AN ANALYSIS OF THE POSTACTIVATION POTENTIATION EFFECT OF THE PRIMARY GLUTEAL MUSCLES FOLLOWING HABITUALLY PRESCRIBED ACTIVATION AND CONDITIONING EXERCISES

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This study examined the effects of a high load gluteal activation protocol on countermovement jump (CMJ) performance and gluteal activation levels. Eight sprinters performed 5 CMJ's prior to and subsequently after a gluteal activation protocol on two separate days. Height jumped (HJ), peak force ($Force_{peak}$), modified reactive strength index (RSI_{mod}) and electromyographic gluteal activation levels were calculated on both days. Paired samples T tests found no significant differences for all reported variables on either day. This suggests that the gluteal activation protocol had no effect on CMJ performance. Future research should incorporate typical error analysis to investigate potentiation effects on an individual basis due to individual nature of the postactivation potentiation response and biological variability.

KEY WORDS: Gluteal muscles, postactivation potentiation, performance quality

INTRODUCTION: Explosive power generation of the lower extremity muscles is a key determinant to sport performance and is involved in components such as jumping and the acceleration of the body to maximal velocity. Research has provided evidence that the primary gluteal muscles adopt a significant role in key activities such as gait and jumping performance through stabilisation of hip joint movement and power production especially vertical force propulsion (Crow et al, 2012). In addition, their importance within rehabilitation to restore optimal movement mechanics and gait function following injury is well documented. Dynamic warm-up protocols for explosive activities such as sprinting and jumping are designed to physically condition the athlete's neuromuscular and musculoskeletal systems for optimal performance through eliciting a postactivation potentiation effect (PAP) (Setiz & Haff, 2015). PAP refers to the phenomena resulting in the acute enhancement of muscular performance characteristics resulting from their contractile history (Healy & Harrison, 2014; Setiz & Haff, 2015). One objective of explosive warm-ups is to attempt to improve the athletes rate of force development (RFD), shifting the force-time curve up and to the left and as a result, generating a greater impulse and allowing for a more explosive power output (Comyns et al, 2015). The enhanced ability of an individual to produce and utilise these forces during dynamic athletic movements can often dictate the outcome of their competitive endeavours (Crow et al, 2012). While there is a growing body of evidence to date, relatively little research examined whether specific gluteal activation load exercises can result in enhancement of performance. The aim of this study is to examine whether a postactivation potentiation effect occurs following the execution of well-established, habitually prescribed gluteal activation exercises (Reiman et al, 2011) amongst national and international level athletes.

METHODS: 8 national/international male (n=4) and female (n=4) sprint participants (Age: 23.3 ± 2.4, height 175.3 ± 10.5 Weight 67.6 ±8.8) participated in the study. All athletes were free from any musculoskeletal injuries at the time of testing and possessed adequate gluteal strength as assessed using the Trendelenburg test. *Testing Protocol*: For all participants, the testing protocol took place over a three-day testing period. The first day provide a practise period to allow the subjects to become accustomed with the testing protocol and become familiarised with the muscle tests and exercises involved. On the initial testing day Two Delsys Trigno^{tm} Wireless Electromyography (EMG) Natick MA, USA sensors were placed on both the gluteus maximus and gluteus medius using SENIAM guidelines. Baseline electromyography (EMG) measures were recorded for both the gluteus maximus and medius via these wireless surface EMG sensors using maximal voluntary isometric tests (MVIC) as outlined by Konrad (2006). EMG data was recorded at 2000 Hz. Each subject performed 5 isometric holds of three second duration with a 30 second rest interval between each contraction. The participants performed 5 standardised countermovement jumps with hands placed on their hips with a 2 minute interval between jumps. Gluteal muscle activation was measured using the Trigno^{tm} wireless sensors while force plate data was acquired using an calibrated AMTI force plate. Force plate data was set to capture 20 s of data at a frequency of a 1000 Hz. Subjects performed a series of commonly prescribed gluteal activation exercises with each exercise consisting of five repetitions on each leg and a 30 second rest interval between exercises. The exercises selected have been shown to elicit a maximal voluntary contraction MVIC greater than 45% elucidating to strength gains originating predominantly from neuromuscular adaptations. Subjects then performed 5 more countermovement jump at time intervals of 1, 3, 5, 10, and 15 minute post exercise intervention. The subsequent testing day consisted solely of repeating the procedure of the initial testing day to verify viability, reliability and consistency in the results data. *Data Analysis*: The dependent force plate variables measured were peak force ($Force_{peak}$) height jumped (HJ) and modified reactive strength index (RSI_{mod}). Peak force was obtained directly from the force plate data. HJ was calculated using an adaptation of the equation outlined by Bosco et al (1983): $HJ = (9.81 * (FT)^2)/16$ where FT represents flight time. The EMG data was analysed using the following excel protocol. RSI_{mod} was calculated from the adaptation of the traditional RSI calculation, modified for the countermovement jump: RSI = height jumped/contraction time. The Raw EMG data was full wave rectified and filtered using a low pass Butterworth filter with a cut off frequency (fc) of 12 Hz. This provided a smooth linear EMG envelope for the trial. The maximum equation was used to find the peak amplitude for each gluteal muscle during each trial using the filtered EMG data. The peak amplitudes of both the pre and post intervention values were then averaged for both days. These values were then represented as a percentage of the maximal voluntary contraction. Normality was established by non-violation of the Shapiro Wilk test. Statistical analyses was conducted using multiple paired samples t- tests with an alpha level set at $p \leq 0.007$ to allow for multiple comparisons.

