Measures of maximum strength and jump performance can predict 30 m sprint time in Rugby Union players

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ABSTRACT

Performance and fitness monitoring in Rugby Union often include jumping, sprinting and strength tests, but repeatability of, and relationships between, these measures are unclear. The level of inter-individual variability in these relationships and their sprint time predictive capabilities are also unknown. This study examined the reliability of, and relationship between, countermovement (CMJ_{IH}), squat (SJ_{IH}), and rebound (RBJ_{IH}) jump heights, rebound jump contact time (RBJ_{CT}), estimated 1RM back squat relative to body mass (SQ_{BM}), and Reactive Strength Index (RSI) to 30 m sprint time of sub-elite, semi-professional Rugby Union players. Measurement reliability was very good, with high average intra-class correlation coefficients (≥ 0.9) and low coefficient of variation (<10.1%). All variables were significantly (p < 0.01) correlated to each other (r > .575), except for SQ_{BM} (only related to CMJ_{IH}, r = .621) and RBJ_{CT} (only related to RSI, r = - .727). SJ_{IH} and SQ_{BM} were the strongest and most consistent predictors of time to 30 m (R = .754 ± .081; SEE = .166 ± .025), but variability in SEE magnitude was observed across the group during bootstrapping. Cross-validation showed a mean difference between actual and predicted 30 m times equivalent to 0.22% of the group average time to 30 m. These results support the importance of multiple aspects of fitness training in Rugby Union players for improving performance in short duration sprinting activities, but highlight the individual nature of their relative importance. Measures of strength and power can be used to predict short sprint performance by the strength and conditioning professional.

Keywords: sprint performance; reactive strength index; fitness monitoring; squat strength; field sports; plyometrics;
INTRODUCTION

Rugby is a demanding sport requiring high speed, strength and agility capacity. The nature of the modern game requires players to be strong to successfully tackle, agile to quickly evade opposition, have high cardiovascular endurance to sustain performance over 80 minutes of activity, as well as have rapid force production capabilities for accelerating and tackling. Players must hence train for all the aforementioned components of fitness, and periodized training programs typically include all aspects of fitness in varying proportions throughout the training year. These components of fitness are frequently assessed to monitor athlete development and progress, but their inter-relationships are not well understood.

Sprint performance is an outcome measure of particular interest to the strength and conditioning professional working with rugby players due to its frequency in the modern game, particularly among backs players (2, 21). Previous work has shown players will need to reach over 90% of maximal velocity during 50% of the sprints performed in a game (9). Metrics from jumping tests such as jump heights and ground contact times (CT) have previously been shown to be indicative of sprint performance (15). Jump height is dependent on the ability of the athlete to rapidly propel their center of mass in a vertical direction, and different types of jumps give insight into different underlying muscle capacities. Height achieved during countermovement (CMJ) and rebound (RBJ) jumps are considered indicative of slow and fast stretch-shortening cycle effectiveness, respectively, whereas squat jump (SJ) performance is primarily thought to represent starting strength capacity. Due to its relevance in injury prevention and performance, strength training is frequently included in periodized training programs, but the relationship between strength, effects of strength training, and sprint performance is less clear with mixed results (4, 6, 20). Incorporating multiple forms of training is likely to be the most effective method of training, with Marques et al. (17) showing that combining squat and sprint training improved sprint performance almost twice as much as each separately (3.4%). Due to the multifaceted nature of the game, several different components of fitness are likely to be trained by the strength and conditioning professional simultaneously. Understanding how modification of one parameter may influence another, or affect potential sprint performance, would be
useful for the strength and conditioning professional when attempting to modify training programs.

To use field test data and apply fitness monitoring appropriately, it is important to understand the relationships between the test measures and their influence on sprint performance. Swinton and colleagues (23) derived multiple regression models of sprint performance based on strength and jump measures and found that the best three predictors of 30 m sprint time were one repetition maximum back squat and deadlift, and average power in jumping activities with all variables normalized using an allometric scaling exponent of 0.67 on body mass. However, the indices of influence (standardized beta coefficients) and the potential effects of multi-collinearity were not reported. Furthermore, the consistency of the correlation scores could be reduced due to the high number of variables examined on a limited sample size (n= 30), as Mertler and Vannata (19) recommend 15 subjects per variable when using regression to avoid variability due to chance in developing a model. When working in an applied sports setting where athlete contact time is limited due to training demands and indeed, potential development of fatigue, obtaining sufficient representative samples for regression studies presents a practically difficult problem which is difficult to resolve without the application of data resampling techniques such as bootstrapping (13). Bootstrapping allows repeated sampling (resampling) of the data with a multitude of different subjects in each sample thus providing an overall picture that is similar to that when using a larger sample that would be more representative of the population. Use of such techniques allows the determination of the mean and standard deviation for beta coefficients, Standard Error of Estimate, and multiple R for models that would represent a larger population when using a small sample such as that typically encountered in a training environment (13).

