PAP phenomenon. So PAP does not always occur in not well-trained people (Gourgoulis et al., 2003; Chiu et al., 2003; Hamada et al., 2003; Khamoui et al., 2009). As a result, we could assume that PAP did not occur in this study because the participants were not elite athletes.

A third explanation could be the selected intensity because, as mentioned above, Smilios et al. (2005) used lower intensity (60% vs 90% of 1 RM) but it contradicts previous studies which proposed that PAP effect is intensity dependent (Xenofondos et al., 2010; Tillin & Bishop, 2009) So, it would be interesting this case to be re-examined in conditions similar to these of the aforementioned study.

According to the current results, no PAP effect was found in recreationally active men on SJs performed between high-intensity resistance sets, independently of the applied interval, and also after the end of the training session. The obtained results indicate that the enhancement of performance due to PAP in ballistic movements does not always occur and fatigue does not play any role. So this issue needs further investigation. However, from practical point of view, it seems that ballistic movements can be performed between resistance sets without interval limitation during power training.

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