EFFECTS OF A POST-ACTIVATION POTENTIATION WARM-UP ON SUBMAXIMAL PARALLEL BACK SQUAT VOLUME, RATING OF PERCEIVED EXERTION, PEAK VELOCITY, AND PEAK POWER.

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ABSTRACT

EFFECTS OF A POST-ACTIVATION POTENTIATION WARM-UP ON SUBMAXIMAL PARALLEL BACK SQUAT VOLUME, RATING OF PERCEIVED EXERTION, PEAK VELOCITY, AND PEAK POWER.

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Resistance training (RT) is effective for improving athletic performance, with specific training loads and volumes dictating the adaptations. A warm-up is necessary to safely and effectively engage in RT: typically with a low intensity aerobic activity, stretching, and movement specific potentiating exercises. Post-activation potentiation (PAP) acutely increases muscular power following a conditioning contraction, though limited research has assessed its use for RT. The purpose of this study was to assess how a PAP warm-up protocol affects volume, rating of perceived exertion (RPE), and peak velocity and power with 75%1RM in the barbell parallel back squat (PBS) exercise across 4 sets. With 26 resistance-trained college aged males, significant differences between sets were found only for repetitions ($p < 0.01$) and RPE ($p < 0.01$). A significant interaction effect was found only between interventions and repetitions; only the first sets were significantly different ($p = 0.045$). These findings suggest a PAP warm-up may increase volume in only 1 set to volitional fatigue. However, the 2.8% increase in volume across all 4 sets could be significant for practical applications in a training program.

Keywords: Hypertrophy, Strength, Power, Resistance Training

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INTRODUCTION

Resistance training (RT) is effective for improving athletic performance through adaptations of the nervous, muscular and endocrine systems, enzymatic and metabolic processes, connective tissue, and body composition (Haff & Triplett, 2016). Specific training loads and volumes dictate the type of responses and adaptations that occur following RT. Desired adaptations are typically periodized where the focus for athletic performance prior to a competitive season begins with hypertrophy, and shifts to strength and power in a macrocycle (Haff & Triplett, 2016). Muscular cross-sectional area is increased through hypertrophic training, allowing increases in strength and power as more muscle mass allows more force production and at a faster rate (Haff & Triplett, 2016). Lower body strength and power are desirable skills for sports performance as they are highly correlated with maximal running, jumping, and change of direction ability (Delecluse, 1997; Keiner, Sander, Wirth, & Schmidtbleicher, 2014; Seitz, Reyes, Tran, de Villarreal, & Haff, 2014). The barbell back squat is one of the most utilized and useful exercises for increasing lower body hypertrophy, strength, and power for athletic performance (Chandler & Stone, 1991).

The specific adaptations to imposed demands (SAID) principle applied to RT states a specific type and threshold stimulus is required for further muscular adaptations to occur (Haff & Triplett, 2016; Schoenfeld, 2010; Toigo & Boutellier, 2006; Vierck et al., 2000). Controllable variables dictating the threshold stimulus include exercise type, range of motion, volume, load intensities, interset rest times, and contraction speed

(Bloomquist et al., 2013; Chandler & Stone, 1991; Esformes & Bampouras, 2013; Kreiger, 2010; McCaulley et al., 2009; Schoenfeld, 2010). Proper technique and prescription of volume, intensity, and interest rest times are necessary to safely achieve desired improvements in hypertrophic adaptations from chronic RT, with stronger individuals requiring greater volume and loads (Howe, Read, & Waldron, 2017; McCaulley et al., 2009; Schoenfeld, 2010; Schoenfeld et al., 2015). A dose-response relationship exists between RT volume with intensities of 75%1RM and hypertrophy adaptations (Haff & Triplett, 2016; Howe et al., 2017; McCaulley et al., 2008; Schoenfeld, 2010). A greater stimulus from increased volume and loads for greater mechanical tension, muscular damage, or metabolic stress is required for further hypertrophic adaptations for resistance trained individuals (Howe et al., 2017; Schoenfeld, 2010; Smilios, Pilianidis, Karamouzis, & Tokmakidis, 2003).

A thorough warm-up is a necessity to safely and effectively engage in RT at intensities of 75%1RM or greater, especially for resistance trained individuals where 75%1RM or greater equates to lifting substantial loads that may increase risk of a musculoskeletal injury (Haff, & Triplett, 2016). Various warm-up strategies fall under the ‘RAMP’ protocol: raising heart rate, respiratory rate, and body temperature with general warm-ups from engaging in low intensity aerobic activities, various types of stretching to activate and mobilize the muscles and joints to be used, and finally to potentiate by progressively increasing intensity of movement specific exercises for acutely improving muscular performance (Behm & Chaouachi, 2011; Haff & Triplett, 2016; Jeffreys, 2007; Ribeiro et al., 2014; Sa et al., 2015).

A post-activation potentiation (PAP) warm-up has been proposed to enhance performance for sport-related movements, specifically for explosive jumping, running, or throwing activities through an acute increase in muscular power following a near-maximal or maximal conditioning contraction (Evetovich, Conley, & McCawley, 2015; Hodgson, Docherty, & Robbins, 2005; Kilduff et al., 2007; Tillin & Bishop, 2009; Weber, Brown, Coburn, & Zinder, 2008). Current studies utilize PAP for subsequent explosive activities involving light loads or unloaded bodyweight movements, which has predominantly been shown to be an effective means of increasing peak and average power output in resistance trained individuals by an average of 2.3% to 8% (Kilduff et al., 2007; Tillin & Bishop, 2009; Wilson et al., 2013). PAP improves power related activities through proposed mechanisms related to acute structural and physiological changes to increase the efficiency of muscular contractions following near maximal or maximal muscular contractions that are not too fatiguing (Hodgson et al., 2005; Tillin & Bishop, 2009). Acute changes are phosphorylation of myosin regulatory light chains which may increase sensitivity to muscle contractions stimulated from Ca^{2+} release, decreased angles of pennation of muscle fibers to allow for increased rate of force production, and the size principle theorizes recruitment and increased sensitivity of all available Type II muscle fiber motor units follow near maximal contractions (Hodgson et al., 2005; Tillin & Bishop, 2009).

