RELATIONSHIP OF REACTIVE STRENGTH AND BODY COMPOSITION IN ELITE AMERICAN FOOTBALL PLAYERS

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Reactive strength represents the ability to change rapidly from eccentric to concentric contraction and may be influenced by body composition. The purpose of the study was to determine if body mass (BM), lean body mass (LBM), or percent fat mass (%FM) were associated with reactive strength. Twenty-five males undergoing training for the National Football League's combine had their Reactive Strength Index (RSI) measured from a 4-jump drop jump (DJ) onto an electronic timing mat, and BM, LBM and %FM assessed via a BodPod. Pearson correlation coefficients showed moderate, negative significant correlations between RSI and BM ($r(23)=-.531$, $p=.006$), and RSI and LBM ($r(23)=-.565$, $p=.003$). RSI was not associated with %FM. Explosiveness appears related to heaviness but not fatness. Coaches may consider effects of body composition modulation on RSI.

KEY WORDS: power, jumping, reactivity

INTRODUCTION: American football is a sport dominated by explosive movements requiring sudden accelerations and decelerations, changes of direction, and jumps. Reactive strength (RS) describes an athlete's ability to efficiently and rapidly produce maximal force in minimal time. RS is essential for success in American football. In a laboratory setting, RS is expressed via the reactive strength index (RSI), a quantitative measure of an individual's ability to quickly switch from an eccentric to concentric muscular contraction. The RSI is used to evaluate explosive ability during depth jumps (DJ) (Flanagan, Ebben, & Jensen, 2008) and is related to increases in athletic performance during jumping, cutting, sprinting, and other explosive movements (Pehar et al., 2017). American football players seeking to be drafted by the National Football League (NFL) may be invited to the NFL combine where they are judged on tests utilizing RS (vertical jump, standing long jump, 40-yard dash, 20 & 60-yard shuttle, 3 cone drill). Thus, assessment and monitoring of the RSI are important to coaches and athletes. Further, positions in American football have distinct requirements that tend to draw players with specific body types (i.e. offensive lineman tend to be taller, heavier and possess greater body fat than wide receivers). Pehar et al. (2017) found that among the centers in professional basketball, the heaviest and fattest had the lowest RSI when compared to guards and forwards. This relationship has not been investigated in elite American football players. Therefore, the purpose of this study was to determine if body composition measures such as BM, LBM or %FM were associated with RS, as measured by the RSI calculated via the drop jump. These participants were amongst the most elite American football players in the United States thus providing rare information for football coaches and researchers.

METHODS: Twenty-five males (age, 22.3$\pm$0.9 yrs; 186.02$\pm$8.54 cm; 101.83$\pm$14.04 kg) undergoing specialized training at an off-campus performance center for the National Football League's (NFL) combine volunteered for this study. All participants had just completed their collegiate football season and were active players training 5-6x per week. The study was approved by the University's Institutional Review Board, and subjects provided written informed consent. All data were collected over two days with each athlete reporting to one testing session. The order of procedures was (1) body composition, (2) warm-up, (3) reactive strength. This study was part of a larger study monitoring pre-post changes in vertical and drop jumping, sprinting mechanics, and bone density over the duration of the 7-week training camp.

Figure 1. Body composition protocol.

Figure 2. DJ RSI test protocol.

Body composition: Body mass was measured on a calibrated digital scale (Tanita Corporation, Tokyo, Japan; modified by Life Measurement, Inc., Concord, CA) to the nearest 0.05 kg. All measurements were taken during a single laboratory visit. Subjects were allowed to drink water, but refrained from eating and training for least two hours prior to being measured. They wore tight-fitting Lycra-type shorts and cap. See figure 1. The Bod Pod was used to estimate lean body mass (LBM) and fat mass percentage (%FM) using air displacement plethysmography (Life Measurement Inc., Concord, CA). All testing, including calibration, was completed in accordance with the manufacturer's instructions.

Warm-up: All participants underwent a standardized 25 min. warm-up in the laboratory instructed by the same coach from the performance center where the athletes were training for the NFL combine. It consisted of dynamic stretching, muscle readiness and reactivity exercises designed to progressively warm-up the athlete for jumping and running activities. Participants showed to the laboratory two at a time, and therefore, were able to immediately begin RSI testing upon completion of the warm-up.

Reactive strength: Participants performed a 4-jump drop jump (DJ) onto an electronic timing mat (Probotics, Inc., Huntsville, AL, USA) from a height of 60 cm as one of three stations in a larger study assessing vertical jumping from a force plate and sprinting on an instrumented treadmill. See figure 2 for DJ protocol used in this report. This electronic timing mat only provides contact time when a 4-jump vs. a 1-jump test is completed. Kipp et al. (2018) determined that although not statistically different, RSI was higher at 60 cm vs. 45 and 30 cm. Thus, 60 cm was selected for this study. Participants were instructed to place their hands on their hips (Sattler et al., 2015) and step forward off the box without stepping down or jumping upward. Upon landing they were to jump as high and quick as possible. This was a bounce jump as described by Marshal and Moran (2013). 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 height is calculated by the electronic timing mat using the equation, (9.81 * flight time^2)/8. RSI was calculated as a ratio of jump height (m) and contact time (s).

$$\boldsymbol{RSI = \frac{jump\ height}{contact\ time}}$$

Data analysis: Jump height and contact time from the electronic timing mat represent the average height and time over the 4 successive jumps completed upon landing. Pearson Correlation Coefficients were used to determine three associations: (a) RSI and BM, (b) RSI and LBM, and (c) RSI and %FM, p<.05.

