INFLUENCE OF JUMPING MEASURES AND SQUAT 1RM ON SPRINT SPEED IN RUGBY UNION PLAYERS

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This study examined the relationship of countermovement (CMJ), squat (SJ), and rebound jumps (RBJ), estimated 1RM back squat (SQ), contact time (CT) and Reactive Strength Index (RSI) for the RBJ to 30 m sprint time of sub-elite, semi-professional Rugby Union players. The results show that with the exception of SQ and CT, all variables were significantly ($p < 0.001$) correlated to each other ($r > .575$). The best determinant of predicting 30 m sprint time was RSI. The relationships of SJ, CMJ, and RBJ jump height and RSI to 30 m sprint time suggest that these rapid movements are all common in Rugby Union players. The results show that estimated 1 RM back squat has little influence on sprint performance.

KEYWORDS: reactive strength index; fitness monitoring; squat strength; field sports

INTRODUCTION: Rugby is a demanding sport that requires high levels of speed strength and agility. Players need to exhibit explosive starts that can be translated to speed and maintained for both short (10 m) and extended (30 m) bursts. Fitness and performance in Rugby have often been assessed using field tests that include: timed sprints of up to 40 m; vertical jumps for height; and measures of muscular strength and endurance such as back squat strength (Baker & Nance, 1999; Cronin & Hansen, 2005). Reactive strength index (RSI) has been related to sprint performance, can be assessed in jumping tasks such as drop or rebound jumps (RBJ), and is defined as the ratio of the jump height divided by ground contact time (Harrison & Bourke, 2009). Since the height in a drop jump or RBJ can be derived from the flight time of the jump with good reliability, RSI can be estimated from ground contact time and flight time using contact mats or force platforms, (Kenny, O'Cairealláin, & Comyns, 2012).
While players and coaches continue to advocate the use of strength exercises such as the back squat to improve sprint performance, (Lockie, et al., 2012), few studies to date have demonstrated any significant transfer of strength training using back squats to sprint performance. Recently, Sáez de Villarreal et al. (2013) found no improvement in sprint performance after 7 weeks of training using back squat exercises.
Despite their widespread using in monitoring performance in Rugby players, the relationship between measures of strength and RSI on sprint performance in Rugby and other field sports remains unclear. In order to ensure the effective use of such field test data and apply fitness monitoring appropriately, it is important to understand the relationships between test measurements and the influence of these measures on sprint performance. Therefore the current research study investigated the relationship of various jumping techniques (CMJ, SJ and RBJ), RSI, contact time during a RBJ, and an estimated 1 RM back squat to 30 m sprint time of sub-elite Rugby Union players.

METHODS: Following institutional ethical approval and written informed consent, twenty-one sub-elite, semi-professional Rugby Union players from two teams competing at a similar level (mean ± SD: age = 19.5 ± 2.1 y; height = 1.84 ± 0.06 m; mass = 94.0 ± 11.5 kg) participated in this study. All testing took place on a single day during the pre-season training period, with subjects asked to refrain from training for 24 hours prior to testing.
Subjects performed three, 40 m sprint trials from a standing start with at least three minutes between trials. Time was recorded for 30 m to the nearest millisecond and was assessed with optical timing gates (Browner Timing Systems, Model: T-C System, Salt Lake City, Utah, USA). Subjects performed three repetitions each of a CMJ, a SJ and a jump from a drop height of 30 cm (RBJ) in a random order.In all cases they were asked to jump as high as possible. For the CMJ they lowered their hands and arms, then jumped vertically, without a preparatory or stutter

step, swinging their arms upward as they jumped. For the SJ they performed the same movement as the CMJ except they paused at the bottom of the counter movement for three seconds. For the drop jump they stepped off the platform and dropped to the floor proceeding directly into a CMJ. Subjects were instructed to minimize ground contact time during the RBJ while still jumping as high as possible. A minimum of two minutes was allowed between each trial. Contact time (CT) from the RBJ and flight time (FT) from all jumps were assessed with an Opto-jump Next system (Microgate, Bolzano, Italy).

