BILATERAL JUMP PERFORMANCE IS NOT RELATED TO KINETIC ASYMMETRY IN ELITE AMERICAN FOOTBALL PLAYERS

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Monitoring kinetic asymmetry may provide coaches with a modifiable variable to improve performance. The purpose of this study was to determine the prevalence and relationship of kinetic asymmetry during a countermovement jump (CMJ) and jumping performance. 26 elite American football players performed drop jumps onto an electronic timing mat and CMJ onto a force plate. Kinetic asymmetry was assessed calculating a symmetry index (SI) from inter-limb peak vertical ground reaction forces at propulsion during the CMJ. Pearson correlation coefficients quantified relationships between SI, reactive strength and jump height from the drop jumps, and jump height from the CMJ, $p<.05$. 9/26 (34.6%) participants exhibited SI of $\geq$10%. SI was not significantly associated with any variables. $p>.05$. Players may compensate for asymmetry in a manner that preserves performance.

KEY WORDS: symmetry index, jumping, jump biomechanics

INTRODUCTION: Assessing inter-limb asymmetries is common practice in clinical settings to determine return to play and/or identify injury risk (Bates, Ford, Myer & Hewett, 2013; Mokha, Sprague, & Gatens, 2016; Nadler et al., 2001) with less than 10% and greater than 15%, respectively, suggested as thresholds (Bishop, Turner, & Read, 2017). While assessment of inter-limb asymmetries is becoming common practice in strength and conditioning, the association with athletic performance is less known. A recent systematic review outlined the presence of inter-limb differences in sports such as swimming, rowing and sprinting, and physical competencies such as strength, power and leg stiffness (Bishop, Turner & Read, 2018). Yoshioka and colleagues (Yoshioka, Nagano, Hay, & Fukashiro, 2010) examined the effect of muscle strength asymmetry on the performance (maximal jump height) of countermovement jumps (CMJ) using computer simulation. Jump heights from the model with a 10% strength asymmetry were not significantly different (<1%) than the model without asymmetry. Conversely, Bell and colleagues (2014) found a greater than 10% kinetic asymmetry (power) during a CMJ resulted in deficits in height jumped indicating that reducing these differences may be advantageous. American football is a sport dominated by explosive movements requiring sudden accelerations and decelerations, changes of directions, and jumps. Players seeking to be drafted by the USA's National Football League (NFL) may be invited to the NFL combine where they are evaluated on jumping performance. Thus, identifying factors impacting jumping performance is paramount to coaches and athletes. Therefore, the purpose of this study to determine the association of inter-limb kinetic asymmetry during a CMJ with jumping performance as measured by reactive strength and heights achieved in drop jumps and CMJ. Knowledge of inter-limb kinetic asymmetry may provide coaches with baseline data that could be monitored and/or modified to improve performance.

METHODS: Subjects were 26 adult males (age, 22.4$\pm$0.9 yrs; height, 1.87$\pm$0.08 m; mass, 102.6$\pm$13.7 kg) undergoing specialized training at an off-campus performance center for the NFL draft. All participants had just completed their collegiate football season and were active players training 5-6x per week. The University's Institutional Review Board approved the study, and subjects provided written informed consent. Data were collected over two days with each athlete reporting for one testing session. All participants underwent a standardized 25 min warm-up, consisting of dynamic stretching, muscle readiness and reactivity exercises designed for jumping and running activities. Participants immediately began testing post warm-up.

Drop Jumps

Participants performed 1-jump (1DJ) and 4-jump (4DJ) drop jumps onto an electronic timing mat (Probotics, Inc., Huntsville, AL, USA) from a height of 60cm. Kipp et al. (2018) determined that although not statistically different, RSI was higher at 60cm vs. 45 and 30 cm. Thus, 60 cm was selected to optimize RSI for this study. Participants were instructed to place their hands on their hips and step forward off the box without stepping down or jumping upward. They could initiate the step forward with the limb of their choice but were instructed to land on both feed. Upon landing they were instructed to jump as high and quick as possible. See Figure 1. Jumping technique was monitored qualitatively to ensure participants utilized a standard "triple extension" during the ascent vs. a "tuck jump" technique. This was done to ensure an accurate flight time since jump heights were calculated by the electronic timing mat using the equation, (9.81 * flight time^2)/8. Jump heights (m) were recorded for the 1DJ and 4DJ tasks. RSI was calculated as a ratio of jump height (m) and contact time (s) for the 4DJ; the electronic timing mat only provided contact time when a 4-jump vs. a 1-jump test was completed. Higher values indicate more reactive strength, or explosiveness.

