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Post Activation Potentiation for Muay Thai Kicking Performance

***Lee Brown[1] Dr Gary Doyle[1] Dr Stewart Bruce-Low[1] Silvino Domingos[1]**

Karl Anthony[1] Fionn Rowan[1] Dr Andy Galbraith[1]

[1] Health, Sport and Bioscience, University of East London, London, United Kingdom

* Corresponding author

*Lee Brown

l.brown@uel.ac.uk

Ph: +44 0208 2232 713

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Abstract

The purpose of this study was to investigate the effects of Post activation potentiation (PAP) on Muay Thai kicking performance based on three different rest intervals using the roundhouse and Teep kick. Seventeen males (25.3 ±3.6 years old; 179.3 ±2.3; 78kg ±5.2), experienced Muay Thai fighters completed a standardized warm-up, of a ten-minute cycle on the Wattbike at 70rpm and thirty body weight squats. Four squat repetitions to their maximum effort were performed, calculated from their percentage of 1RM, then the subjects rested in a holding area, for two, five and eight minutes on separate days with 72hours between each condition, then the subjects struck the PowerKube Tm using the roundhouse and Teep kick technique. The alpha level of significance set for the study was $\rho \leq 0.05$. Significant increases in both roundhouse (χ^2 (3) = 32.9, $p \leq 0.001$) and Teep kick, (χ^2 (3) = 23, $p \leq 0.001$) striking power were observed when compared to baseline. A post hoc test, Wilcoxon rank test showed that when subjects rested for 2 minutes this resulted in a small effect size for the roundhouse (r =0.1) and the Teep (r =0.2) and was not significant for either kick strike (p = $\geq$0.05), whereas both five- and eight-minute rest periods was significant ($p \leq 0.01$) and a large effect size (r = 0.6) with the roundhouse, and the Teep kick at five minutes rest demonstrated a moderate effect (r = 0.4) and large effect (r = 0.6) for eight-minutes rest. The results indicate that longer restorative periods greater than 5 minutes are required to allow for superior PAP effects for increased power output. This demonstrates that PAP is highly effective at increasing power output in Muay Thai kicks and could be placed into an athletic training programme to induce performance increases.

Keywords- Muay Thai, Thai boxing, PAP, post activation potentiation training.

Introduction.

Muay Thai is a combat sport, originated in Thailand and is referred to as the art of the eight limbs, where Competitors can kick, punch, knee, and elbow their opponents, as well as using a clinch (19,20, 26). A Muay Thai bout can run up to five rounds of three minutes each but is sometimes shortened depending on the competitors' competence and experience. As is the case with most combat sports, contestants are matched according to their weight. Fitness is be acquired in Muay Thai by a traditional mixture of running, pad work, strength and fighting. Most athletes are averse to strength training for fear of losing flexibility and gaining body mass (24). The latter aspect is critical and creates a substantial obstacle, as athletes frequently compete at their lightest feasible weight to battle against opponents of lesser mass (26).

Combat sports that have benefited from advancements in strength and conditioning science, where research has analyzed sport-specific kinematics that enable coaches to identify exercises that are specific to generate force output, improving athletic performance when compared to traditional training methods (24). In Muay Thai, the roundhouse kick can be an effective technique when powered by a high hip angular velocity; Diniz et al. (10) found that when comparing the roundhouse kick technique used in other striking based martial arts to Muay Thai, the angular velocity of the hip is greater and can produce a higher impact, causing increased damage to gain points or incapacitate their opponent. The Teep kick (front push kick) also has similar efficacy; it is one of the most used techniques in Muay Thai for attacking and countering attacks from the opponent (14,19,22).

Identifying training modalities that effectively increase force production that can be transmuted through the core to the striking limbs is beneficial to winning performances in combat sports such as boxing and Muay Thai (8). Post activation potentiation (PAP) is of a phenomenon of increased power output after a maximum strength contraction through resistance exercise. Where an increase in type II muscle fiber motor unit recruitment, rate coding and low-frequency tetanic force (3, 20) which can be readily applied to elicit increased rate of force development (RFD) for athletic performance, has been observed. Myosin regulatory light chain (RLC) phosphorylation is increased in type II muscle fibers during PAP, making the actin-myosin complex more sensitive to calcium (Ca2+), increasing muscle twitch response (5).

