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Effects of Post-Activation Potentiation on Physical Performance Parameters: A Brief-Review

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Introduction

When applied correctly, techniques to induce PAP have the potential to enhance performance in high-intensity, short duration sports including: track sprinting, jumping and events, and a limited capacity to enhance performance in team sports such as Football and Rugby [1]. Defined as the increase in force of a plyometric exercise immediately following a similar heavy resistance exercise, PAP is typically applied using complex training, necessitating the performance of a high-load weight training exercise before executing a plyometric exercise with a similar biomechanical profile [2]. Heavy resistance exercise is typically low velocity, while movements such as vertical jumping involve high velocity application [3, 4]. However, more traditional methods separating the weight training and plyometric sessions could also induce PAP. It remains to be seen which method is more effective at eliciting a performance benefit, and how PAP could be best exploited to enhance sport performance.

The primary physiological mechanism responsible for PAP is the phosphorylation of myosin regulatory light chains. This biochemical reaction causes a rapid influx of calcium to create more active binding sites within the sarcomere. The second mechanism responsible for PAP is activation of higher order motor units, which allows type II fibers to produce higher force and velocity [10]. Vandenboom, Grange, and Houston found that by inducing phosphorylation of myosin light chains in mouse extensor digitorum with a 5 Hz 20 second conditioning stimulation, myosin light chain phosphate content was increased nine fold, and peak isometric force was increased by as much as 15% [11].

Chatzopoulos et al. [2] recruited 15 amateur team game (basketball, handball, volleyball, and soccer) players with a minimum of 5 years of experience in each respective sport. Subjects also regularly performed resistance training a minimum of twice per week for a minimum of 1 year prior to participating in the study. During the first session, participants tested 1 repetition maximum (1RM) back squat, and were familiarized with the equipment and experimental conditions. For the first testing session, participants executed 10 single sets at 90 percent of 1RM for the back squat. After 3 minutes of rest, subjects then performed 3 trials of a 10 meter sprint, with the best time recorded. The same procedure was used during the second session, but with a 5 minute rest between the squat and sprint. No significant enhancement of running performance after execution of the back squat during the 3 minute rest trial was noted ($p > 0.05$). The researchers hypothesized that during the first 3 minutes after the heavy stimulus, fatigue is more dominant in the muscle than PAP. The results of the 5 minute rest trial showed an improvement in running time and running acceleration ($p < 0.05$). The 5 minute rest likely provided enough time for fatigue dissipation, facilitating a significant effect of PAP [2].

McCann and Flanagan recruited 8 male and 8 female NCAA Division I volleyball athletes with at least 1 year of experience with resistance and plyometric training. During the initial testing session, subjects completed 5 repetitions of back squats at 80 percent 5RM, followed by a 4 minute rest [3]. Following rest, subjects performed two sets of five maximal effort countermovement vertical jumps on a force plate embedded in the floor, with jump height being collected using a Vertec jump apparatus. Subjects were then given 15 minutes rest before repeating the same testing procedure again, but with 5 minutes between exercises. Subjects performed the same procedure 48 hours later, but with 5 repetitions of hang clean at 50 percent 5RM. Results showed that there was no significant difference between the squat and hang clean tests. In both cases, countermovement vertical jump performance following the 4 minute rest improved significantly from the baseline vertical jump data ($p = 0.016$). Results from the 5 minute rest interval intervention demonstrated no significant improvement relative to baseline vertical jump performance ($p = 0.117$) [3].

High levels of muscular power and sprinting performance are essential in many activities required of team sport athletes [5, 6]. PAP necessitates that an athlete to perform a heavy resistance exercise followed by a biomechanically similar plyometric exercise, such as a sprint or a vertical jump, to take advantage of the enhancement in neurological facilitation associated with the heavy resistance exercise [7, 8]. Optimal rest interval and movement selection to maximize PAP across various power and speed movements are still in question, with multiple studies have tested varying exercises and rest intervals in an effort to optimally

induce PAP [12]. Wong, Dobbs, Watkins, and Barillas conducted a study using sled towing as the loaded PAP stimulus, and found mixed results among subjects in regards to value of attempted PAP in a 30 meter sprint [9]. The researchers concluded that PAP was highly individualized based on rest time, with some subjects showing evidence of PAP across a broad variety of rest intervals.

Bevan et al. [7] recruited 16 professional rugby players. At the time of entry, all players had recently completed a power phase in the annual training cycle that incorporated Olympic lifts and complex training. Participants tested 3RM squat in a familiarization session 48 hours prior to the first testing session. Subjects completed baseline 10 meter sprints in the beginning of the testing session after a warm up routine. Subjects performed a 3RM squat as the preload stimulus, then performed a 10 meter sprint after 4, 8, 12, and 16 minutes of rest. No significant increase in sprint performance among subjects for any of the rest intervals was noted ($p = 0.401$). However, the study reported large variance of responses between individuals based on rest time [7]. Approximately 53.3% of subjects demonstrated significantly improved sprint times 8 minutes after the squat preload stimulus. While results were not significant for the whole group, adequate individualized rest time could show improvement in sprint time due to PAP [7].

While PAP is an interesting phenomenon, its applicability to sport is still very much in question. With the present knowledge and understanding of this phenomenon, functional application would be fairly limited due to the relatively significant amounts of required equipment and time to induce PAP prior to sporting events and have the potentiated state last longer than only a few minutes. Future studies should explore the decay rate of PAP to determine exactly how long a muscle remains in a potentiated state following a contraction. It would also be beneficial to determine the effects of repeatedly inducing PAP using maximal contractions and the role of acute neuromuscular fatigue in hindering the physiological effects.

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