Various studies (4, 7, 8, 14, 16, 20) reveal apparently conflicting findings concerning the influence of strength and jumping performance measures on sprint performance, which is problematic for the strength and conditioning professional working with elite athletes requiring focused, effective training protocols. Since jump and back squat performance measures are commonly used to monitor player fitness levels and as part of talent identification protocols, there is a need to re-examine the strength of the relationships of these tests and their influence on sprint performance. The aim of this
study was to investigate the relationships between commonly used training metrics (jump heights during CMJ, SJ, and RBJ from 30 cm, contact time during RBJ (RBJ<sub>CT</sub>), reactive strength index (RSI), estimated one-repetition maximum strength, and time to 30 m) to inform best practice in training program design in this particular population. Specific objectives were to establish the reliability of these test measures, identify the strength of the relationship between them, and to develop a predictive equation from these commonly used test variables to predict sprint performance.

METHODS

Experimental Approach to the Problem
Twenty-one sub-elite male Rugby Union players performed three CMJ, SJ, RBJ from 30 cm, sprints to 30 m, and one maximum back squat strength test on one day. These variables were selected as they are commonly used fitness tests by the strength and conditioning professional, with sprint time chosen as the dependent variable for the regression analysis due to its importance in the modern Rugby Union game. Use of multiple trials allowed for calculation of reliability indices for the sprinting and jumping variables. The sample size chosen was appropriate for use in regression analyses, and facilitated use of bootstrapping analysis techniques.

Subjects
Following institutional ethical review board approval, twenty-one sub-elite semi-professional adult (over 18) Rugby Union players (mean ± SD: age = 19.5 ± 2.1 year; height = 1.84 ± 0.06 m; mass = 94.0 ± 11.5 kg; 40 yd (36.58 m) sprint time = 5.382 ± 0.352 s) from two teams competing at similar level, volunteered to participate in the study. After being informed of the benefits and risks of the study, subjects signed an institutionally approved informed consent form and completed a Physical Activity Readiness-Questionnaire. All testing took place on a single day during the preseason training period. Subjects were asked to refrain from training for 24 hours prior to testing. All tests were completed in one day and completed in a randomized order.

Procedures: speed 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 (Brower Timing Systems, Model: T-C System, Salt Lake City, Utah, USA).

**Procedures: jumps testing**

Subjects performed three repetitions each of a CMJ, SJ, and RBJ from 30 cm with their hands on their hips. For the CMJ, subjects were instructed to jump vertically without a preparatory or stutter step, and to jump as high as possible. For the SJ, subjects squatted to approximately 90 degrees knee angle which was held for 2-3 seconds, prior to jumping as high as possible without any countermovement. This was checked by placing a hand under the chin prior to performance of the jump; if a dip was detected by this, the jump was repeated. For the RBJ they stepped off a 30 cm box with their preferred jumping limb and dropped to the floor with both limbs, proceeding directly into a CMJ as high as possible while minimizing the preceding CT. A minimum of two-minutes rest took place between each trial. Contact time from the RBJ (RBJ\(_{CT}\)) and flight time (FT) from all jumps were assessed with an Opto-jump Next system (Microgate, Bolzano, Italy). The validity of the Opto-jump Next system as a field test of jump performance has been demonstrated by Castagna et al. (5). Jump height in each of the three jump conditions was calculated using FT assuming an equal parabola of flight:

\[
\text{Jump height} = \frac{9.81 \times F{T}^2}{8}
\]

Jump heights are subsequently described as CMJ\(_{JH}\), SJ\(_{JH}\), and RBJ\(_{JH}\).

Reactive Strength Index (RSI) was determined from the following equation:

\[
RSI = \frac{RBJ_{JH}}{CT}
\]

Where CT refers to the CT immediately preceding the RBH\(_{JH}\).