Limited research has been conducted on the effects of PAP on essential variables related to RT, with the exception of one unpublished study by Björk (2014) showing an acute increase in volume with strength training loads for a single set. Björk (2014) found more repetitions to volitional fatigue could be completed with the barbell back squat exercise, in a single set with 80%1RM, following a set with 85%1RM for 1 repetition. Though significant for a single set, research shows increased benefit of multiple sets for resistance trained individuals to further hypertrophy adaptations (Krieger, 2010). Therefore, the purpose of this study was to assess if a PAP warm-up protocol may increase squat volume at intensities recommended for muscular hypertrophy, lower ratings of perceived exertion (RPE), and increase peak velocity and power in resistance trained men across multiple sets.

METHODS

Experimental Approach to the Problem

A total of 3 experimental days, performed at the same time of day for each subject, with at least 2 days between each trial was completed. Each experimental day began with the same standardized warm-up that included a low intensity cycle ergometer warm-up and a series of guided dynamic stretches to improve lower body range of motion: which included bodyweight squats, lunges in multiple planes, and controlled hip rotations. Subjects performed a 1-repetition maximum (1RM) PBS test on the first day based on the National Strength and Conditioning Association (NSCA) guidelines following the standardized warm-up (Haff & Triplett, 2016). The following 2 sessions followed a counter-balanced design to minimize learning or order effects. Each session involved the standardized warm-up and either the PAP or non-PAP warm-up for the PBS, followed by 4 sets of 75%1RM to volitional fatigue as seen in Figure 1. Completing 3 repetitions with 85%1RM has successfully been used in other studies, and was intended to be a near maximal contraction without being too fatiguing as it is below the maximum allowable repetitions with this intensity, and intensities up to 93%1RM can decrease squat performance (Björk, 2014; Haff & Triplett, 2016; Weber et al., 2008). To minimize a warm-up effect from greater volume load with the PAP warm-up, volume load of the non-PAP warm-up was equated with an extra set of 4 repetitions with 75%1RM.

Volitional fatigue was reached when the subject could no longer complete a repetition on their own. Training to volitional fatigue has been recommended in order to ensure meeting adequate threshold stimulus for hypertrophic adaptations (Dankel et al., 2016; Howe et al., 2017). Multiple sets at intensities between 67% to 80% have been shown to be more beneficial for inducing hypertrophic adaptations than a single set (Haff & Triplett, 2016; Krieger, 2010). An 8-minute rest period followed the PAP or non-PAP warm-up as researchers have shown the greatest increase in power output 5 to 12 minutes following a conditioning contraction (Kilduff et al., 2007; Seitz, Villareal, & Haff, 2014). 90-second interset rest intervals were chosen for hypertrophy training to induce a metabolic stimulus for adaptation (Haff & Triplett, 2016). Longer rest periods have not been shown to increase volume, or hormonal and muscular responses, with hypertrophic training compared to shorter rest periods when training to volitional fatigue in resistance trained men (Ahtianen, Pakarinen, Alen, Kraemer, & Hakkeinen, 2005; Howe et al., 2017).

Each PBS was made consistent by noting the subject's squat rack height, and tape was placed on the floor as a guide for foot position across all conditions and repetitions. Depth of repetitions was made consistent with the use of the Brower Timing System set to emit an audible tone when the subject's greater trochanter reached the top of the patella as shown in Figure 2 and Figure 3. The laser system was used to prevent potential alteration of squat technique compared to squatting to an object as other studies use (Björk, 2014). All trials were completed in a Hammer Strength brand squat rack with a 20kg Olympic style loadable barbell.

Subjects

Subjects were recruited in the Humboldt State University Student Recreation Center weight room. Subjects included former NCAA Division II football and soccer players, and recreational powerlifters and weightlifters. Following a verbal and written explanation of all risks and benefits associated with this study, subjects signed an informed-consent form approved by the Humboldt State University (HSU) Internal Review Board. Data collection took place on 3 separate occasions within a 2-week period at HSU's Human Performance Lab for each subject.

A total of 26 resistance trained males, operationally defined as a minimum 1RM PBS of at least 1.5 times their bodyweight and having at least 2 years of experience training the PBS at least twice a week, participated in the study to ensure subjects were experienced and possessed the prerequisite strength for the neuromuscular adaptations from PBS training to elicit the PAP effect (Seitz et al., 2014; Tillin & Bishop, 2009). Descriptive characteristics of subjects are shown in Table 1. Subjects showed good health and were free of any musculoskeletal injuries. Each subject was requested to adhere to pre-test instructions before each trial to avoid contamination of results by abstaining from stimulants, be well hydrated, free of soreness, and not to eat within 3 hours of testing.

Procedures

Day 1: 1RM PBS Test

The initial intake session involved obtaining informed consent and a health history questionnaire to determine eligibility, anthropometric measures of height, weight, age, and 1RM test following the NSCA's guidelines with a combination of general, dynamic stretching, and movement specific warm-up for the musculature used in the PBS (Haff & Triplett, 2016). The general warm-up consisted of 5-minutes on a cycle ergometer with a 50W resistance at 50rpm, followed by a series of dynamic stretches aimed to increase range of motion in the hips, knees, and ankles, and 10 repetitions with 40% estimated 1RM, 5 repetitions with 60% estimated 1RM, 3 repetitions with 75% estimated 1RM, 1 repetition with 85%1RM, and 1 repetition with 90% estimated 1RM, each separated by 2-minutes of rest. Estimated 1RM was assessed by asking each subject what they thought they were capable of lifting on that day. Each subject was then allowed up to 4 attempts to increase the load of the bar for a tested 1RM, with 5-minutes of rest between attempts. Subjects ended the session if they could not lift the load by themselves, or accomplished all 4 consecutive attempts at a 1RM.

