Short Communication

Relationships between jump and sprint performance in first-class county cricketers

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Objectives: Research across a number of sports has identified a meaningful relationship between jump and sprint performance. The aim of this study was to investigate these relationships in first-class county cricketers.

Design and Methods: Using a within-subjects repeated measures design, sixteen male cricketers (23.8 ± 3.7 years; body mass, 85.40 ± 9.37 kg; height, 185.34 ± 6.90 cm) performed countermovement jumps (CMJ), depth drop jumps (DDJ), and 20m sprints on three separate occasions.

Results: Intraclass correlation coefficients (ICC) demonstrated a high within- (ICC ≥ 0.936; $p \leq 0.001$) and between- (ICC ≥ 0.807; $p \leq 0.001$) session reliability for all tests. Low smallest detectable differences (SDD), between-sessions, were observed for CMJ height (5.26%) and sprint times (2.72-5.80%). CMJ height demonstrated the strongest correlation with 20m sprint time ($r = -0.741$, $p = 0.006$, power = 0.99), whereas DDJ reactive strength index demonstrated a moderate, although non-significant relationship with 20m sprint time ($r = -0.495$, $p > 0.05$, power = 0.70).

Conclusion: The results demonstrate that athletes with a higher CMJ performance demonstrate quicker 20m sprint time. These findings also imply that the acceleration phase of a sprint may involve the slow stretch shortening cycle (SSC) to a greater extent than the fast SSC. Strength and conditioning coaches should, therefore, focus on enhancing these attributes through the development of maximal strength and enhancement of SSC ability through the use of appropriate plyometric tasks. Additionally, when identifying performance changes in CMJ height and 5, 10 and 20 m sprint times, changes of >5.26%, 5.80%, 2.98%, and 2.72%, respectively, signify a meaningful change.
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Key words: Acceleration ■ Short sprint ■ Smallest detectable difference ■ Stretch shorten cycle

INTRODUCTION

Cricket has changed dramatically over recent years, with the game now becoming more athletically and physically demanding, in both Twenty20 and one day cricket in particular. The number of sprints in a game has increased and they are often performed in situations that directly affect the outcome of a game, for example, during a potential run-out situation, by both the fielder, and the batsman running between the wickets. As a result, high running speed is now considered an important attribute to possess.[1] Along with sprint tests, vertical jump tests, such as the countermovement jump (CMJ) test, have also been included as part of physiological testing batteries for professional cricketers, as it is considered to be an important attribute to cricket performance.[2]

Sprinting, particularly during the acceleration phase, involves the use of the stretch shortening cycle (SSC) at each ground contact. It is thought that during the acceleration phase, the long SSC is utilised, as ground contact time (GCT) is relatively slow (>250 ms) and joint angular displacement is large.[3] When maximum speed is reached, the short SSC is utilised as GCT decreases (<250 ms) and joint angular displacement is smaller.[3] During a sprint start, the horizontal velocity of an athlete's centre of mass typically ranges between 3.5 and 4.0 m.s⁻¹ and has reached 4.5-5.0 m.s⁻¹ by the third stride[4]. This highlights the importance of force production during the acceleration phase of sprinting (i.e. when overcoming the inertia of, and accelerating, an athlete's own body mass), with force produced during the propulsion phase being highly correlated with running velocity ($r = 0.74$, $p<0.05$).[4]

Numerous studies have found that maximum strength correlates well with both jump height and sprint time. For example, Wisloff *et al*.[5] found strong correlations between one repetition maximum half squat performance and CMJ height ($r = 0.78$, $p<0.02$), 10 m sprint time ($r = 0.94$, $p<0.001$), and 30 m sprint time ($r = 0.71$, $p<0.01$). Other research also shows strong correlations between maximum strength and CMJ height ($r = 0.760$, $p<0.001$) and 20 m sprint time ($r = -0.672$, $p<0.001$).[6] Comfort *et al*.[7] found that 20 m sprint time improved when lower body strength increased, demonstrating decreases in 20 m sprint time from 3.03 ± 0.09 s to 2.85 ± 0.11 s ($p<0.001$) when relative strength (kilograms lifted per kilogram of body mass) was increased from 1.78 ± 0.27 kg. kg⁻¹ to 2.05 ± 0.21 kg.kg⁻¹ after an 8 week training period.