$$\boldsymbol{RSI = \frac{jump\ height\ (m)}{contact\ time\ (s)}}$$

Countermovement Vertical Jump

Countermovement vertical jump (CMJ) height was measured using a Vertec device (JUMPUSA.com, Sunnyvale, CA, USA). First, standing reach height was obtained using the Vertec. Then, participants performed 2 maximal effort CMJ in accordance with the NFL's combine protocol (http://www.nfl.com/combine/workouts). Participants could freely flex the hip, knee and ankle joints and utilize the upper extremities in preparation for take-off. Since the laboratory only had one in-ground force plate (Bertec, Columbus, OH, USA), one jump was performed with the right foot on the force plate and the second jump with the left foot on the force plate. See Figure 2. The best CMJ (m) was recorded and used for analysis. Force data were sampled at 1000Hz and post-processed with a low pass Butterworth filter with a cut-off frequency of 40Hz. Variables of interest were the peak vertical ground reaction forces (vGRF) during the propulsive phase from right and left foot contacts. vGRF from each side were used to calculate the Symmetry Index (SI) as the absolute difference between the right and left sides divided by the sum of the left and right sides, then multiplied by 100. SI is a percentage with values increasing from 0% denoting larger asymmetry magnitudes and is recommended for bilateral tasks (Bishop, Read, Lake, Chavda, & Turner, 2018).

$$\boldsymbol{SI = \frac{(High-Low)}{Total} \times 100}$$

Figure 1. Subject completing a drop jump.

Figure 2. Subject completing a countermovement vertical jump.

Data were transferred to a customized Excel file to extract the dependent variables. Statistics Package for Social Sciences (ver. 25; IBM Corporation, New York, NY, USA) was used for statistical analyses. Pearson's correlation coefficients were calculated to determine associations between 1DJ (m), 4DJ (m), VJ (m), RSI and SI (%) for all subjects, $p<.05$. Correlation strength was determined according to Hinkle, Wiersma, and Jurs (2003) and is as follows: .90 to 1.00 (-.90 to -1.00) as very high, .70 to .90 (-.70 to -.90) as high, .50 to .70 (-50 to -.70) as moderate, .30 to .50 (-.30 to -.50) as low, and .00 to .30 (.00 to −.30) as negligible.

RESULTS AND DISCUSSION: Table 1 presents the associations between 1DJ, 4DJ, RSI, CMJ and SI for all subjects. There was only one statistically significant result, a moderate high positive correlation between 1DJ and 4DJ (r = .513, p = .007). Subjects who jumped higher during the 1DJ also jumped higher in the 4DJ. SI was not associated with any jumping performance variables. Table 2 presents the means of 1DJ, 4DJ, CMJ, RSI, SI and right and left vGRFs for all subjects. Nine of 26 (34.6%) of participants had a SI of greater than 10%. Figure 3 depicts vGRF asymmetry during the preparation and propulsion phases of the CMJ for a sample subject. Figure 4 depicts vGRF symmetry during the CMJ for a sample subject.

Table 1: Correlations between Jump Heights, Reactive Strength Index, and Symmetry Index for All American Football Players (N=26).

Variable	1DJ (m)	4DJ (m)	CMJ (m)	RSI	SI (%)
1DJ (m)	1				
4DJ (m)	.513*	1			
VJ (m)	.177	.456	1		
RSI	.139	.293	.179	1	
SI (%)	-.278	-.257	-.076	-.088	1

Note: * denotes statistically significant difference, $p\leq.05$.