Day 2 and 3: PAP and Non-PAP Treatments with Four 75%1RM Tests

The next 2 days begun with the same standardized warm-up as used in the 1RM test session with the cycle ergometer and stretches, and either the PAP or non-PAP warm-up protocol as shown in Figure 1.

Specific Measurements

Repetitions to volitional fatigue were counted if the subject could complete the repetition on their own and reached adequate range of motion signified by the laser system. Borg's CR-10 RPE scale was used in a novel manner of identifying how heavy the 75%1RM load felt on a scale of 1-10, opposed to how difficult the set or session felt immediately following each set to measure subjectively if a PAP warm-up may psychologically aid in perception of difficulty (Day, McGuigan, Brice, & Foster, 2004). A PUSH™ wearable device was worn around the subject's forearms, as seen in Figure 2, shown to be a valid and reliable device for measuring PBS peak velocity in meters per second and peak power in watts (Balsalobre-Fernández, Kuzdub, Poveda-Ortiz, & Campo-Vecino, 2015).

Statistical Analysis

A separate 2-way repeated measures analysis of variance (ANOVA) was performed to compare the differences between the 4 sets for each dependent variable, and for an interaction effect of the warm-up conditions. Dependent variables measured and analyzed with tests of within-subjects effects included mean repetitions to volitional fatigue, mean RPE, mean peak velocity, and mean peak power per set. When a significant F-ratio was obtained indicating a significant main effect, a post hoc test was performed to analyze for significant simple effects. All statistics were run through the IBM Statistical Package for Social Sciences (SPSS v21.0). All data are presented as the mean $\pm$ *SD.*

Tables

Table 1. Subject Descriptive Characteristics (n = 26)

Variable	Mean ± SD
Age (years)	22.54 ± 3.47
Training Experience (years)	7.04 ± 0.45
Height (cm)	177.58 ± 8.87
Weight (kg)	92.24 ± 16.48
1-Repetition Maximum (kg)	170.32 ± 30.75
Strength to Weight Ratio	1.86 ± 0.24

Table 2. Dependent Variable Means ± SD

Condition	Dependent Variable	Set 1	Set 2	Set 3	Set 4
PAP	Repetitions to Volitional Fatigue	16.51 ± 3.28*	7.19 ± 2.19	5.12 ± 1.88	4.92 ± 1.83
Non-PAP		15.08 ± 3.38*	7.00 ± 2.33	5.69 ± 1.89	5.07 ± 1.55
PAP	Rating of Perceived Exertion	6.65 ± 1.72	7.42 ± 1.42	7.88 ± 1.18	8.08 ± 1.65
Non-PAP		6.77 ± 1.88	7.54 ± 1.42	8.04 ± 1.25	8.46 ± 1.3
PAP	Peak Velocity (m/s)	0.81 ± 0.15m/s	0.79 ± 0.21m/s	0.81 ± 0.26m/s	0.77 ± 0.2m/s
Non-PAP		0.8 ± 0.18m/s	0.75 ± 0.18m/s	0.77 ± 0.22m/s	0.75 ± 0.19m/s
PAP	Peak Power (W)	1,971.52 ± 857.65W	1,971.43 ± 931.03W	1,992.87 ± 1,131.53W	1,828.98 ± 758.33W
Non-PAP		1,995.86 ± 803.94W	1,874.96 ± 709.70W	1,930.06 ± 921.81W	1,852.2 ± 785.47W