**Procedures: strength testing**

To prepare for 1RM squat estimation, subjects warmed up with 3-5 repetitions of 10-20% of their estimated three-repetition max (3RM) load. They then rested for two
minutes followed by 3-5 repetitions of 40-50% of the estimated 3 RM load and after another two minutes performed 2-4 repetitions of 70-80% of the estimated 3 RM load. Following an additional two-minutes rest subjects completed as many repetitions as possible in 30 seconds. For the full squat, the athlete descended until the top of the thigh was below parallel with the floor. This depth was visually assessed by a Certified Strength and Conditioning Specialist. Estimated 1RM for the back squat was determined according to Adams (1) where:

\[
1RM (kg) = \frac{\text{Back squat load}}{1 - (0.02 \times \text{number of repetitions})}
\]

This 1RM was then normalized to an individual’s body mass (SQBM).

Statistical Analyses
All statistical analyses were completed using SPSS v.22 (PASW, Chicago, IL). Reliability of data were assessed using two-way mixed measures average and single intra-class correlation coefficients (ICC) with absolute agreement, and coefficient of variation. Between-trial differences were assessed using repeated measures analysis of variance. Normality was assessed via Kolmogorov-Smirnov and Shapiro-Wilks tests. To establish the strength of the relationship between individual test results, Pearson bivariate correlations were calculated for all variables. These values were interpreted using the scale of Hopkins (12), where correlations were interpreted as small (\( r = 0.1 \) to 0.3), moderate (\( r = 0.3 \) to 0.5), large (\( r = 0.5 \) to 0.7), very large (\( r = 0.7 \) to 0.9) and almost perfect (\( r = 0.9 \) to 1.0). To determine the influence of the independent variables on 30 m sprint time, regression analysis using a bootstrap technique was performed (13). Regression entering the independent variables in a block, via forced entry, was carried out 30 times by randomly selecting data from 15 of the 21 subjects. Independent variables were the average of the three trials for CMJ_{JH}, SJ_{JH}, RB_{JH}, RB_{JCT}, and the score from the SQ_{BM} test. Average data was used as it was considered representative of a typical performance. Other variables (RSI, FT) were not included as they were not independent from others included in the model and therefore would not allow for singularity of the variables. The influence of the variables was determined by assessing the standardized beta coefficients in each equation according to Sheskin (22) where the larger the standardized beta coefficient the greater the importance in
predicting the outcome variable, in this case 30 m sprint time. Since the standardized beta coefficient of some variables had a negative sign in one run and positive in others, comparisons were made using the absolute value of the standardized beta coefficient. Multiple R and Standard Error of Estimation (SEE) were also determined for the 30 bootstrapped equations. For each iteration of the regression, cross-validation was completed using the remaining six subjects. Alpha level used in all cases was $p \leq 0.05$.

RESULTS

Reliability
Measurement reliability was very good, particularly for average data (all ICC $\geq 0.9$). Reliability of single measures of CMJ$_{H}$, SJ$_{H}$ and time to 30 m were also very reliable (ICC $>0.9$). No differences were observed across the three trials of the variables of interest ($p > 0.09$) and coefficient of variation was low (Table 1).

<Insert Table 1 about here>

Means and correlations
Correlation analysis of the variables indicated that most variables were significantly related ($p < 0.01$) with moderate to very large correlation coefficients, $r > \pm .575$ (Table 2). The two exceptions were SQ$_{BM}$ which was only related to CMJ$_{H}$ ($r = .621$) and RBJ$_{CT}$, which was only related to RSI ($r = -.727$).

<Insert Table 2 about here>

Regression analysis
Results of the regression analysis using the 30 bootstrapped equations to predict 30 m sprint time indicated that when all variables were collated, SJ$_{H}$ and SQ$_{BM}$ were the strongest predictors of sprint time (standardized beta coefficients of 0.508 and 0.459 respectively) while CMJ$_{H}$ was the weakest predictor (standardized beta coefficient of 0.339; Table 3).

