# *Postactivation Potentiation and Athletic Performance*

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## Introduction

Postactivation potentiation (PAP) refers to the enhancement of muscle function following a high force activity. For instance, increased muscle twitch properties have been documented following electrical stimulation. This improvement in muscle performance makes the high force activity an attractive option as a warm-up prior to competition. Although these enhanced contractile properties have been consistently observed in the laboratory using single muscle fiber or isolated muscle models (1 – 3, 6, 7), attempts at augmenting whole-body movements has produced mixed results (4, 5, 8, 11 – 17). Most studies have typically assessed jump or sprint performance following a back squat because the potentiating exercise exhibits the greatest transfer to biomechanically and/or physiologically similar events (e.g. jumping and sprinting, which require rapid force expression from the hip and knee extensors).

## PAP and Jump Performance

The majority of current, and prior, PAP research utilized heavy load back squats as the high force activity prior to jumping. Performance after the back squat intervention improved in several studies but not others (4, 5, 8, 11, 13-15, 17). With respect to those that demonstrated the benefits of a potentiating back squat, an early study by Young et al. (17), found an increase in loaded countermovement jump height after a 5RM back squat. Likewise, Chiu et al. (4) demonstrated improvements in jump power after a back squat intervention of 90% 1RM in athletes but not recreationally trained subjects. Similarly, Saez Saez de Villareal et al. (13) found greater jump height in professional volleyball players after a cluster of back squats consisting of 2 sets of 4 reps, 2 sets of 2 reps, and 2 sets of 1 rep at 80-95% 1RM. Gilbert and Lees (5) found increased jump heights following 5 sets of 1 at 100% 1RM in elite throwers and power lifters while Weber et al. (15) observed greater peak and average squat jump heights following a 5RM back squat intervention in collegiate track and field athletes. In contrast to these results, Khamoui et al. (8) did not find significant improvements in vertical jump height, ground reaction force, impulse, or velocity at take-off after 2, 3, 4, or 5 repetitions of an 85% 1RM back squat in recreationally trained men. Scott and Docherty (14) also found no significant increase in horizontal or vertical jump performance following a 5RM back squat in subjects with a year of back squat experience. Collectively, these results indicate that a potentiating exercise can be used to enhance jumping performance but the optimal factors to elicit the best outcomes still need to be identified.

## PAP and Sprint Performance

Several studies have also examined sprint performance following a high force back squat intervention. McBride et al. (12) assessed 40-meter sprint performance in collegiate football players and reported a decrease in completion time subsequent to 1 set of 3 back squat repetitions at 90% 1RM. In similar fashion, Yetter and Moir (16) found increased speed during the 10-20 and 30-40 meter intervals of a 40-meter sprint after a back squat intervention consisting of 5 repetitions at 30% 1RM, 4 repetitions at 50% 1RM, and 3 repetitions at 70% 1RM in football, track and field, and weightlifting athletes. Though the quantity of research investigating linear speed and acceleration after a potentiating exercise may not be as vast as jumping, it appears that a heavy load back squat could potentially augment sprint performance.

## PAP and Subject Characteristics

The studies mentioned above seem to implicate an important role of subject training status in the capacity to generate and benefit from PAP. A quick examination of those investigations which observed improvements in jumping and sprinting, revealed that subjects had resistance training backgrounds in addition to current competitive experience in weightlifting, football, track and field, or volleyball. This indirectly points to an influential role of training history on the ability to benefit from PAP. More specifically, the physical requirements of weightlifting, football, track and field, and volleyball suggest that individuals with a capacity for rapid force generation may be ideal for benefiting from a potentiating exercise. Khamoui et al. (8) also provided support for this idea as they reported significant decreases in vertical jump ground reaction force and impulse following an 85% 1RM back squat in recreationally trained men, indicating a fatiguing effect of the potentiating exercise rather than a potentiating one. It should be noted, however, that Young et al. (17) classified subjects as recreationally trained and still observed improvements in loaded countermovement jump height after a 5RM back squat. The broad classification of recreationally trained individuals may have contributed to this discrepancy. In any case, much more support can be found for the potential benefits of PAP in explosively trained athletes compared to recreationally trained individuals.

## PAP and Potentiating Exercise Load

The studies reviewed above also seem to strongly establish the efficacy of heavy back squats as an appropriate stimulus to induce PAP. A variety of back squat loads ranging from 70% 1RM up to 100% 1RM improved subsequent whole body performance (4, 5, 8, 12, 13, 15 – 17). The majority of investigations which observed performance enhancements used loads in the 85 – 90% 1RM region. The most effective load within the heavy range has not been established and the influence of load assignments within that range on performance outcomes, if any, would be a relevant question to investigate. Furthermore, back squat loads closely relates to subject training status, as individuals must be able to perform the exercise such that fatigue will not hinder subsequent whole body performance. In any case, the literature seems to agree upon the use of a heavy load back squat to generate PAP (>70% 1RM).

## PAP and Recovery Duration

Kilduff et al. (9) assessed vertical jump power within 15 seconds, 4, 8, 12, 16, and 20 minutes following a 3RM back squat in professional rugby players. Peak power increased significantly 8 and 12 minutes post-intervention. Another study by Kilduff et al. (10) examined vertical jump height within 15 seconds, 4, 8, 12, 16, 20, and 24 minutes after a back squat intervention of 3 sets of 3 repetitions at 87% 1RM. Post-back squat assessment of jump height revealed a significant improvement in jump height at 8 minutes but not any other time. In highly trained rugby athletes, 8 – 12 minutes appears optimal, however, this value may be a function of other variables such as load and volume of the potentiating exercise and subject training status (i.e. greater recovery periods for greater back squat loads, back squat volume, or less trained individuals).

## Conclusion

The equivocal results of previous PAP research suggest that a strategy to best exploit this physiological event requires identification. The nature of the potentiating exercise may influence performance outcomes and would be a logical area to begin identifying the optimal parameters of the high force activity. Characteristics of interest include the load and volume of the potentiating exercise, and recovery duration following the potentiating exercise. Perhaps the foremost issue regarding PAP research would be to establish a greater degree of confidence with the population who would best be served by a potentiating exercise (athletes, specific athletic groups, recreationally trained individuals) followed by determination of the optimal characteristics of the potentiating exercise (load, volume) and recovery durations for that population.

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