Research has also shown a strong relationship between jump height and sprint time. For example, Bosco *et al*.[8] found a very strong inverse relationship between CMJ height and 30 m

sprint time (r = - 0.93, p<0.01), similar to the correlation between the same variables found by Hori *et al*.[9] (r = - 0.69, p<0.01). Lopez-Sigovia *et al*.[10] found an inverse correlation between CMJ height and 20 m sprint time of r = - 0.54 (p<0.05), and Requena *et al*.[11] found a correlation between the same variables of r = - 0.47 (p<0.05). Nesser *et al*.[12] found a moderate inverse correlation of r = - 0.464 (p<0.05) between vertical jump height and 40 m sprint time.

The aim of this study was to determine the relationships between jump height and 5-, 10-, and 20 m sprint time in first-class county cricketers, given the importance of these tasks to cricket performance. It was hypothesised that the relationship between jump height and sprint time would demonstrate a strong correlation, similar to that previously reported by Hori *et al*.[9], who used subjects with similar age and anthropometric characteristics to the present study. It was also hypothesised that CMJ height and sprint time would demonstrate a stronger correlation than depth drop jump (DDJ)-reactive strength index (RSI) and sprint time due to type of SSC action. It was further hypothesised that the CMJ, DDJ-RSI and 5-, 10-, and 20 m tests would all be reliable tests.

METHODS

Experimental Design

The aim of the study was to investigate the relationship between jump (DDJ and CMJ) and short sprint performance in first-class county cricketers. The sprint distances (5, 10, 20 m) were chosen as they have commonly been used within the literature and representative of the short sprints that are performed running between the wickets (17.68 m). Both of the jump tests are commonly used to assess SSC ability in athletes. The subjects were all familiar with performing all the tests. The CMJ test was selected to assess the long SSC, as the contribution of the stretch reflex action is thought to be less during the long SSC when the GCT is longer, and there are large angular displacements at ankle, knee and hip.[3] The DDJ-RSI was used to assess the short SSC. During short GCT, where the angular displacement of the hip, knee and ankle is small, the muscle relies on a high contribution from the reflex action to produce the muscle force along with the return of elastic energy.[3] The tests were performed three times per session across three sessions interspersed by a one week period, in order to assess within- and between-session reliability.

Subjects

All subjects were first-class county cricketers (n = 16; 23.8 ± 3.7 years; body mass, 85.40 ± 9.37 kg; height, 185.34 ± 6.90 cm) from the same club who had 5.1 ± 2.3 years of experience of competing at this level. They were provided with full participant information and all provided written informed consent. The study protocol was approved by the institutional review board and conformed to the principles of the World Medical Association's Declaration of Helsinki (1983).

Testing took place at the end of the cricket season, when players were playing four-day county championship matches. All subjects rested for two days prior to each of the three testing sessions and were instructed to arrive as they would to training, in a fed and hydrated state. All testing was completed on an indoor cricket surface which the subjects were accustomed to training on.

Procedures

The subjects performed the tests in the following order: DDJs, CMJs, 20 m sprints, following a standardized dynamic warm up, which all players were familiar with.

Jump Tests

Prior to the DDJ tests, the subjects undertook a short preparation, identical to that which they performed daily prior to DDJs completed for monitoring purposes. This involved progressive stiff-legged plyometric double-footed hops. All subjects performed 3 DDJ trials from a 30 cm high box, with 2 minutes recovery time between each trial. The subjects were instructed to land consistently throughout each DDJ trial, to perform the DDJs with a self-selected depth (during the eccentric phase) designed to elicit their maximum jump height and to keep their legs straight (i.e. avoid tucking) during the flight phase of the jump. The best of the 3 trials was reported for comparison between days and the best performance across the three days was used for correlation analysis.