For 1RM squat estimation, following warm-up, subjects completed as many repetitions of a full squat as possible in 30 seconds where the athlete descended until the top of the thigh was below parallel with the floor. Estimated 1RM for the back squat was determined according to Adams (1994).

All statistical analyses were completed using SPSS v.18 (PASW, Chicago, IL). Pearson bivariate correlations were determined for all the variables. Regression analysis, with bootstrap technique was used to examine the influence of the independent variables on 30 m sprint time (Jensen & Kline, 1994). Regression entering all independent variables in a block was carried out 30 times by randomly selecting data from 15 subjects. Independent variables were, countermovement jump height, squat jump height, rebound jump height, contact time during the rebound jump, reactive strength index of the rebound jump, and estimated 1RM for the back squat. The influence of these variables was determined by assessing the standardized beta coefficients in each equation according to Sheskin (2007); with larger standardized beta coefficients indicating the importance in predicting the outcome variable (i.e. 30 m sprint time). Alpha level used in all cases was $p = 0.05$.

RESULTS: Mean ± SD for the variables of interest were: 30 m sprint time = 4.517 ± 0.271 s; Estimated (non-normalized) 1 RM squat = 112.3 ± 20.4 kg; CMJ height = 0.298 ± 0.056 m; SJ height = 0.266 ± 0.049 m; RBJ height = 0.271 ± 0.041 m; CT = 0.313 ± 0.063 s; RSI = 8.94 ± 2.03 $m \cdot s^{-1}$. Correlation analysis of the variables indicated that most variables were significantly related ($p < 0.01$) with moderate to large correlation coefficients, $r > \pm.575$ (see Table 1). The two exceptions were estimated 1RM back squat which was not related to any of the other variables ($p > 0.05$); and contact time, which was only related to RSI ($r = -.727$).

Table 1. Correlation matrix of performance variables (average values used for those with more than one trial). Correlations greater than R = .575 were significant ($p < 0.001$) all others were not ($p > 0.05$).

	Sprint 30m	RSI	RBJ Ht	CMJ Ht	SJ Ht	CT
RSI	-.671					
RBJ Ht	-.685	.576				
CMJ Ht	-.665	.621	.871			
SJ Ht	-.695	.637	.848	.927		
CT	.270	-.727	.127	-.006	-.060	
Est 1RM	.135	.074	.198	.277	.325	.073

Results of the regression analysis to predict 30 m sprint time indicated that the variables that were determined from the rebound jump (RBJ height, RBJ contact time, and RSI) displayed the highest standardized beta coefficients. However, high correlations of RSI, RBJ, and CT to each other resulted in a high degree of multi-collinearity in the regression equations. Therefore RSI was selected to represent the variability of these variables because it had the highest standardized beta coefficient. The two lowest means of the standardized beta coefficient were CMJ height (Mean = -0.239; 95% CI = -1.064 to 0.586) and 1 RM back squat (Mean = 0.363; 95% CI = 0.183 to 0.543). Therefore the same 30 samples of 15 subjects were used with RSI as the only variable to predict 30 m sprint time. For these 30 equations, *R* ranged from .536 to .796 and the Standard Error of Estimate (SEE) ranged from 0.135 to 0.238 seconds (see Table 5). A holdout group of the remaining six subjects from each sample was used to cross validate the regression equations. The predicted to actual 30 m sprint time had a mean difference of -0.005 ± 0.017 seconds and a mean correlation of $r = 0.596 \pm 0.040$ (see Table 5).

Table 2. Summary statistics of the bootstrap technique using RSI to predict 30 m sprint speed from 30 regression equations and the cross validation of those equations.

