EFFECTS OF POST-ACTIVATION PERFORMANCE ENHANCEMENT ON JUMP ASYMMETRY USING BANDED SQUATS WITH PROFESSIONAL AMERICAN FOOTBALL PLAYERS

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Understanding the effects complex training has on symmetry could supply practitioners with the knowledge to provide safe and effective training for their athletes. The purpose of this study was to determine the effects of post-activation performance enhancement (PAPE) using banded squats on symmetry during a countermovement jump (CMJ). Professional American football players (n=8) performed four trials of CMJs on dual force plates to record jump height and limb asymmetry of concentric and eccentric impulse, concentric and eccentric peak force, eccentric rate of force development (RFD), and peak landing force. A potentiation effect was induced with a set of heavy banded squats between each trial. There were no significant changes in asymmetry across the 4 trials, $p>.05$. However, jump height did improve $F_{(3,21)} = 3.69$, $p=0.028$. Banded squat training has no effect on jump symmetry.

KEYWORDS: countermovement jump, complex training, jump height

INTRODUCTION: Explosive power development is a key component in training American football players. Post-activation performance enhancement (PAPE) describes the acute increases in performance (e.g., jump height) from pre-loading the muscles with high resistance loads (80-90% of 1RM) in an exercise of similar biomechanics (e.g., squat) (Blazevich & Babault, 2019). Researchers have attributed the occurrence of PAPE due to the after-effects from post-activation potentiation (PAP) in the muscles. PAP occurs when (a) phosphorylation of the myosin light chains resulting in an increase in calcium sensitivity in actin-myosin, and (b) an increase in synaptic excitation of the alpha motor neurons (Lorenz, 2011). PAP is a fast occurrence (~23 seconds), but the force enhancements can be found minutes. This could be possibly due to changes in muscle and temperature along with muscle/cellular water content, and these changes are known as PAPE (Blazevich & Babault, 2019). An example of utilizing the effects of PAPE during a strength and conditioning session would be to superset a loaded barbell squat with a maximal effort jump. Barbell loaded squats have been frequently researched, but the band loaded squat is scarcer in research relating to PAPE. Heavy banded squats are an adequate choice for practitioners to use to load the participants when aiming to incorporate the effects of PAPE in their training session. By placing the bands on the participant, the bands elongate during the concentric lifting phase of the squat which increases the resistance of the band towards the end of the movement. This is known as accommodative resistance (AR) and allows for near-maximal contractions to be performed at high velocities thus inducing the greatest neural adaptations. AR may optimally elicit PAPE, especially in skill positions (i.e., wide receivers, running backs) (Miret, Mokha & Bommarito, 2022). However, AR effects on inter-limb symmetry are less known. Asymmetries are commonly monitored in clinical settings for injury risk identification and return to activity criteria (Bates, Ford, Myer & Hewett, 2013; Mokha, Sprague, & Gatens, 2016) with less than 10% and greater than 15%, respectively, suggested as thresholds (Bishop, Turner, & Read, 2017). Bell and colleagues (2014) found a greater than 10% kinetic asymmetry (power) during a countermovement jump (CMJ) resulted in deficits in height jumped indicating that reducing these differences may be advantageous. Lower limb symmetry was associated with increased performance in explosive movements such as jumping and sprinting (Heishman et al., 2019). Asymmetry of peak landing force, concentric peak force, concentric impulse, eccentric rate of force development, eccentric impulse, and eccentric peak force were all analysed to grasp a better understanding on if PAPE has any effect on symmetry for American football players using AR.

The purpose of this study was to assess the effects of PAPE using AR (banded squats) on countermovement jump symmetry in professional American football players. Knowledge of the influence complex training while using AR has on symmetry can help practitioners to implement a more effective and safe training style.