*Statistically Significant

Figures

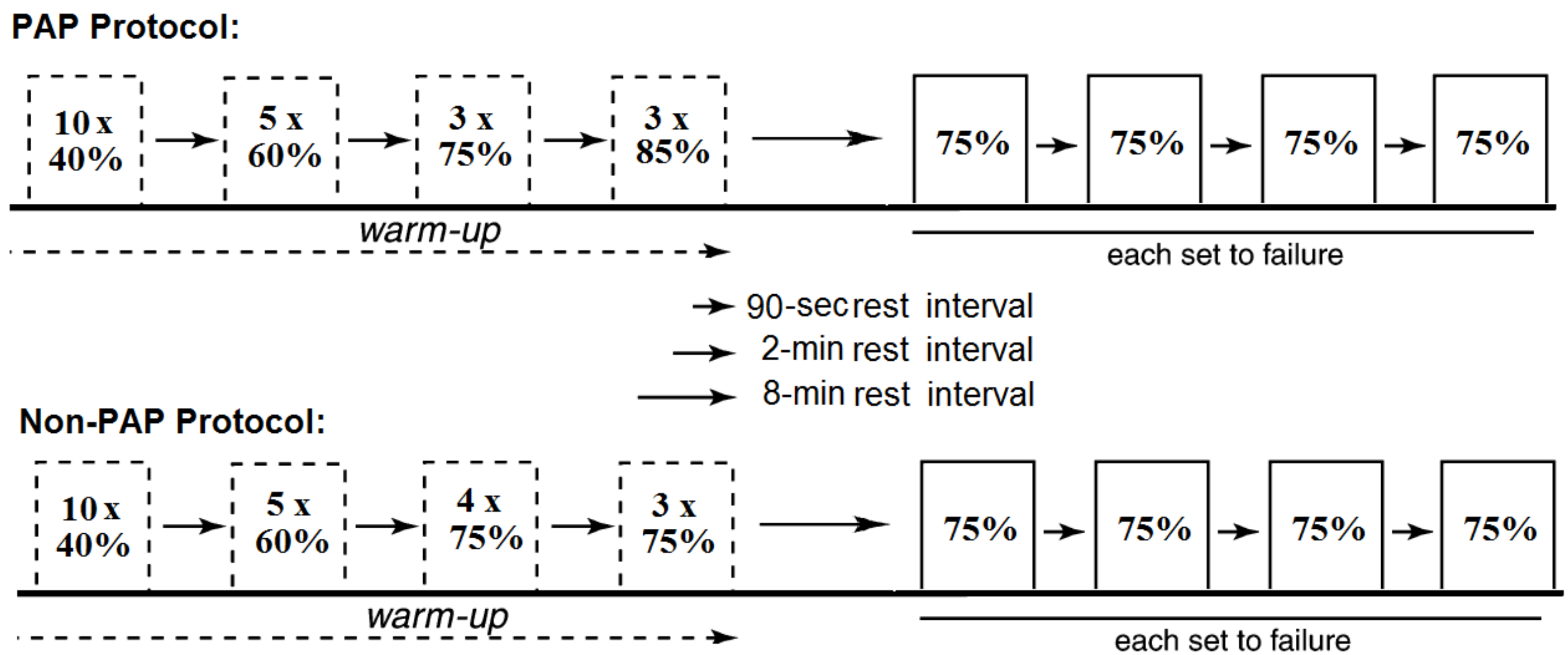

Figure 1. Intervention Protocols

Figure 2. Testing Setup

Figure 3. Testing Setup

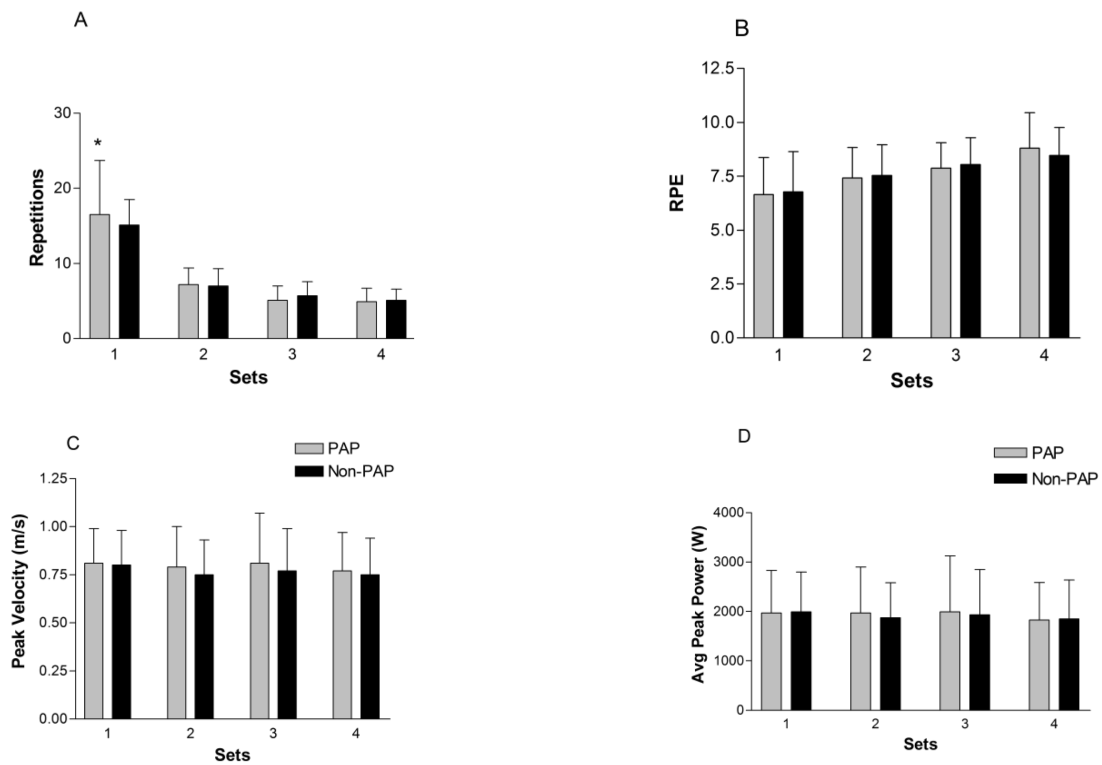

Figure 4. Means per Set between Conditions.

A. Mean repetitions per set between conditions. B. Mean RPE per set between conditions.

C. Mean peak velocity per set between conditions. D. Mean peak power per set between conditions. Significant difference found only for set one for repetitions between PAP and non-PAP conditions. *Statistically significant ($p < 0.05$).

RESULTS

Repetitions to Volitional Fatigue

Mauchley's test of sphericity was violated for main effects for sets and interaction between sets and warm-up conditions ($p < 0.01$), so the Greenhouse-Geisser correction was used. Repetitions to volitional fatigue decreased with each set in both conditions ($F = 224.4$, $p < 0.01$), as seen in Table 3 and Figure 4a. A significant interaction effect was found between sets and warm-up conditions ($F = 4.885$, $p < 0.01$), and a post-hoc test for simple main effects showed only set 1 was significantly different between conditions ($p = 0.045$).

Rating of Perceived Exertion

Mauchley's test of sphericity was violated for main effects for sets and interaction between sets and warm-up conditions ($p < 0.01$), so the Greenhouse-Geisser correction was used. RPE increased per set in both warm-up conditions ($F = 41.652$, $p < 0.01$), as seen in Table 3 and Figure 4b. No significant interaction effect between sets and warm-up conditions was found ($F = 0.587$, $p = 0.553$).