DDJ-RSI was then calculated by dividing jump height by GCT, as derived via a portable jump mat (FitTech, Australia). Each trial was required to have a GCT of less than 200 ms for the purpose of these tests to ensure the action was ballistic and utilised the desired short SSC. If this criterion was not met, the subject then rested before repeating the trial.

Prior to the CMJ, subjects undertook a 5 minute non-fatiguing plyometric warm-up. This included mobilisation exercises and non-fatiguing jumping activities. All subjects performed 3 trials with 2 minutes recovery time between each trial. The best of the 3 trials was reported for comparison between days and the best performance across the three days was used for correlation analysis.

The subjects were required to keep their hands on their hips throughout both sets of jump trials to eliminate the use of the arms. Jump height was assessed using a portable jump mat (FitTech, Australia), which calculated jump height from flight time. Flight time was defined as the period between the instants of take-off and subsequent ground contact upon landing. This time was then used in the equation of uniform acceleration (1) to determine jump height:

$$JH = \frac{9.81 \times FT^2}{8} \tag{1}$$

Where JH = jump height and FT = flight time

Sprint Tests

The subjects undertook a standardised 10 minute warm-up which included activation and mobilisation exercises as well as sprint drills and progressive sprints. The subjects performed 3 sprints each, with 150 s rest between each trial. The time taken to run 5 m, 10 m, and 20 m was measured using Brower timing gates (Draper, Utah, USA). The subjects started 0.5 m behind the first timing gate at 0 m, using a two

point stationary start. The best of 3 trials was reported for comparison between days and the best performance across the three days was used for correlation analysis.

Statistical Analyses

Intraclass correlation coefficients (ICC) were used to assess the reliability of each test within- and between-sessions. Normal distribution was assessed using Shapiro-Wilk's test of normality. The relationships between variables were determined using Pearson's correlation coefficients (for parametric data), and Spearman's correlation coefficients (for non-parametric data). SPSS software (version 20.0, IBM) was used in all the above calculations. Correlation coefficients were interpreted as being weak (0.1-0.3), moderate (0.4-0.6) and strong (>0.7) in line with previous recommendations [13]. The standard error of measurement (SEM) and smallest detectible difference (SDD) were calculated using the equations described by Munro & Herrington.[14]

Post-hoc statistical power calculations performed using G.Power 3.1 [15] showed a statistical power of 0.80, 0.95 and 0.99 for the relationship between CMJ & 5, 10 and 20 m sprint

performance, respectively and 0.70 for the relationship between DDJ-RSI & 20 m sprint performance.

RESULTS

Shapiro-Wilk's test for normality showed that the data from DDJ-RSI, CMJ, and 20m tests was normally distributed (p>0.05) both within- and between-sessions. Data from the 5 m and 10 m sprints was found to be non-parametric (p<0.05). The ICC's show a very high reliability for all tests within-session (ICC ≥0.936; p≤0.001) (Table 1) and a high reliability between-sessions (ICC ≥0.807; p≤0.001) (Table 2).

Pearson's correlation coefficients demonstrated a moderate although non-significant (r = - 0.495, p>0.05) relationship between DDJ-RSI and 20 m sprint time. In contrast, CMJ showed a strong, inverse, significant (r = - 0.741, p = 0.006) relationship with 20 m sprint time (Figure 1), with a coefficient of determination of $r^2 = 0.555$.

Spearman's correlation coefficients showed a moderate, inverse, significant relationship between CMJ height and 5 m sprint time (r = - 0.634, p<0.05), and a strong, inverse, significant relationship between CMJ height and 10 m sprint

Table 1. Within-session descriptive statistics and reliability for jump and sprint performances

	DDJ-RSI	CMJ (cm)	5m (s)	10m (s)	20m (s)
Mean	1.76 ± 0.33	42.10 ± 5.30	1.06 ± 0.06	1.79 ± 0.07	3.08 ± 0.12
ICC (R)	0.936*	0.987*	0.948*	0.964*	0.964*
SEM	0.08	0.6	0.02	0.02	0.03
SDD	0.23	1.68	0.04	0.05	0.08
SDD (%)	12.99	3.98	3.83	0.3	2.7

*p<0.001

DDJ = Depth drop jump; RSI = reactive strength index; CMJ = countermovement jump;
ICC = intraclass correlation coefficient; SEM = standard error of measurement;
SDD = smallest detectible difference.