	Mean	SD	Minimum	Maximum
Development				
R	0.690	0.013	0.536	0.796
SEE	0.203	0.005	0.135	0.238
Unstandardized Beta Coefficients				
Constant	5.336	0.023	5.081	5.540
RSI	-0.092	0.002	-0.112	-0.069
Validation				
Correlation	0.596	0.040	0.040	0.956
Mean Difference	-0.005	0.017	-0.139	0.250
t Value	-0.339	0.224	-2.648	2.483

DISCUSSION: The significant correlations found between the variables reveal moderate to strong relationships between jumping variables (CMJ, SJ and RBJ jump height, RSI) and 30 m sprint times. These findings agree with previous research (Baker & Nance, 1999; Cronin & Hansen, 2005; Harrison & Bourke, 2009). Jump height in the SJ, CMJ, and RBJ have been used as field measures of power and their relationship to one another and running speed is not surprising. RSI has been used as a measure of the stretch shortening cycle (SSC) function and an individual's ability to quickly change directions (Flanagan, Ebben & Jensen, 2008) thus its relationship to agility and sprinting would be anticipated and has been noted previously (Flanagan & Comyns, 2008; Harrison & Bourke, 2009). The best determinant of 30 m sprint time was RSI and using it to predict 30 m sprint time was supported by cross-validation.

CT is related to RSI since it is used in calculating RSI, but was not related to any of the other variables. This is in contrast to previous research (Flanagan & Comyns, 2008). A consideration may be the length of the CT during the RBJ where 15 of the 21 subjects attained values that were greater than 250 ms. Flanagan and Comyns (2008) note that when the CT is above 250 ms, the movement can be considered a slow SSC and is not as important in the performance of fast movements.

The estimated 1RM back squat was not related to any of the other variables. This is most likely due to the fact that the back squat is a relatively slow movement (Cronin & Hansen, 2005), while all the other variables involve rapid movements and fast eccentric – concentric muscle actions. The results of the regression analysis on the estimated 1RM back squat indicated that back squat was a poor predictor of 30m sprint time. However, some authors have noted that running and jumping require high levels of back squat strength (Comfort, Haigh, & Matthews, 2012; Wisloff, Castagna, Helgerud, Jones, & Hoff, 2004) and various research studies have indicated significant correlations between a range of strength measures and sprinting performance over various distances (Cronin & Hansen, 2005; Young, McClean, & Ardagna,1995). By contrast, other researchers (Requena, Gonzalez-Badillo, Sáez de Villareal, et al., 2009; Sáez de Villarreal et al., 2013) examined strength and sprint performance in professional soccer players and found only weak correlations between 1RM back squat and performance in short sprints, which is consistent with the findings of this investigation. In a review of transfer of strength to sports performance, Young (2006) concluded that:

> *"Using sprinting performance as an example, exercises involving bilateral contractions of the leg muscles resulting in vertical movement, such as squats and jump squats, have minimal transfer to performance."*

The results of the current investigation provide further support for this conclusion and emphasize that while non-specific resistance training can induce increases in force production of individual muscles, the transfer of strength to performance requires specificity in both movement patterns and contraction velocity.

RSI appeared to be the variable most related to determining 30 m sprint time and this is not altogether surprising since the RSI scores reflect the individual's capacity in fast SSC activities which include drop jump, rebound jump, and sprinting. Harrison and Bourke (2009) showed that rugby players who performed resisted sprint training improved both RSI and acceleration in short sprints. The multi-collinearity of RSI with other variables such as CT and jump heights is understandable due to its mathematical dependence on these variables. Overall it appears that RSI describes the performance characteristics in jumping activities which are most relevant to sprint performance.

CONCLUSIONS: The relationships of SJ, CMJ, and RBJ jump height and RSI to 30 m sprint times suggest that these rapid movements are all common in Rugby Union players. The lack of relationship of 1RM back squat to the other variables was possibly due to the slower nature of this test compared to the faster nature of the other variables. These analyses indicate that 1RM back squat performance has little relevance to sprinting in rugby players, although other aspects of rugby performance may have greater dependence on the back squat strength. The results suggest that speed performance in rugby may be effectively monitored using a combination of sprinting and jump tests and evaluation of RSI. From a practical perspective squat performance has little relevance in monitoring sprint performance in Rugby and possibly in other sports.

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