Mean Peak Velocity

Mauchley's test of sphericity was violated for main effects for sets ($p < 0.01$), so the Greenhouse-Geisser correction was used. No significant difference for between sets for both warm-up conditions was found ($F = 2.731$, $p = 0.065$), as seen in Table 3 and

Figure 4c. Mauchley's test of sphericity was not violated for the interaction between sets and warm-up conditions ($p = 0.491$). No significant interaction effect between warm-up conditions and sets was found ($F = 0.939$, $p = 0.426$).

Mean Peak Power

Mauchley's test of sphericity was not violated for main effects for sets ($p = 0.166$). Mauchley's test of sphericity was violated for the interaction between sets and warm-up conditions ($p < 0.01$), and the Greenhouse-Geisser correction was used. No significant difference between sets for both warm-up conditions was found ($F = 1.959$, $p = 0.127$), as seen in Table 3 and Figure 4d. No significant interaction effect between sets and warm-up conditions was found ($F = 0.880$, $p = 0.425$).

DISCUSSION

The findings of this study were similar to that of Björk (2014), where a statistically significant difference in total repetitions to volitional fatigue was completed and an increase in power output was observed in the set following an 85%1RM back squat PAP warm-up protocol. A significant difference was not observed across the subsequent sets, which may have been caused by training to volitional fatigue producing enough metabolic stress and fatigue to all available motor units that 90-second interset rest intervals was not long enough to allow for full recovery to take advantage of the acute changes following a PAP warm-up. Training to volitional fatigue has been shown to recruit all available motor units, and 90-seconds is not long enough to fully recover the phosphagen system used in RT (Dankel et al., 2016; Haff & Triplett, 2016). However, studies have shown rest periods up to 5 minutes still do not allow for significant increases in volume for repeated sets if training to volitional fatigue, and longer rest times would reduce training density (Howe et al., 2017; Richmond & Godard, 2004).

RPE was not significantly different between conditions, though a slightly lower RPE on average in the PAP condition was observed. The 75%1RM load may have felt slightly lighter on average to each subject, but was not significant. Fatigue from training to volitional fatigue may be the explanation for a progressive increase in perception of how heavy the load felt, despite the load remaining constant across all 4 sets. Outcomes for RPE may have been different if the session RPE scale were used instead in a protocol that did not require training to volitional fatigue (Day et al., 2004). Although not significantly different, a small increase in peak velocity and peak power output across all subjects was similarly observed compared to other studies following a similar PAP warm-up protocol, but still did not allow for significantly different repetitions for all sets (Björk, 2014; Kilduff et al., 2007; Seitz et al., 2014). However, with going to volitional fatigue inducing the same amount of metabolic stress to elicit hypertrophic adaptations, performing just a few more repetitions could also lead to more time under tension, mechanical stress, and training density to further stimulate adaptations for resistance trained men (Howe et al., 2017).

A limitation to this study involved the motivation to perform to volitional fatigue. Some subjects were hesitant following the delayed onset muscle soreness lasting up to 6 days for some subjects that occurred following the first intervention session. This decreased motivation to induce that pain again may be a factor that led to the wide ranges of repetitions where some subjects had up to a 15% decrease in volume or up to 48% increase in volume following the PAP warm-up protocol compared to the non-PAP warm-up protocol. Some subjects may or may not have been previously exposed to the concept of utilizing PAP for RT, which could also have affected motivation of some subjects to put forth more effort in accomplishing more repetitions during the PAP session or subconsciously lowering RPE since they may have the preconceived idea that it is supposed to be more beneficial. Some subjects also had different types of training goals up to the point of testing; some mentioned they were in the midst of training for hypertrophy, muscular strength, or muscular endurance. Their training adaptations up to the point of testing could have an effect on how many total repetitions they could complete per set if they were not accustomed to completing over 5-10 repetitions, which are repetition ranges typically used for strength or hypertrophy training (Haff & Triplett, 2016; Howe et al., 2017; Wilson et al., 2013). These could have been factors leading to inter-individual variance of responses similar to what has been observed based on strength levels that could revolve around how to best recruit all available motor units without inducing fatigue (Robbins, 2005; Seitz et al., 2010).

Though average increase in volume or decrease in RPE was not statistically different aside from set 1 for repetitions, future research should assess any other factors that may lead to inter-individual variances of who may benefit from this type of warm-up (Robbins, 2005). Absolute strength may be a covariance possibly related to selective recruitment or the size principle where highly trained individuals can selectively recruit all motor units without the need of a near maximal PAP protocol that could lead to fatigue. Some subjects seemed to benefit from the PAP protocol and some did not; 13 of the 26 subjects completed an average of 37 $\pm$ 4.6 total repetitions in the PAP condition compared to 32.77 $\pm$ 4.48 repetitions in the non-PAP condition, compared to the 30.54 $\pm$ 7.09 and 32.92 $\pm$ 7.94 repetitions of the other 13 subjects. Strength to weight ratios were similar for those who completed more repetitions with the PAP warm-up (1.82 $\pm$ 0.22) and those who completed more repetitions in the non-PAP warm-up (1.9 $\pm$ 0.26), however benefiters of the PAP warm-up condition had a lower average absolute 1RM, 157.23 $\pm$ 30.36kg compared to 183.41 $\pm$ 26.01kg.

Future studies should also assess if a different method of eliciting PAP may be beneficial for increasing volume and reducing RPE based on inter-individual differences in responses to PAP, as other studies have shown similar increases in power output following power based exercises focused on maximum velocity with lighter loads opposed to a strength based exercise with heavier loads which may similarly recruit all available motor units based on selective recruitment in resistance trained individuals (Andrews et al., 2011; McCann & Flanagan, 2010; Young, Jenner, & Griffiths, 1998). Subjects may needed to be blinded to which warm-up session they are completing in future studies to account for a subconscious reduced effort during a non-PAP warm-up condition. Longitudinal effects within a training program for a potential increase in hypertrophy, strength, and power should be assessed to truly inform practical applications.