Table 2. Within-session descriptive statistics and reliability for jump and sprint performances

	DDJ-RSI	CMJ (cm)	5m (s)	10m (s)	20m (s)
Mean	1.78 ± 0.35	42.80 ± 4.40	1.03 ± 0.05	1.76 ± 0.06	3.05 ± 0.11
ICC (R)	0.911*	0.966*	0.807*	0.893*	0.923*
SEM	0.11	0.8	0.02	0.02	0.03
SDD	0.29	2.25	0.06	0.05	0.08
SDD (%)	16.36	5.26	5.8	2.98	2.72

*p<0.001

DDJ = Depth drop jump; RSI = reactive strength index; CMJ = countermovement jump;
ICC = intraclass correlation coefficient; SEM = standard error of measurement;
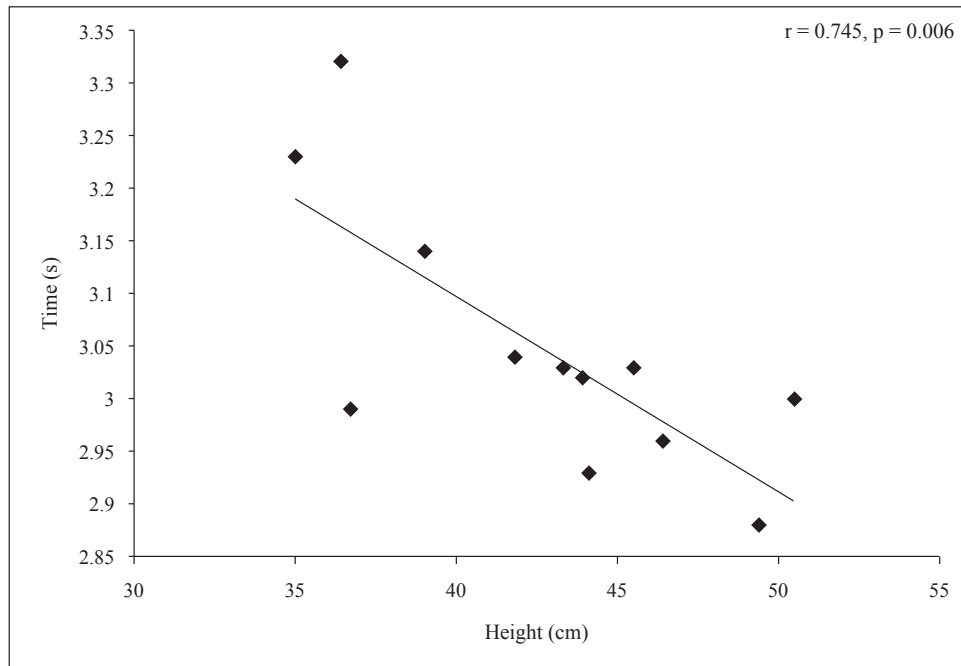SDD = smallest detectible difference.

Figure 1. Relationship between CMJ height and 20 m sprint time

time (r = - 0.748, p<0.01).

Within-session SDD for each test, expressed as a percentage of the mean was low for all assessments (range 0.30-3.98%) excluding the DDJ-RSI test (12.99%). Between-session SDD for each test followed the same pattern (range 2.72-5.80% for all tests except the DDJ-RSI test (16.36%)) (Table 2).

