BODY COMPOSITION COMPONENTS ARE RELATED TO VERTICAL JUMP KINETICS IN ELITE AMERICAN FOOTBALL PLAYERS

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American football players vary in body composition across player positions. Components of body composition may affect jumping performance. The purpose of this study was to investigate the relationships between lean body mass, fat mass, total body mass, vertical jump (VJ) height, VJ reactive strength, and VJ kinetic asymmetry. Thirty-nine players had their body composition assessed using a BOD POD and VJ kinetics via a force plate. Pearson correlation coefficients quantified relationships between the variables, alpha = 05. VJ height and reactive strength were highly and very highly negatively associated with lean body mass, fat mass, and total body mass, $p<.05$. VJ kinetic asymmetry was not associated with any component of body composition. Results indicate that player heaviness is inversely related to explosiveness in the VJ.

KEY WORDS: symmetry index, body composition, reactive strength index modified

INTRODUCTION: Body composition in athletes is commonly associated with athletic performance. The proportions of low body fat and high lean mass provide basis for locomotor activities and specific technical skills of the sport. Body composition is routinely assessed to guide planning and evaluation of training and nutrition programs. American football players vary in size and body composition across various player positions (Dengel et al., 2014; Kraemer et al., 2005; Melvin et al., 2014) with linemen reported as having the largest body fat and overall mass. Mean total body mass, fat mass and lean body mass have been reported as 102.9 kg, 16.8 kg, and 86.1 kg, respectively in elite American football players training for the National Football League's (NFL) combine (Antonio et al., 2018) indicating they are massive athletes. Players seeking to be drafted by the USA's NFL may be invited to the combine where they are evaluated on jumping performance, specifically vertical jump (VJ) height and broad jump range. Thus, identifying factors impacting jumping performance is paramount to coaches and elite American football players. Therefore, the purpose of this study to determine the association between body composition and VJ kinetics. Specifically, we examined the relationships between lean muscle mass, fat mass and overall mass with VJ height in meters, VJ reactive strength using modified reactive strength index (RSImod) and VJ kinetic asymmetry using a symmetry index (SI). Knowledge of body composition associations with performance may provide coaches with baseline data that could be monitored and/or modified to improve performance.

METHODS: Participants were 39 adult males (age, 22.0$\pm$0.7 yrs, height, 1.86$\pm$0.06 m; mass, 104.1$\pm$20.4 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 5-6 times per week. The University's Institutional Review Board approved the study, and participants provided written informed consent. Data were collected over three days with each athlete reporting for one testing session. This study was part of a larger study monitoring pre-post changes in vertical jumping, sprinting mechanics, and body composition over the duration of the 6-week training camp. Body composition was assessed using air displacement plethysmography via a BOD POD (COSMED USA Inc., Concord, CA, USA) according to manufacturer's guidelines. Data of interest were total body mass, lean body mass and fat mass. 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. A countermovement vertical jump (VJ) 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 VJ 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 (Figure 1). The best VJ (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). vGRF curves were also used to calculate the modified reactive strength index (RSImod). Time to take-off was determined as the length of time from the start of the unweighting phase of the VJ until flight was achieved (beginning and end of each critical period determined using a 7 N threshold).

$$\boldsymbol{SI} = \frac{(\boldsymbol{High-Low})}{\boldsymbol{Total}} \times \mathbf{100} \qquad \boldsymbol{RSImod} = \frac{\boldsymbol{jump\ height}\ (\boldsymbol{m})}{\boldsymbol{time\ to\ take-off}\ (\boldsymbol{sec})}$$

Figure 1. Subject completing a 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 all variables 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: Table 1 presents the means and standard deviations of the body composition and VJ kinetics for all subjects. Table 2 presents the correlations between VJ kinetics and body composition variables for all subjects.

Table 1: Means (±SD) Body Composition and VJ Kinetics for All American Football Players.

Total body mass (kg)	Lean body mass (kg)	Fat mass (kg)	VJ height (m)	RSImod	SI (%)
104.1±20.4	87.8±9.9	15.6±11.6	0.73±0.10	0.92±0.17	0.56±4.27

Table 2: Correlations between Body Composition Variables and VJ Kinetics for All American Football Players.

Variable	Total body mass (kg)	Lean body mass (kg)	Fat mass (kg)	VJ height (m)	RSImod	SI (%)
Total body mass (kg)	1					
Lean body mass (kg)	.838*	1				
Fat mass (kg)	.925*	.624*	1			
VJ height (m)	-.723*	-.598*	-.681*	1		
RSImod	-.673*	-.532*	-.641*	.825*	1	
SI (%)	.149	-.164	.288	-.230	-.164	1

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

DISCUSSION: Results yielded a very high negative association between total body mass and VJ height, and high negative associations between VJ height and both lean body mass and fat mass. These findings may indicate that regardless of the composition (fat or lean), heavier American football players don't jump as high as lighter ones. Further, there were high negative associations between for RSImod and all three body composition variables indicating that heavier American football players are not as explosive as lighter players regardless of "what" makes them heavier. High lean muscle mass is considered a positive attribute in athletes. However, it does still add to total body mass and overall heaviness. American football players may be limited in their jumping abilities by their heaviness. Participants were symmetrical in their propulsive forces during the VJ with mean SI below 1%. SI was not associated with any body composition variable. Other factors that may have influenced the results, but were not assessed include neuromuscular control, muscle cross sectional area, joint coordination and muscle strength.

CONCLUSION: This study resulted in sport-specific findings regarding body composition and vertical jumping kinetics. Lower jump heights and explosivity were associated with heavier participants. American football players may be limited by their heaviness when it comes to jumping biomechanics and performance. More research is required to understand other biomechanical variables (e.g., muscle function) related to jump performance in elite American football players.

REFERENCES:

Dengel, D. R., Bosch, T. A., Burruss, T. P., Fielding, K. A., Engel, B. E., Weir, N. L., & Weston, T. D. (2014). Body composition and bone mineral density of national football league players. *J Strength Cond Res, 28 (1)*:1-6.

Kraemer, W., J., Torine, J. C., Silvestre, R., French, D. N., Ratamess, N. A., Spiering, B. A., Hatfield, D. L., Vingren, J. L., Volek, J. S. (2005). Body size and composition of National Football League players. *J Strength Cond Res, 19 (3):*485-489.

Hinkle, D.E., Wiersma, W., & Jurs, S.G. (2003). Applied statistics for the behavioral sciences (5th ed.). Boston, MA: Houghton Mifflin.

Melvin, M. N., Wingfield, H. L., Trexler, E. T., Roelofs, E.F. (2014). Muscle characteristics and body composition of NCAA division I football players. *J Strength Cond Res, 28 (12):*3320-3329.