PRACTICAL APPLICATIONS

Considering a dose-response relationship exists between resistance training adaptations for hypertrophy and intensities of 75%1RM and volume, the results of this study may present an opportunity for coaches and athletes to increase volume in each training session (Haff & Triplett, 2016; Howe et al., 2017; McCaulley et al., 2009; Schoenfeld, 2010). Though a significant difference was not observed for total volume completed between the warm-up conditions, an average of 2.8% and up to 48.2% of increase in a single session could lead to substantial increases in volume among months or years' worth of training by adjusting the warm-up protocol. There is potential that this exercise protocol will not be effective for every individual, however it may be worth assessing on an individual basis to determine who may benefit from utilizing this in their training.

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APPENDICES

Informed Consent Form

Humboldt State University Department of Kinesiology
Informed Consent to Participate in Research

The Effect of a Post-activation Potentiation Warm-Up on
Acute Submaximal Parallel Back Squat Volume

This form will explain the study to you, including the possible risks as well as the possible benefits of participating. This is so you can make an informed choice about whether or not to participate in this study. Please read this Consent Form carefully. Ask the investigators or study staff to explain any words or information that you do not clearly understand.

The period of this study is from July 5th, 2016 through May 23, 2017.

Purpose and General Information
You are being asked to participate in a research study conducted by Carlton Wei, B.Sc, . (Principal Investigator) and Dr. Young Sub Kwon, Ph.D. It is well established that participating in different warm-ups prior to any type of activity, especially resistance training, can increase performance through a variety of physiological mechanisms. Post-activation potentiation is a physiological phenomenon and type of warm-up not often utilized, but has the potential to increase muscular performance for hypertrophy, or muscular growth, as it has been shown to increase muscular power and total repetitions to failure in a single set. The purpose of this research is to determine if there is any further benefit in resistance training performance across multiple sets of parallel back squatting for trained males.

What will happen if I participate?

Participation in this study will take a total of 3-4 hours over a 3-day period separated by 2-3 days.

All testing will take place in the Human Performance lab in the Kinesiology and Athletics building, Room 254, HSU.

You will be asked not to drink alcohol for 24 hours prior to each session, not to drink caffeine 3 hours prior to each session, and to not eat 2 hours prior to each session.

Day 1: Screening process, paperwork, 1 repetition max (1RM) test (1 hour)
- You will complete this informed consent form and a physical activity questionnaire.

- Your blood pressure, height, and weight will be measured.
- You will be screened for eligibility for this study based on your resting blood pressure, and responses to the Athletic Background and Training Status Questionnaire and the Humboldt State University Health and Wellness Institute Medical Information and History and Release of Liability. If the criteria are not met, you will be excluded from the study.
- You will be asked if you have any soreness or injury to your lower back or legs.
- You will be verbally instructed on the use of the modified Rating of Perceived Exertion (RPE) scale and on the general procedure of the study.
- 1RM Back Squat Testing: You will be required to perform a 5-minute submaximal cycling warm-up at 50 revolutions per minute, followed by a series of guided stretches for the lower body. Your squat stance will be assessed and measured for consistency, along with depth checked with a laser system that provides an audible beep when pre-determined depth of the hip joint being parallel to the top of the knee is met. You will perform warm-up sets with 10 repetitions with 40%, 5 repetitions with 60%, 3 repetitions with 75%, and 1 repetition with 85%, and 1 repetition with 90% of your estimated 1RM with appropriate range of motion met by the audible beep from the laser system. 2 minutes of rest will be given between each set. 4 attempts will be given to determine your 1RM in the back squat exercise with 5-minutes rest between attempts. Spotters will be available to assist you should you not be able to complete the repetition yourself.

Day 2: Post-activation Potentiation (PAP) and 75% of 1RM (1 hour)

- Day 2 will be scheduled 48-72 hours after day 1.
- You will be asked if you have any soreness or injury to your lower back or legs.
- If you are experiencing any soreness, then the session will be postponed one additional day.
- You will be asked if you have refrained from caffeine in the previous 3 hours and alcoholic beverages in the previous 24 hours.
- You will perform the same cycling and stretching warm-up as day 1 followed by 10 repetitions with 40%1RM, 5 repetitions with 60%1RM, 4 repetitions with 75%1RM, and 3 repetitions with 85%1RM with 2-minute rest intervals, and depth of squat measured by the laser system. 8-minutes of rest will be given before you completed 4 sets of 75%1RM to failure with 90-seconds rest between sets. You will give an RPE from 1-10 of how difficult each set felt.

Day 3: Non-PAP and 75%of 1RM (1 hour)

- Day 3 will be scheduled 48-72 hours after day 2.
- You will again be asked if you have any soreness or injury to your lower back or legs.
- If you are experiencing any soreness, then the session will be postponed one additional day.

- You will be asked if you have refrained from caffeine in the previous 3 hours and alcoholic beverages in the previous 24 hours.
- The same cycling, stretching warm-up, 10 repetitions of 40%1RM, 5 repetitions of 60%1RM, 4 repetitions of 75%1RM, and 3 repetitions of 75%1RM prior to completing 4 sets with 75% of 1RM to failure again.

You may be randomly assigned to complete the Day 3 intervention before Day 2.

What are the possible risks or discomforts of being in this study?
Every effort will be made to minimize any risk to you. The risks to you include muscle soreness, muscle fatigue, and common injuries and issues associated with exercise.