The equation to determine 30 m sprint time was

$$Time \ to \ 30 \ m = 4.838 + 1.731(RBJ_{CT}) - 0.023(RBJ_{HT})$$
\[-0.011(CMJ_{HT}) - 0.025(SJ_{HT}) + 0.648(SQ_{BM})\]

Following bootstrapping using the 30 test equations, $R^2$ ranged from 0.584 to 0.903 and SEE ranged from 0.078 to 0.221 seconds, the equivalent of 1.7 to 4.9% of measured sprint time and within the measured variability (Table 3). The 30 bootstrapped equations performed well in cross-validation, with mean differences between predicted and actual 30 m sprint times of $0.010 \pm 0.143$ seconds (0.22% of group average time to 30 m). Range of the difference was -0.214 to 0.520 s. Mean correlation for the predicted versus actual values for the 30 bootstrapped equations was $r = 0.560 \pm 0.294$. The mean t-value for the cross validation of the 30 bootstrapped predicted versus actual values was $-0.101 \pm 1.753$ (range: -2.389 to 6.432).

**DISCUSSION**

The aim of this study was to establish the reliability of, and investigate the relationships between, the commonly used fitness testing measures of RBJ_{CT}, RBJ_{JH}, CMJ_{JH}, SJ_{JH}, SQ_{BM}, and time to 30 m. Measures were shown to be very reliable, with several being reliable even when single measures were obtained. Jump height measures were shown to be highly correlated to one another and to sprint times. An equation combining the results from these tests was developed and could predict 30 m sprint time to within 5%, giving the strength and conditioning professional a tool which could be used to establish potential effects of modifying training programs where sprint performance is a measure of interest.

The high reliability of the measures presented in Table 1 is a positive outcome for the strength and conditioning professional as it indicates that even when the amount of trials an athlete can complete is limited, data acquired will be reliable. The significant correlations found amongst the variables revealed moderate to strong relationships between jumping variables (CMJ_{JH}, SJ_{JH} and RBJ_{JH}) and 30 m sprint time. Similar to sprinting, both the CMJ and RBJ require utilization of the stretch-shortening cycle, so these relationships would be expected. A relationship between SJ_{JH} and time to 30 m has also been identified previously (14). RSI had a moderate to strong relationship to 30 m sprint performance and other jump variables. The relationship with RBJ_{JH} and
RBJ_{CT} is unsurprising given these are the variables from which it is derived. RSI has been used as an index of stretch shortening cycle function and an individual’s ability to quickly change directions thus its relationship to sprinting would be anticipated and in agreement with previous research on Rugby players (3, 7, 11). Although related to RSI (since it is used in its calculation), CT was not related to any of the other variables. This contrasts to previous research (10, 18) and may be due to the duration of the RBJ_{CT}. While reliability was high (average ICC = .900 with no differences between trials; see Table 1), 15 of the 21 subjects attained values that were greater than 250 ms. Flanagan and Comyns (10) noted that when RBJ_{CT} is above 250 ms, the movement can be considered a slow stretch-shortening cycle (SSC) which is not as important in the performance of fast rebounding movements. Therefore, if RBJ_{CT} of the current athletes was typical of a slow SSC, its relationship to the other variables examined in this investigation would most likely disappear. As SJJ_{JH}, CMJ_{JH}, and RBH_{JH} have all been used as field indices of jump impulse, their strong relationships to one another and running speed is not surprising. The weaker relationship between SQBM and CMJ_{JH} (r = .621) compared to most other significant relationships is most likely because the back squat is a relatively slow movement. In contrast, all the other variables involve rapid movements or fast eccentric – concentric muscle actions which maximize stretch-shortening cycle performance.

The results of the regression analysis provided an equation which allowed an acceptable prediction of 30 m sprint time, accounting for 75.4% of variance with a relatively small SEE of 0.166 s (3.7% of average time to 30 m). It performed particularly well during cross-validation, with mean differences of 0.22% of the group average time to 30 m. The SJJ_{JH} and SQBM performances were found to have the greatest influence on 30 m sprint time as shown by the standardized beta coefficients (.508 and .459), and CMJ_{JH} the lowest (.339). Use of bootstrapping facilitates a more detailed analysis of how variable these beta coefficients were through analysis of the 95% confidence intervals and range observed. The influence of SH_{JH}, although on average the largest, is also the most variable with coefficients varying from .163 to 1.152 (range of .901); the range of coefficients observed for CMJ_{JH} was also high (.783). Variability of the other measures were lower, but still highlight the influence of different fitness characteristics on 30 m sprint time varies considerably across subjects. This variability may help to explain the somewhat contradictory finding that SQBM had the greatest
influence in the regression analysis when considered with the other variables, but a lower correlation. This highlights the need to still consider each athlete as an individual. Results are consistent with the variable correlations between 1RM back squat strength and sprint performance observed by other researchers (24).