METHODS: Participants were eight adult males (n = 8, height = 187.25±1.9 cm, mass = 111.95±21.24 kg) highly skilled veteran players in the National Football League (NFL). All participants were partaking in an off-season lower body training block. The data were collected during a live training session in a performance center on a single day. All participants completed an extensive dynamic warm-up directed by their strength and conditioning coach, which was immediately followed by testing. Each participants performed three baselines maximal effort CMJs with hands on hips (Trial 1). CMJ were performed on dual uniaxial force plates (Vald Performance, Queensland, Australia) and the ForceDecks software provided measures of inter-limb asymmetry (%) and jump height (cm). Once the first trial of CMJs were completed, the participants then performed a set of heavy banded squats loaded by placing bands on the ends of the barbell. This ensured AR which establishes an increase in load towards the top of the squat to attempt to increase velocity through the full range of motion (ROM). After the set of squats were performed, the participants were then given 2-to-4-minute rest before their next trial of CMJs. This process of was performed for a total of 4 trials.
There were seven variables that were chosen to be analysed during the CMJ. Limb asymmetry (%) was recorded for concentric and eccentric impulse, concentric and eccentric peak force, eccentric rate of force development (RFD), eccentric peak force, and peak landing force. Asymmetry calculations were found by utilizing $((R - L)) / ((R + L))$. A lower percentage value for asymmetry will indicate an increase in inter-limb performance and a reduction in injury probability. Jump height (cm) was also chosen to evaluate if the participants reached a potentiated state. This was ensured if there was an acute increase in jump height between trial one compared to the other jump trials. Table 1 explains the definitions of the variables that were recorded and analysed during the CMJs.

Table 1: Definition of Variables that were Chosen to Analyse

Variable	Definition
1. Asymmetry of concentric impulse (%)	L/R symmetry during impulse in the upward phase of jump
2. Asymmetry of concentric peak force (%)	L/R symmetry of peak force produced in the upward phase of jump
3. Asymmetry of eccentric impulse (%)	L/R symmetry during impulse in the downward phase of jump
4. Asymmetry of eccentric rate of force development (RFD) (%)	L/R symmetry of speed at which force is produced during the downward phase of jump
5. Asymmetry of eccentric peak force (%)	L/R symmetry of peak force produced in the lowering phase of jump
6. Asymmetry of peak landing force (%)	L/R symmetry of highest force produced while landing
7. Jump height (cm)	The height of jump that was performed; derived from flight time

Once all trials of CMJ were recorded, the data were extracted into an Excel file and then transferred into Statistics Package for Social Sciences (SPSS) for analysis. Repeated Measured Analysis of Variance, $\propto$ = 0.05 were used to reduce the data across the 4 trials.

RESULTS: Table 2 presents the mean and standard deviations (SD) between each trial of the limb asymmetries of concentric (CON) and eccentric (ECC) impulse, CON and ECC peak force (PF), ECC rate of force production (RFD), ECC PF, and peak landing force (PLF). Jump height of each CMJ is also depicted. Only jump height ($F_{(3,21)}$= 3.69,p=0.028) showed significant changes. There were no significant changes in asymmetry values.

Table 2: Comparing Sets of Particular Variables of Asymmetry and Jump Height in the Counter Movement Jump (N=8).

Variable	Trial 1	Trial 2	Trials 3	Trial 4	p-value
CON Impulse (%)	3.89±2.49	3.83±2.10	3.75±1.92	3.35±1.79	.90
CON PF (%)	5.51±4.26	5.16±3.70	4.95±2.95	5.64±3.26	.84
ECC Impulse (%)	7.46±5.74	7.46±5.62	6.87±2.31	9.13±3.76	.37
ECC PF (%)	7.02±5.28	6.34±4.89	5.71±3.05	6.7±3.51	.63
ECC RFD (%)	9.15±2.95	9.44±4.18	9.21±3.59	8.03±5.82	.86
PLF (%)	14.47±3.45	15.42±7.57	13.69±6.82	18.61±8.86	.50
Jump height (cm)	45.77±8.64	47.28±9.05	47.69±9.38	47.51±10.01	.03*

Note: * denotes statistically significant difference, p≤.05.

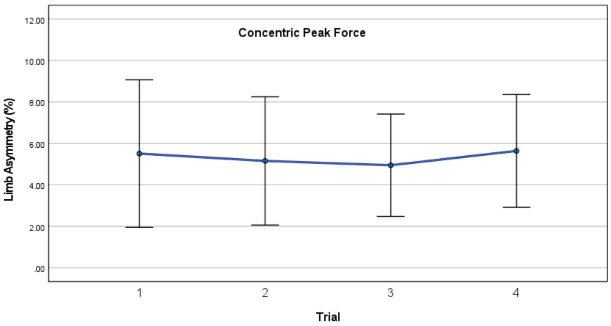

Figure 3. Concentric peak force asymmetry across 4 trials .