What are the possible benefits of being in this study?
There are no direct benefits to you from being in this study. However, your participation may help answer the question of the acute effects of a post-activation potentiation warm-up on back squatting performance for muscle growth. These findings could ultimately increase our knowledge related to prescribing intensities in strength and conditioning or general fitness training settings.

Will I be paid for taking part in this study?
There will be no compensation.

Can I stop being in the study once I began?
Yes, you can withdraw from this study at any time without consequence.

How will my information be kept confidential?
Your name and other identifying information will be maintained in files, available only to authorized members of the research team for the duration of the study. For any information entered into a computer, only unique study identification (ID) numbers will be used. Any personal identifying information and record linking that information to study ID numbers will be destroyed when the study is completed. No protected health information will be collected and associated with your name in this study.

Protected health information (PHI)
By signing this consent document, you are allowing the investigators to use your protected health information for determination of eligibility to participate in this study. This information will include: resting blood pressure, height, weight, age, and self-reported responses to Humboldt State Universities Health and Wellness Institute Medical Information and History and Release of Liability.

Right to Withdraw
Your authorization for the use of your health information shall not expire or change unless you withdraw or change that information. Your health information will be used as long as it is needed for this study. However, you may withdraw your authorization at any

time provided you notify the Humboldt State University investigators in writing. To do this, please contact to:

Carlton Wei, B.Sc.
Department of Kinesiology
Humboldt State University

Please be aware that the research team will not be required to destroy or retrieve any of your health information that has already been used or shared before your withdrawal is received. You have the right to stop participating at any time, in doing so, the researchers retain the right to use any already collected non-protected health information data for the purposes of this study.

What if I have questions or complaints about this study?
The investigator will answer any question you have about this study. Your participation is voluntary and you may stop at any time. If you have any questions, concerns, or complaints about this study, please contact Carlton Wei, B.Sc at cw1152@humboldt.edu or (415)728-6646, or the faculty adviser Dr. Young Sub Kwon, Ph.D. at young.kwon@humboldt.edu or at (707) 826-5944. If you have any concerns with this study or questions about your rights as a participant, contact the Institutional Review Board for the Protection of Human Subjects at irb@humboldt.edu or (707) 826-5165.

Liability
You recognize that by participating in this study, you are assuming all liability of any injury that may occur.

Consent and Authorization

You are making a decision whether to participate in this study. Your signature below indicates that you read the information provided (or the information was read to you). By signing this Consent Form, you are not waiving any of your legal rights as a research subject.

Sincerely,
Carlton Wei, B.Sc.
cw1152@humboldt.edu

I have read the consent form and had an opportunity to ask questions and all questions have been answered to my satisfaction. By signing this consent form, I agree to participate to this study and give permission for my health information to be used or disclosed as described in this consent form.

I have no self-reported health issues that may exclude me from participating in this study, and have completed the Humboldt State University Health and Wellness Institute Medical Information and History and Release of Liability to participate in the use of the Human Performance Lab.

A copy of this consent form without my name attached will be provided to me.

____

Signature of participant   Date

Health History Questionnaire

Humboldt State University Health and Wellness Institute Medical Information and History and Release of Liability

Name ____

Address ____

Home Phone ________________________ Work Phone ____

Age __________ Date of Birth __________________ Gender ________

The following questions are designed to help us tailor the health and fitness assessment and follow-up counseling to your personal situation. It is extremely important for us to know if you have any medical conditions which may affect your testing process or your progress in our program. Please take the time to answer these questions accurately.

Medical History

YES	NO	In the past five years have you had:
( )	( )	1. Pain or discomfort in chest, neck, jaw, or arms
( )	( )	2. Shortness of breath or difficulty breathing at rest or with mild exertion (e.g., walking)
( )	( )	3. Dizziness or fainting
( )	( )	4. Ankle edema (swelling)
( )	( )	5. Heart palpitations (forceful or rapid beating of heart)
( )	( )	6. Pain, burning, or cramping in leg with walking
( )	( )	7. Heart murmur
( )	( )	8. Unusual fatigue with mild exertion

Have you ever had:

( )	( )	9. Heart disease, heart attack, and/or heart surgery
( )	( )	10. Abnormal EKG
( )	( )	11. Stroke
( )	( )	12. Uncontrolled metabolic disease (e.g., diabetes, thyrotoxicosis, or myxedema)
( )	( )	13. Asthma or any other pulmonary (lung) condition
( )	( )	14. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)
( )	( )	15. Liver or kidney disease
( )	( )	16. Are you currently under the care of a physician?
( )	( )	17. Do you currently have an acute systemic infection, accompanied by a fever, body aches, or swollen lymph glands?
( )	( )	18. Do you have a chronic infectious disease (e.g. mononucleosis, hepatitis, AIDS)?
( )	( )	19. Do you have a neuromuscular, musculoskeletal, or rheumatoid disorder that is made worse by exercise?
( )	( )	20. Do you have an implantable electronic device (e.g. pacemaker)?
( )	( )	21. Do you know of any reason why you should not do physical activity?

If you answered yes to any of these questions, please explain.

____

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Risk Factors

YES	NO	DON'T KNOW	
( )	( )	( )	1. Are you a male 45 years of age or older?
( )	( )	( )	2. Are you a female 55 years of age or older
( )	( )	( )	3. Do you have a father or brother who had a heart attack or heart surgery before age 55?
( )	( )	( )	4. Do you have a mother or sister who had a heart attack or heart surgery before age 65?
( )	( )	( )	5. Do you smoke or have you quit in the past 6 months?
( )	( )	( )	6. Do you have frequent secondhand smoke exposure?
( )	( )	( )	7. Do you know your blood pressure?_____/______________mmHg-Date:
( )	( )	( )	8. What is your total cholesterol?_________mg/dL-Date:
( )	( )	( )	9. Are you taking cholesterol lowering medication?
( )	( )	( )	10. Do you know your HDL cholesterol?___mg/dL-Date:
( )	( )	( )	11. Is your HDL cholesterol > 60mg/dL?
( )	( )	( )	12. What is your fasting blood glucose?____mg/dL – Date:
( )	( )	( )	13. Do you exercise regularly? If so, explain.