PAP requires the execution of the working muscles in a maximal voluntary contraction activity, i.e., the back squat, leading to increased muscle force exertion (18, 23). Sale (20) found mainly through type II muscle fibers as myosin RLC have greater phosphorylation potential. Xenofondos et al. (27) found that muscles mainly consisting of type II fibres will show greater PAP, but this also dependent on the training background. Given the importance of Type II fibres and the net balance of potentiation and exhaustion, the individual's athletic status will almost certainly play a role in determining the best way to induce PAP.

When training for PAP to target specific increases to the RFD, rest interval periods are placed between the preceding maximal loaded exercises, such as squats or bench press with low volumes, followed by explosive conditioning activity such as a punch or kick strike. Research into PAP has been conducted to examine different timings for rest interval periods to identify the most effective potentiation effect (25); Bevan et al. (4) demonstrated that eight minutes was the optimal rest time for the improved sprint times succeeding maximal squats. Do Carmo et al. (11) described rest intervals that elicited the most significant results in vertical jump athletes were determined by the subjects in the study, as opposed to preset intervals, which may allow for adequate recovery. According to studies (1, 2, 3), PAP is higher in those with an increased strength baseline, which suggests that strength levels is an essential factor when being applied to athletic populations.

The proposed purpose of carrying out PAP is to improve performance for a specific modality, through a concept called complex training, which occurs from an increased peak force (5,6,7). Although there is no current clear indication of rest periods that are known for PAP in complex training, for Muay Thai, Aandahl et al. (1) used elastic band tubing to initiate a PAP response in a warm-up with a velocity increase of 3.3% with Taekwondo style kicking. A handful of studies have been carried out on complex training that would contrast the entirety of variables and sporting movements sought by using PAP, and without an abundant of longitudinal studies for this phenomenon, the question of how it can be placed adequately and effectively by a coach into the training regime (16,17).

Turner (24) hypothesized that complex training is an effective stimulus for neuromuscular adaptation and can be used in conjunction with Olympic lifts, where rest periods and intensity are high and volume low, which is suited for the maximum strength, power, transition, and tapering phases of athletic preparation periodised modelling protocols (15), allowing for integration to the training programme without interruption (9). The purpose of this study was to investigate the effects of PAP on Muay Thai kicking performance based on three different rest intervals, where there is a dearth of studies that have investigated the specific effects of PAP on Muay Thai. Therefore, this study aims to quantify and indicate timing protocols for conditioning coaches when training athletes that may be used in complex training.

METHODS.

Approach to the problem.

A repeated measures design was used to compare different restorative periods to test the hypothesis that longer rest periods improved the PAP response, when striking with a Teep and Roundhouse kick. The subjects had their baseline strength testing prior to PAP testing to ensure they could lift over 1.5times their bodyweight. The subjects were then instructed to repeat the same protocol three times but each time using a different rest interval (2,5 and 8 minutes). Each condition was randomly assigned an order for each participant to ensure there was no order bias.

Subjects.

Seventeen males (25.3 $\pm$3.6 years old; 179.3 $\pm$2.3; 78kg $\pm$5.2), experienced Muay Thai fighters from gyms based in London with a minimum of two years competitive experience with 32$\pm$7professional bouts, a with over two years in resistance training experience (3.2 $\pm$0.9). All subjects reported being clear of injury for a minimum of six months free from ill-health. Participant's stature (Seca 213, Birmingham, UK) and body mass (Seca 761, Birmingham, UK) were measured before testing. All subjects provided written informed consent to participate, and the study was approved by the institutional ethics committee at the University of East London.

Procedures.

Subjects arrived at the laboratory in a rested state, with no exertional work or physical training prior to testing 72 hours before. BASES participation to exercise questionnaire was completed by the subjects, showing no illnesses or injuries, and cleared for testing.