RESULTS

The mean results for EMG activation (Table 2) and force variables (Figure 1) are included below. Average post intervention increases were found for the left gluteus medius (Day One: 15.74% day Two: 6.81%) right gluteus medius (Day Two: 9.08%) and left gluteus maximus (Day One: 10.35%) over the testing period. A reduction in activation post intervention was found for right gluteus medius (Day One: -17.8%) left gluteus maximus (Day Two: -30.22%) and right gluteus maximus (Day One: -8.69% Day Two: -11.04%) over the test period. Paired samples T test found no significant differences in activation level for all gluteal muscles over both testing days. Height jumped increased by 0.007m (Day One) and 0.31m (Day Two). Peak force increased by 22.61N (Day One) and 56.52N (Day 2). Reactive strength index increased by 0.81 (Day One) and 0.48 (Day Two) respectively. Paired samples T test found no significant difference between height jumped and modified RSI variables. A significant difference was found for Day two post intervention peak force ($P<0.05$). The effect size for each force plate variable is reported in table 3 which shows a large effect size for day two post peak force variable.

Table 2. Mean Gluteal Muscle Activation Pre and Post Intervention

	Gluteal Muscle	Pre Average	Standard Deviation	Post Average	SD	Sig.
Day One						

	L. Gluteus Medius	85.52	60.50	101.26	100.19	.679
	R. Gluteus Medius	71.62	75.23	53.82	40.98	.233
	L. Gluteus Maximus	57.70	64.73	68.05	73.11	.303
	R. Gluteus Maximus	147.88	164.68	139.19	224.77	.840
Day Two						
	L. Gluteus Medius	60.71	40.86	67.52	42.45	.667
	R. Gluteus Medius	66.69	41.06	75.77	49.27	.088
	L. Gluteus Maximus	134.47	110.56	104.25	73.84	.406
	R. Gluteus Maximus	124.79	101.48	113.75	104.28	.162