The importance of SJJH to 30 m sprint performance is reasonable since it has been related to early acceleration in sprinting (15). Given that acceleration in short sprints is mechanically determined by impulse, players could use variable strategies to generate impulse which could be either force-dominated with short CT or CT-dominated with lower forces. In sprints longer than 30 m, a reduction in the influence of SJJH and an increase in the influence of RBJH and CMJJH could be expected since performance in longer sprints relies less on early acceleration ability and more on maximum speed. Therefore, it is likely that in longer sprints, the influence of SSC capacity, such as that quantified during activities such as the CMJ and RBJ would increase while the influence of the isometric strength capacity assessed in the SJ would decrease.

**PRACTICAL APPLICATIONS**

Results of the current investigation demonstrate the relevance of performance in jumping tasks such as the SJ, CMJ and RBJ and lower body strength to performance in short sprints, and highlight that although all are relevant, the degree of influence is athlete-specific. The equation developed can predict sprint performance to within 5% and could be a useful tool for the strength and conditioning professional interested in understanding how modification of particular aspects of a training program may influence sprint performance. Results support the importance of both strength and jump-based (plyometric) training in optimizing short sprint performance.
REFERENCES:


Table 1. Reliability for three trials of jump contact time, heights and time to 30 m (n = 21).

<table>
<thead>
<tr>
<th></th>
<th>Group average ± standard deviation</th>
<th>Coefficient of variation (%)</th>
<th>Average ICC (95% CI)</th>
<th>Single ICC (95% CI)</th>
<th>Effect of trial (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBJCT(ms)</td>
<td>0.313 ± 0.063</td>
<td>9.3</td>
<td>.900</td>
<td>.792 - .956</td>
<td>.934</td>
</tr>
<tr>
<td>RBJJH (m)</td>
<td>0.271 ± 0.041</td>
<td>6.0</td>
<td>.926</td>
<td>.847 - .968</td>
<td>.672</td>
</tr>
<tr>
<td>RSI</td>
<td>0.894 ± 0.203</td>
<td>10.1</td>
<td>.913</td>
<td>.820 - .962</td>
<td>.798</td>
</tr>
<tr>
<td>CMJJH (m)</td>
<td>0.298 ± 0.056</td>
<td>5.1</td>
<td>.966</td>
<td>.930 - .985</td>
<td>.523</td>
</tr>
<tr>
<td>SJH (m)</td>
<td>0.266 ± 0.049</td>
<td>4.6</td>
<td>.975</td>
<td>.945 - .989</td>
<td>.083</td>
</tr>
<tr>
<td>Time to 30 m (s)</td>
<td>4.517 ± 0.271</td>
<td>1.2</td>
<td>.965</td>
<td>.928 - .985</td>
<td>.361</td>
</tr>
</tbody>
</table>
Table 2. Correlation matrix of performance variables (average values were used for those with more than one trial). Significant correlations (p < 0.01) indicated in bold text with 95% Confidence Intervals in parentheses.