Baseline strike power testing:

Baseline testing used the PowerKube^{TM} (Birmingham, U.K) to measure the impact power produced (Watts) for the roundhouse and Teep kick, all subjects were given a familiarization session with the Muay Thai coach overseeing technique (Figures 1&2). A baseline was taken two days before the first PAP protocol and before the squat 1RM testing, with an hour to recover. The PowerKube ^{TM} identifies the striker's impact power using a padded dynamometer (8), being preferred over a metal force plate which has an increased risk of injury when struck by forceful kicks; overseen by their Muay Thai coach to ensure correct technique was performed. Three strikes, using the roundhouse and then three strikes using the Teep kick were carried out by each participant after a 10-minute cycle on a Wattbike Pro (Nottingham, U.K.) at 60watts. Dynamic stretches preceded the strikes, which were carried out by experienced fighters that were overseen by qualified and experienced K1 coaches and the best of ten strikes recorded.

Baseline strength testing:

Subjects tested for maximum strength using the NSCA one repetition maximum (1RM) protocols for back squat (15). A ten-minute cycle on the Wattbike (Nottingham, U.K.) at 60watts preceded thirty bodyweight squats and then rested for two minutes. The subjects then preformed their 1RM, strength testing, which was overseen by an NSCA certified and registered strength and conditioning specialist (CSCS, RSCC) to spot the lifts and identify the correct technique.

Post activation potentiation testing protocols:

Between the initial baseline testing and the following 48 hours, subjects were instructed to avoid strenuous exercise After 48hours had passed from completing the baseline testing, the subjects were required to attend a further laboratory session. Warm up was completed that consisted of a ten-minute cycle on the Wattbike at 60watts followed by a series of dynamic stretches for safe lifting. This was followed by the subjects performing thirty bodyweight squats, then resting for two minutes. Four squat repetitions to their maximum effort were performed, calculated from their percentage of 1RM. Following the squats, the subjects rested in a holding area, allowing them to sit and wait for eight minutes, then the subjects struck the PowerKube Tm with ten roundhouse and ten Teep kicks, with the highest scores recorded.

This was then repeated identically for each subject with the interval being changed to either a five-minute rest, or a two-minute rest. Each of the protocols was conducted with a 72hours rest in between to ensure there was full recovery from any residual neuromuscular fatigue (15).

Statistical Analyses.

Descriptive statistics for all variables are expressed as a mean ± SD, and the alpha level of statistical significance was set at $p \leq 0.05$ (SPSS Version 21.0; SPSS Inc., IL, USA). Shapiro-Wilk statistics showed the data to be not normally distributed, hence a Friedman test was used to identify any significance differences between groups. Scale data produced by the PowerKube (watts) was ranked in ordinal format to produce the Friedman test in SPSS (12). Post hoc test, Wilcoxon signed rank test was carried out for significance between groups and effect sizes (r) were calculated with between timing intervals and baseline. Effect size and the magnitude is rated at 0.1 - 0.3 = small effect; 0.3 - < 0.5 = moderate effect; >0.5 = large effect (12,13).

Figure 1. Roundhouse strike on the PowerKube^{TM}.

Figure 2. Teep kick on the PowerKube^{TM}.

RESULTS.

Significant increases with roundhouse striking power were observed when compared to baseline (χ^2 (3) = 32.9, $p \leq 0.001$) and Teep kick, (χ^2 (3) = 23, $p \leq 0.001$). Resting for two minutes did not produce significant results for the Roundhouse ($p = \geq 0.5$). and the Teep kick ($p = \geq 0.5$). Rest times of five minutes were significant for both Roundhouse significant ($p = <0.01$) and Teep kick ($p = \leq 0.01$) and for and eight minutes rest with the Roundhouse ($p = \leq 0.01$) and Teep kick ($p = \leq 0.01$). Effect sizes between timing intervals and baseline as seen in tables 1&2, showing that resting for less than five minutes had a small effect for the roundhouse ($r = 0.1$) and the Teep ($r = 0.27$). Both five- and eight-minute rest periods saw a large effect size on the roundhouse ($r = 0.6$). However, the Teep kick was identified, as seen in table 2, as a larger effect size at eight minutes ($r = 0.6$) with a moderate effect for the five-minute rest period ($r = 0.49$). Roundhouse striking performance was improved by

30.4% after eight minutes rest with 37.2% with the Teep kick performance, five minutes for the Roundhouse was 20.7% and Teep kick improved by 30.21%. Striking performance on the roundhouse changed 2.4% negatively and only 13.5% improved for Teep kick. Figures 3&4 displaying the differences in change between groups from baseline.