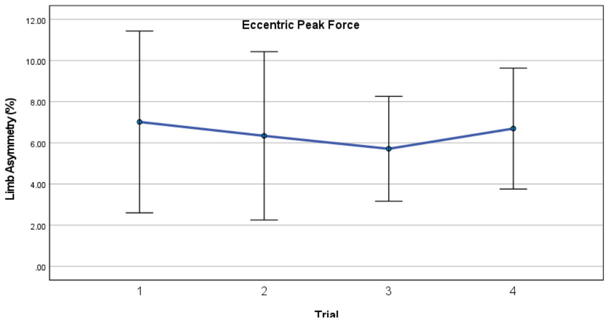

Figure 4. Eccentric peak force asymmetry across 4 trials.

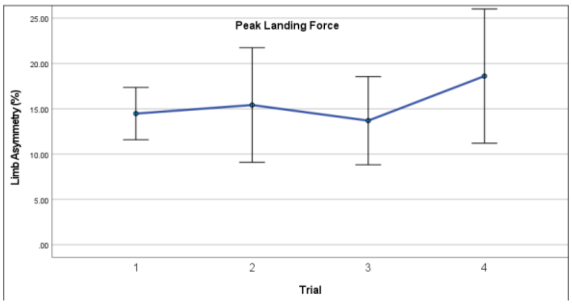

Figure 5. Peak landing force asymmetry across 4 trials.

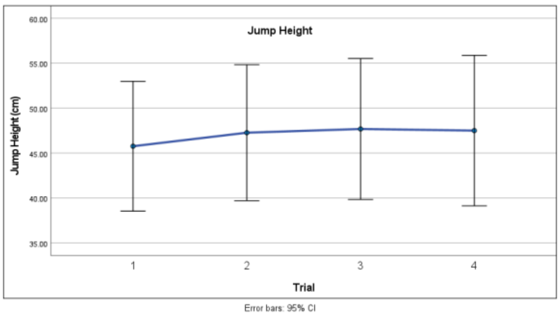

Figure 7. Jump height asymmetry across 4 trials.

DISCUSSION: The purpose of this study was to determine the effects that PAPE has on inter-limb asymmetries during a CMJ when using AR during complex training. Low numerical values are desired when comparing inter-limb asymmetries during the CMJ because of the increase of performance in explosive movements when symmetry is present (Heishman et al., 2019). Alternatively, high asymmetry values have been correlated to an increase in injury probability (Bell, 2014); therefore, placing an athlete in a state where limb-symmetry is not present should be avoided by the practitioner. The results in this study show that there was no significant change in symmetry (p>0.05) during the complex training style protocol that attempts to elicit the effects of PAPE between any of the four trials. This could perhaps be due to the small sample size along with the large variability. The heavy banded squats that were performed before trials 2-4 were implemented to ensure the participants were in a potentiated state. Jump height was recorded to ensure acute changes in the data were occurring between the four jump trials, which would imply the participants were in a potentiated state. Since the data for the jump height increased (45.77±8.64 vs 47.51±10.0) between the trials along with the p value being found at .028, this implies that the participants were in a slightly potentiated state due to the heavy banded squats. This data suggests that PAPE does not have a significant positive or negative effect on symmetry when performing a CMJ after reaching potentiation by banded squats. Although the data is promising, the slight increase in jump height may not be significant enough to allow for alteration of the inter-limb asymmetries during the CMJs; therefore, the data cannot ensure practitioners in the strength and conditioning field that complex training utilizing AR to induce PAPE will negatively or positively effect inter-limb asymmetry when utilizing CMJ.

Other factors that may have influenced the results but were not assessed include muscle strength, velocity during the CMJ, and the AR during the end of the banded squats. Although the participants were highly motivated and familiar with the movement; the AR could have induced a different effect for the taller compared to the shorter participants during their jump because the band would have more resistance for the taller individuals. There is still an importance of no significant effect in the inter-limb asymmetries while being in a slightly potentiated state, but more research will need to be performed to further understand the effects AR has on symmetry while performing complex training.

CONCLUSION: This study provided sport-specific findings for elite American football players who are implementing accommodative resistance complex training in their programming. Results depicted that there was a slight increase in jump height for the participants between trial 1 and trial 4. This ensures that potentiation occurred in the participants, but the data is not significant for asymmetry values during the CMJ. Further research will need to be conducted to grasp a better understanding of the effects that accommodating resistance complex training has on inter-limb asymmetries during the countermovement jump.

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