<table>
<thead>
<tr>
<th></th>
<th>SQBM</th>
<th>RBJCT</th>
<th>RBHJH</th>
<th>RSI</th>
<th>CMJJH</th>
<th>SJH</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBJCT (ms)</td>
<td></td>
<td>-0.223</td>
<td></td>
<td>0.487</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-0.597 to 0.231)</td>
<td>(-0.322 to 0.530)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RBJH (m)</td>
<td>0.487</td>
<td></td>
<td>0.127</td>
<td>0.074</td>
<td>-0.727</td>
<td>0.576</td>
</tr>
<tr>
<td></td>
<td>(0.069 to 0.759)</td>
<td></td>
<td>(-0.322 to 0.530)</td>
<td>(-0.370 to 0.490)</td>
<td>(-0.882 to -0.430)</td>
<td>(0.191 to 0.807)</td>
</tr>
<tr>
<td>RSI</td>
<td>0.074</td>
<td>-0.727</td>
<td></td>
<td>0.621</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-0.370 to 0.490)</td>
<td>(-0.882 to -0.430)</td>
<td></td>
<td>(0.245 to 0.997)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CMJJH (m)</td>
<td>0.621</td>
<td></td>
<td></td>
<td>0.006</td>
<td>0.871</td>
<td>0.621</td>
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<tr>
<td></td>
<td>(0.245 to 0.997)</td>
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<td></td>
<td>(-0.437 to 0.427)</td>
<td>(0.703 to 0.947)</td>
<td>(0.245 to 0.997)</td>
</tr>
<tr>
<td>SJH (m)</td>
<td>0.538</td>
<td></td>
<td></td>
<td>0.848</td>
<td>0.637</td>
<td>0.927</td>
</tr>
<tr>
<td></td>
<td>(0.138 to 0.787)</td>
<td></td>
<td></td>
<td>(0.479 to 0.382)</td>
<td>(0.656 to 0.937)</td>
<td>(0.825 to 0.970)</td>
</tr>
<tr>
<td>Time to 30 m (s)</td>
<td>-0.276</td>
<td>0.270</td>
<td>-0.685</td>
<td>-0.685</td>
<td>-0.665</td>
<td>-0.695</td>
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<tr>
<td></td>
<td>(-0.632 to 0.177)</td>
<td>(-0.183 to 0.628)</td>
<td></td>
<td>(-0.682 to -0.359)</td>
<td>(-0.682 to -0.359)</td>
<td>(-0.852 to -0.326)</td>
</tr>
</tbody>
</table>
Table 3. Summary statistics for $R^2$, Standard Error of Estimate, and absolute values of the standardized beta coefficients for the independent variables from 30 bootstrapped equations using RBJ_{CT}, RBJ_{JH}, CMJ_{JH}, SJ_{JH} and SQ_{BM} to predict 30 m sprint time

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard deviation</th>
<th>95% CI</th>
<th>Minimum</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>Maximum</th>
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</thead>
<tbody>
<tr>
<td>$R^2$</td>
<td>0.754</td>
<td>0.081</td>
<td>0.584 to 0.882</td>
<td>0.583</td>
<td>0.716</td>
<td>0.771</td>
<td>0.809</td>
<td>0.903</td>
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<tr>
<td>SEE</td>
<td>0.166</td>
<td>0.025</td>
<td>0.113 to 0.213</td>
<td>0.078</td>
<td>.153</td>
<td>0.166</td>
<td>0.179</td>
<td>0.221</td>
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Standardized Beta Coefficient values

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard deviation</th>
<th>95% CI</th>
<th>Minimum</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>Maximum</th>
</tr>
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<tbody>
<tr>
<td>RBJ_{CT}</td>
<td>0.387</td>
<td>0.162</td>
<td>0.013 to 0.623</td>
<td>0.010</td>
<td>0.324</td>
<td>0.388</td>
<td>0.499</td>
<td>0.652</td>
</tr>
<tr>
<td>RBJ_{HT}</td>
<td>0.376</td>
<td>0.313</td>
<td>0.044 to 0.623</td>
<td>0.012</td>
<td>0.130</td>
<td>0.290</td>
<td>0.495</td>
<td>1.289</td>
</tr>
<tr>
<td>CMJ_{HT}</td>
<td>0.339</td>
<td>0.217</td>
<td>0.052 to 0.835</td>
<td>0.036</td>
<td>0.146</td>
<td>0.294</td>
<td>0.492</td>
<td>0.914</td>
</tr>
<tr>
<td>SJ_{HT}</td>
<td>0.508</td>
<td>0.241</td>
<td>0.180 to 1.081</td>
<td>0.163</td>
<td>0.352</td>
<td>0.434</td>
<td>0.626</td>
<td>1.152</td>
</tr>
<tr>
<td>SQ_{BM}</td>
<td>0.459</td>
<td>0.207</td>
<td>0.139 to 0.817</td>
<td>0.107</td>
<td>0.290</td>
<td>0.434</td>
<td>0.613</td>
<td>0.825</td>
</tr>
</tbody>
</table>

Model validation

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Difference</th>
<th>t Value</th>
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</thead>
<tbody>
<tr>
<td>Correlation</td>
<td>0.560</td>
<td>-0.214 to 0.335</td>
<td>-2.389</td>
</tr>
<tr>
<td>Mean Difference</td>
<td>0.010</td>
<td>-0.214 to 0.335</td>
<td>-0.935</td>
</tr>
<tr>
<td>t Value</td>
<td>-0.101</td>
<td>-3.024 to 4.203</td>
<td>-0.041</td>
</tr>
</tbody>
</table>