Table 1. Power outputs differences in Watts, between baseline and rest intervals for roundhouse kicks

Rest intervals for subjects (n=15) roundhouse kicks	Mean differences between baseline and condition(W)	Percentage change from baseline	Effect sizes for the roundhouse kicks (*r*)
Two minutes	-585 (+ 824)	2.4	0.1 (small effect)
Five minutes	7560* (+ 1453)	20.7	0.6 (large effect)
Eight minutes	10544* (+ 1219)	30.4	0.6 (large effect)

* Denotes significant difference between groups (p<0.01)

Table 2. Power outputs differences in Watts, between baseline and rest intervals for Teep (front) kicks

Rest intervals for subjects (n=15) Teep kicks	Mean differences between baseline and condition(W)	Percentage change from baseline	Effect sizes for the Teep kick (*r*)
Two minutes	1096 (+1818)	13.5	0.27 (small effect)
Five minutes	2624*(+1604)	30.21	0.49 (moderate effect)
Eight minutes	3251*(+1892)	37.2	0.6 (large effect)

*Denotes significant difference between groups (p<0.01)

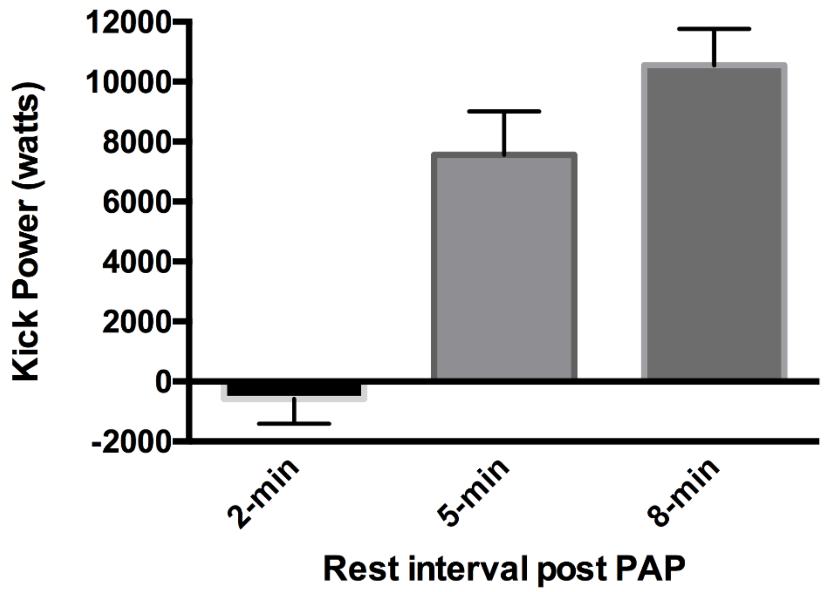

Figure 3. Roundhouse kick mean differences between the baseline and rest periods (2,5 & 8minutes), demonstrating the increase in power output with longer periods rested and the shorter 2minute period negated performance.

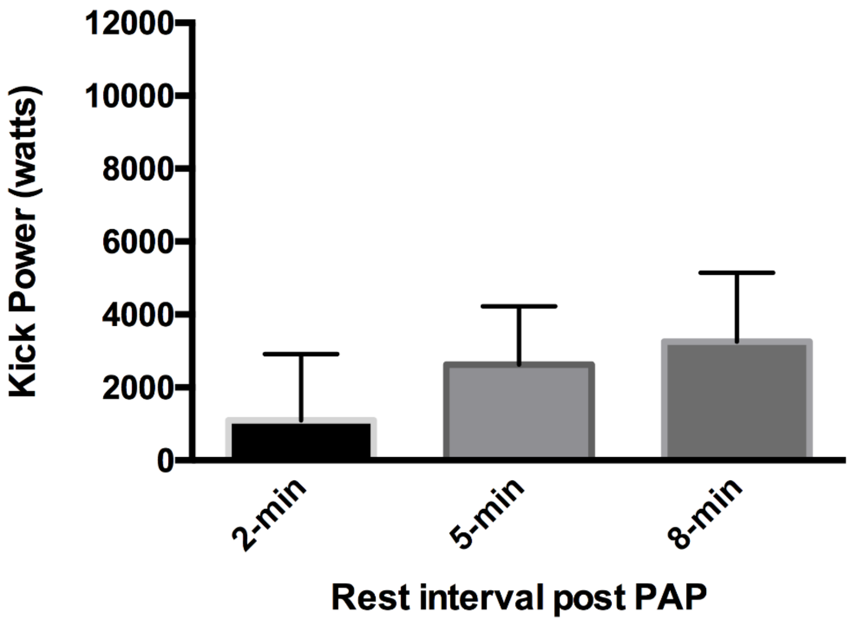

Figure 4. Teep kick mean differences between the baseline and rest periods (2,5 & 8minutes), demonstrating the increase in power output with longer periods rested, but, showing a positive influence at the shorter 2minute rest time than the roundhouse.