If you answered yes to any of these questions, please explain.

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____

____

Office Use

BMI_____ SBP_____ DBP_____ TC_____ LDL_____ HDL____

FBG_____ Family History_______ Smoking______ Sedentary_____

Health-Related Questions

YES	NO	
( )	( )	1. Are you pregnant?
( )	( )	2. Are you allergic to isopropyl alcohol (rubbing alcohol) or latex?
( )	( )	3. Do you have any allergies to medications, bees, foods, etc.? If so please list ______________________________
( )	( )	4. Do you have any skin problems?
( )	( )	5. Do you have any other medical condition(s)/surgeries?
( )	( )	6. Have you had any caffeine, food, or alcohol in the past 3 hours?
( )	( )	7. Have you exercised today?
( )	( )	8. Are you feeling well and healthy today?
( )	( )	9. Do you have any other medical concerns that we should be aware of?

If you answered yes to any of these questions, please explain.

____

____

____

____

Medications

Please Select Any Medications You Are Currently Using:

Diuretics	Other Cardiovascular
Beta Blockers	NSAIDS/Anti-inflammatories (Motrin, Advil)
Vasodilators	Cholesterol
Alpha Blockers	Diabetes/Insulin
Calcium Channel Blockers	Birth Control
Other Drugs (record below)	

Please list the specific medications that you currently take:

What are your health and fitness goals?

I certify that the information I have provided is complete and accurate to the best of my knowledge.

Date ___________ Signature of Subject ____

Date ___________ Signature of Witness ____

Office Use Only

______Low Risk **______Moderate Risk** **______High Risk**

<u>HUMBOLDT STATE UNIVERSITYRELEASE OF LIABILITY, PROMISE NOT TO SUE, ASSUMPTION OF RISK AND AGREEMENT TO PAY CLAIMS</u>

I have read this form, and I understand the test procedures that I will perform and the attendant risks and discomforts. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this test.

In consideration for being allowed to participate in this Activity, on behalf of myself and my next of kin, heirs and representatives, I **release from all liability and promise not to sue** the State of California, the Trustees of The California State University, California State University, Humboldt State University and their employees, officers, directors, volunteers and agents (collectively "University") from any and all claims, **including claims of the University's negligence,** resulting in any physical or psychological injury (including paralysis and death), illness, damages, or economic or emotional loss I may suffer because of my participation in this Activity, including travel to, from and during the Activity.

I am voluntarily participating in this Activity. I am aware of the risks associated with traveling to/from and participating in this Activity, which include but are not limited to physical or psychological injury, pain, suffering, illness, disfigurement, temporary or permanent disability (including paralysis), economic or emotional loss, and/or death. I understand that these injuries or outcomes may arise from my own or other's actions, inaction, or negligence; conditions related to travel; or the condition of the Activity location(s). **Nonetheless, I assume all related risks, both known or unknown to me,** of my participation in this Activity, including travel to, from and during the Activity.

I agree to **hold** the University **harmless** from any and all claims, including attorney's fees or damage to my personal property that may occur as a result of my participation in this activity, including travel to, from and during the Activity. If the University incurs any of these types of expenses, I agree to reimburse the University. If I need medical treatment, I agree to be financially responsible for any costs incurred as a result of such treatment. I am aware and understand that I should carry my own health insurance.

Date:________ Signature of Subject:____

Date:________ Signature of Witness:____

Data Collection Form

Effects of a Post-Activation Potentiation Warm-up on Acute Submaximal Parallel Back Squat Volume

Data Collection Form
Identification Code:__________________
Tested 1RM (kg/lbs):__________________
Bodyweight (kg/lbs):__________________
Strength/Weight Ratio:_________________
Laser System Height:__________________

PAP Warm-Up Day 2 [ ]
PAP Warm-Up Day 3 [ ]

Subject has satisfied all Humboldt State University requirements to participate in testing in the Human Performance Lab [ ]

Day 1: 1RM Test

Reps x %1RM	Load (kg/lbs)	RPE (1-10)	Peak Power (W)	Average Power (W)	Peak Velocity (m/s)	Average Velocity (m/s)
10x40%	/					
5x60%	/					
3x75%	/					
1x85%	/					
1x90%	/					
Attempt 1	/					
Attempt 2	/					
Attempt 3	/					
Attempt 4	/					

Day 2/3: PAP

Reps x %1RM	Load (kg/lbs)	Reps	RPE (1-10)	Peak Power (W)	Average Power (W)	Peak Velocity (m/s)	Average Velocity (m/s)
10x40%	/						
5x60%	/						
3x75%	/						
3x85%	/						
Set 1 75%	/						
Set 2 75%	/						
Set 3 75%	/						
Set 4 75%	/						

Day 2/3: Non-PAP

Reps x %1RM	Load (kg/lbs)	Reps	RPE (1-10)	Peak Power (W)	Average Power (W)	Peak Velocity (m/s)	Average Velocity (m/s)
10x40%	/						
5x60%	/						
4x75%	/						
3x75%	/						
Set 1 75%	/						

Reps x %1RM	Load (kg/lbs)	Reps	RPE (1-10)	Peak Power (W)	Average Power (W)	Peak Velocity (m/s)	Average Velocity (m/s)
Set 2 75%	/						
Set 3 75%	/						
Set 4 75%	/						