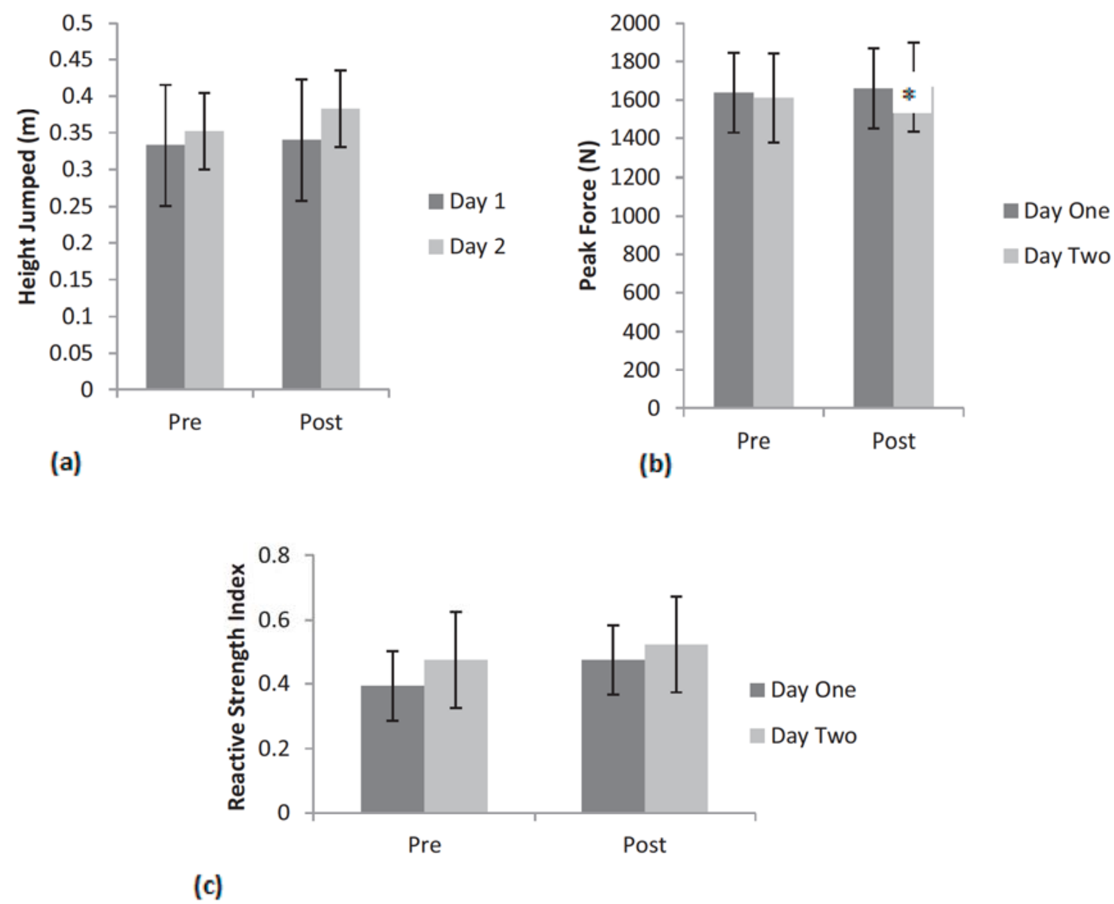

Figure 1. Mean results for (a), height jumped (b), peak force (c) and Modified reactive strength index. * denotes statistically significant differences between pre and post intervention ($p \le 0.05$)

Table 3. Effect Size for Force Plate Variables

Variable	Mean Difference	Std Dev. Differences	Effect Size (Cohen Dz)
D2PREHJ - D2POSTHJ	0.0310	0.411	0.75
D1PREPF - D1POST PF	22.611	167.24	0.14
D2PREPF - D2POST PF	56.52	45.27	1.25[#]
D1PRERSI - D1POSTRSI	0.009	0.84	0.11

D2PRERSI - D2POSTRSI	0.05	0.74	0.65

#Large Effect Size Cohen Dz > 0.8

DISCUSSION: The results of the study demonstrated both improvements and reductions in gluteal activation post intervention however, no changes were statistically significant. An initial statistical significant difference was found for peak force on day two but with Bonferroni corrections led to the modification of the alpha level to 0.007 which deemed the result non significant. The large effect size found for day two peak force requires further investigation and could reach statistical significance if a larger sample size was incorporated. Results are similar to that of Healy & Harrison (2014) who found no significant improvement in drop jump performance following the execution of a low to moderate load gluteal activation protocol. Contrastingly, Crow et al (2012) found that the execution of low to moderate gluteal load activation exercise regimes produced potentiation effect during the countermovement jump although the 4.2% increase was observed in peak power and not peak force. Crow (2012) noted that the relatively low activation intensities of the exercises could suggest that a true post-activation potentiation effect was not elicited. Potential limitations may also be due to the use of conventional statistical hypothesis tests to detect PAP differences due to the individual nature of the PAP fatigue potentiation relationship. Studies have highlighted that due to individual biological variance in the PAP response that conventional group statistics may not be able to determine positive effects. It is recommended that PAP protocols should be considered on an individual basis (Lim & Kong, 2013). The typical error method should be incorporated to detect if any PAP related changes exist as it compares individuals' alterations in performance post intervention against the biological variability of the individual baseline performance. This is shown in Whelan et al, (2014) who investigated the ability of resisted sprints to enhance 10 m sprint performance. Initial results demonstrated an enhancement in sprint factor determinants and running speed in 10 m sprints. The incorporation of typical error analysis highlighted that the observed enhancement was limited and unsystematic in nature concluding that limited weak evidence existed on the ability of PAP to enhance sprint performance.

CONCLUSION: The gluteal activation protocol was found to have no statically significant acute enhancement in gluteal activation levels. No statistically significant performance enhancing or impairing effects were found on subsequent countermovement jump performance. Future research should consider typical error analysis in PAP intervention studies to investigate potentiation effects on an individual basis.

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