DISCUSSION.

The result from the current study shows a significant change ($p<0.001$) between groups from baseline of striking power output to differing rest times, with longer periods of five- and eight-minutes rest to show the largest effect size changes ($r = 0.49 – 0.6$). Smaller effect sizes ($r = 0.1-0.27$) were demonstrated by the shorter timing of two minutes, which reflects other research in different sports and exercise modalities (11,16). All subjects were strength trained and had considerable combative experience, which again is seen in previous literature (1,2, 3), gives a positive result in athletic performance, although the underlying mechanisms are still to be thoroughly determined.

However, given the importance of Type II fibres and the net balance of potentiation and exhaustion, the individual's features will almost certainly play a role in determining the best way to induce the PAP phenomena. PAP is higher in stronger subjects, according to studies, which suggests that strength levels may be an important predictor of PAP and should be taken into consideration when planning periodised training cycles (20, 21, 23, 27). The subjects in this study all demonstrated strength level baselines above 1.5times their bodyweight in their one repetition maximum, which would agree with current literature on the need for existing strength levels to be high for PAP (2, 4,7, 16)

The effectiveness of complex training across a short training cycle, where club and experienced level athletes who participated in a periodized complex training cycle improved their lower body power production significantly (16,17, 21). These studies illustrate how, with the right combination of relatively well-trained athletes and appropriate intra-complex recovery, complex training for power development may be efficiently implemented in a training cycle. With this study, it is seen that PAP, with longer rest times (5-8mins) is seen to produce higher power output with kicking, with an integrated complex training system in place, this would be beneficial to the Muay Thai fighters' performance by improving the ability to exact more powerful strikes on their opponents.

The squat, performed in this study prior to execution of the kicks, focuses on hip and lower limb extension, which is kinematically similar the Teep kick and the motor unit firing patterns that are improved during training of these exercises would likely enhance the firing pattern of these motor units during both strikes. When placed in a block training programme, it is seen that this stimulus will crossover to athletic performance (17) and improve rate of force development due to the change in neuromuscular and muscle cell adaptions. Safe and effective maximal exercises that are relatively specific to the mode of explosive post exercise are recommended, although exercise selection efficacy has not been thoroughly examined in current literature.

The only foreseeable challenge is how to employ the rest intervals efficiently between complex pairings and workout sets, with the coach being unlikely to allow the athlete up to eight minutes of waiting around, where the athlete may become disinterested. A viable option is to tailor mobility and/or stability drills for unaffected limbs that are not being used in the complex training session (i.e., upper body/core corrective exercises for lower body complex exercise sets) with the goal of resolving inefficient movement patterns that might lead to decreased performance and increased injuries. Addressing muscle asymmetries in the rest period by implementing slow and light intensity mobility movements could enhance this rest period and not causing fatigue.

PRACTICAL APPLICATIONS.

Maximum strength and power phases in periodised programming require the athlete to rest between 3-8minutes between sets, dependent on intensity (15), to allow for optimal recovery for repeated work at the same rate, with high intensity and low volume. Work rates at high intensity require longer restorative periods to allow for neuromuscular recovery, which suits the stimulus of complex training; a carryover of high intensity exercise modalities, followed by 10 reps of strikes for PAP to be effective and to transfer the potentiation to the neuromuscular system for increased power output. Therefore, coaches are advised to carry out PAP within complex training in the maximum strength and power macrocycles of the periodised block, where restorative periods are already set to similar times of PAP recovery. This also applies to tapering for competition, where the athlete's volume is decreased and the intensity is high to maintain rate of force development, without central fatigue and will give the ideal stimulus to the central and peripheral nervous system to increase firing rates and therefore power output.

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