Table 2: Means (±SD) of Jump Height, Reactive Strength Index, Symmetry Index and Vertical Ground Reaction Forces for All American Football Players (N=26).

1DJ (m)	4DJ (m)	VJ (m)	RSI	SI (%)	Rt. vGRF (BW)	Lt. vGRF (BW)
0.52±0.10	0.49±0.08	0.74±0.10	1.27±0.41	9.25±8.44	0.75±0.15	0.74±0.15

Notes: Rt. denotes right side peak propulsion vGRF. Lt. denotes left side peak propulsion vGRF.

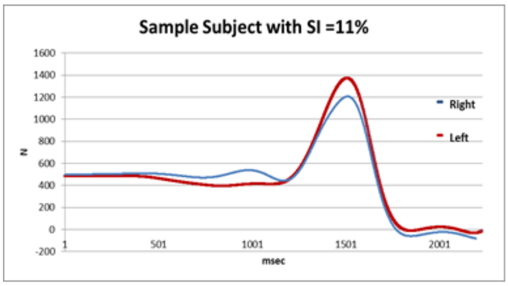

Figure 3. Kinetic asymmetry in a subject.

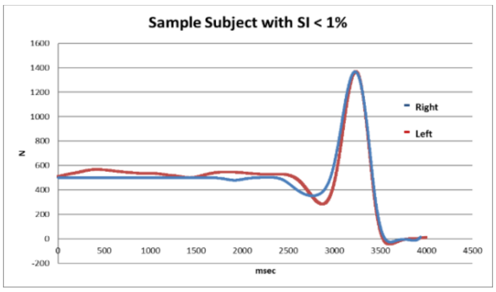

Figure 4. Kinetic symmetry in a subject.

The purpose of this study was to determine the relationship between kinetic asymmetry during a CMJ, and overall jump performance. During a CMJ, it is typically expected that both limbs will contribute equal force, otherwise performance could be compromised. Yet, a certain amount of asymmetry in athletes may also be expected, considering confounding strength factors such as limb dominance, previous injury, and sport task requirements. Indeed, 22/26 (84.6%) of participants had SI ≥ 1%, and 9/26 (34.6%) had SI ≥10%. However, results showed that kinetic asymmetry, as measured by SI, was not significantly associated with selected drop jump or CMJ performance. Assuming strength differences existed in our sample, these findings are congruent with Yoshioka et al. (2000) but not Bell et al. (2014) who found lean muscle mass and power asymmetry negatively affected jump height. In this group, participants

with kinetic asymmetries greater than the 10% appeared still able to perform well in the jumping tasks bringing into question the use of 10% as return to activity guideline. This standard requires continued investigations with athletic populations. Other factors that may have influenced the results, but were not assessed include neuromuscular control, muscle cross sectional area, joint coordination and muscle strength.
This study is not without limitations. The use of a single force plate for the CMJ resulting in the comparison of inter-limb forces between two separate jumps may have affected the validity of vGRFs used for SI. However, CMJ heights did not differ more than 0.0254 m, providing a level of consistency between the two jumps. The participant group was highly motivated, accustomed to these tests, and highly skilled. Further, higher vGRF production was present in some participants on the left [7/26 (26%)] and some on the right [19/26 (74%]) although all performed the first jump with the left foot on the plate. Additionally, kinematics were not assessed to verify if participants moved laterally during the preparation phase of the CMJ and distributed load proportional to muscle strength of the legs. Finally, the mean SI of 9.25% was relatively low, with >50% of participants falling below this value. However, SI ranged from 0-31% demonstrating individual variability that was not captured in the mean.

CONCLUSION: This study resulted in sport-specific findings regarding kinetic asymmetry during jumping tasks by elite American football players. Results indicate that kinetic asymmetry, as measured by the Symmetry Index, is not related to jump height or reactive strength. It appears elite American football players achieve high performance regardless of symmetry. However, coaches may still want to monitor it for individual athlete variation. Further research should continue to analyze the measurement and role of kinetic asymmetry on jumping performance and role in injury prevention.

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