RESULTS: Table 1 presents the means and standard deviations for the body composition and reactive strength variables. A moderate, negative significant correlation was found between RSI and BM (r(23)=-.531, p=.006) and RSI and LBM (r(23)=-.565, p=.003). Athletes with higher RSI had lower BM; athletes with higher RSI had lower LBM. There was no significant correlation between RSI and FM (r(23)=-.248, *p*=.231). See figures 3-5.

Table 1. Body Composition and Performance (N=25).

Variable	Mean ± SD
Body mass (kg)	101.83 ±14.04
Lean body mass (kg)	85.32 ± 8.24
Fat mass (%)	15.72 ± 4.97
Reactive strength (RSI)	1.26 ± 0.40
Contact time (s)	0.42 ± 0.14
Jump height (m)	0.49 + 0.09

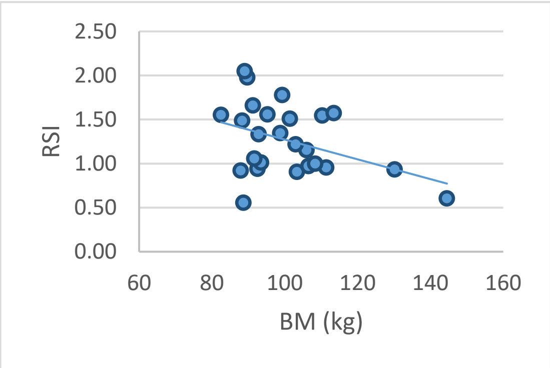

Figure 3. Relationship between BM & RSI

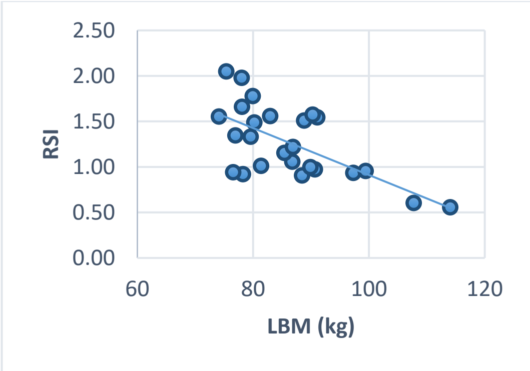

Figure 4. Relationship between LBM & RSI.

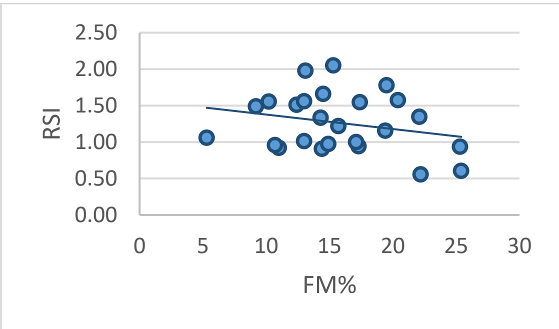

Figure 5. Relationship between %FM & RSI.

DISCUSSION AND CONCLUSIONS: We sought to determine if relationships existed between RSI and various measures of body composition in elite American football players. We hypothesized that BM and %BF would be negatively associated with RSI, that heavier athletes and those with greater adiposity would have lower RS during the DJ. We hypothesized that LBM would be positively associated with RSI. The RSI obtained in this study using a 4-jump DJ protocol are similar to other reports of youth soccer players (1.17-1.27) (Lloyd, Oliver, Hughes, & Williams, 2009), and trained athletes (1.5-2.5) (Flanagan, Comyns, 2008), but somewhat lower than those reported in adult soccer players (1.29-1.7) (Mcclymont, 2003). We analysed 25 well-trained collegiate American football players preparing for the NFL combine. RSI ranged from 0.6-2.0. This sample group of elite American football players most likely produced lower RSI than other studies because of (a) the 4-jump RSI protocol, and (b) inclusion of heavier participants. The 4-jump DJ protocol was necessary due to the practical nature of the testing (timed station approach) and the limitation of the device only providing contact time for a 4-jump series. Results will be discussed in consideration of these factors.

Sattler et al. (2015) reported no significant differences in BM and %FM in males (American football, basketball and handball) between achievement groups on the stop-and-go reactive agility and stop-and-go change of direction speed (CODS) drills. RS was significantly higher in the high achieving group on the CODS drill, and while not statistically different, this group was the heaviest. Our results showed that RS was negatively related to heaviness, having large LBM and overall BM were associated with lower reactive ability. Quickly reversing downward velocity into vertical velocity upon landing to achieve the highest possible jump height proved challenging to heavier players in this study. Results indicate mass gain is a potential conflict in improving RS. Resistance training increases strength but plyometric training appears to have a greater impact on athletic power (Potach & Chu, 2000). Plyometric training also has a higher stimulus on the stretch shortening cycle (SSC) which is a key contributor to RS. Training the fast SSC will make it more efficient; decreasing contact time and improving performance (Ball & Zanetti, 2012). Contact time is the duration for an individual to produce power, which Goss-Sampson et al. (2002) suggest an optimal time of 0.26 s. Mean contact time in this study was 0.42s, but reflects an average over 4 consecutive jumps. Athletes with higher contact times resulting in lower RS would require training to increase reactive strength, power, and the SSC but that training should be relative to weight to optimize performance. We conclude that explosiveness appears related to heaviness in elite American football players but not fatness. Coaches may consider the effects of body composition modulation on RS.

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