DISCUSSION

This study found a strong significant inverse relationship between CMJ performance and 20 m sprint time (r = - 0.741, p<0.01), as hypothesized. Additionally, CMJ performance showed a stronger correlation with 20 m sprint time than DDJ-RSI (r = - 0.495, p>0.05), as hypothesized. As expected, all tests were found to be reliable, although the between-session SDD for the DDJ-RSI was rather large (16.36%).

The findings of this study are similar to those reported by Bosco *et al.*[8], and Hori *et al.*[9] who found strong and moderate inverse relationships of r = - 0.93 (p<0.01) between 30 m and CMJ and r = - 0.69 (p<0.01) between 20 m and CMJ performances, respectively. The correlations in this study are not as strong as those reported by Bosco *et al.*[8] although the subjects used in the earlier study were a mixed group of male and female jump athletes which may have increased the range of values attained. Hori *et al.*[9] used subjects with similar age and anthropometric characteristics to the present study, with the mean values for 20 m sprint time and CMJ height (3.17 s and 41.5 cm) similar to those reported in the present study (3.05 s and 42.8 cm).

The difference in the strength of correlations observed between 20 m time and CMJ height and 20 m sprint time and DDJ-RSI in the present study contradicts the findings of Hennessy and Kilty[16] who found that DDJ performance was the primary variable related to 30 m sprint time, accounting for 63% of the variance seen in sprint time. However, Hennessy and Kilty[16] related DDJ height to sprint performance whereas the present study correlated RSI to 20 m sprint performance which may explain the differences observed between studies. Although the greater sprint distance of 30 m utilised in the study conducted by Hennesy and Kilty[16] would have likely resulted in a higher running velocity and shorter GCTs than those attained in the present study, 30 m sprint performance is also reflective of the acceleration phase of sprint running which, like 20 m sprint performance, would mainly involve the use of the long SSC. Young *et al.*[17] suggested that the DDJ-RSI reflected the utilisation of the short SSC to greater extent than DDJ height did and that DDJ-RSI may better relate to the maximum velocity, rather than to the acceleration, phase of sprint running.

The mean CMJ height achieved by the cricketers tested in the present study (43 ± 4 cm) was similar to the mean value reported for professional cricketers in an earlier study (45 ± 5 cm).[2] To the author's knowledge, no previous research has been conducted in cricketers to allow for a comparison of sprint times tested over the same distances presented here, but the 20 m sprint times attained by the subjects in the present study (3.05 ± 0.11 s) were similar to those reported for semi-professional Australian Rules football players[9], as mentioned earlier, and to those of young well-trained footballers.[6, 10] However, the international football players in the study by Wisloff *et al.*[5] displayed much greater CMJ height (56.4 ± 4.0 cm), despite similar 20m sprint times (3.00 ± 0.30 s). As would be expected, semi-professional sprinters also displayed significantly quicker 20 m sprint times (2.85 ± 0.13 s) and greater jump height (53.6 ± 4.9 cm).[11]

Because much of the sprint running performed in team sports, and in particular cricket, is over a very short distance,

the ability to increase velocity in the first few ground contacts of the acceleration phase may be considered more important to team sport performance than maximal velocity running. These first few ground contacts consist mainly of concentric muscle actions and propulsive forces.[4] Therefore, the ability to produce a great concentric force through the knee and hip extensors is important in generating high running velocity. Resistance training is a widely used method of training for speed and power athletes due to the large amount of research outlining its positive effect on sprint performance. One method of resistance training may improve one phase of a sprint but have no effect on another, therefore, it is important that strength training is viewed multi-dimensionally.[18] The above evidence[4] would suggest that, in order to target improvements in the acceleration phase of sprinting, coaches should include exercises emphasising concentric muscle actions, examples of these include; squat jumps, CMJ, clean variations. Further research could be performed to determine the efficacy of undertaking this specific type of resistance programme versus a traditional mixed programme, and its specific effect on sprint acceleration performance.

It should be noted that a strong correlation between CMJ height and 20 m sprint time does not mean that there is a cause-effect relationship between these variables. However, the findings are similar across most research, and it could be suggested that vertical jump, or lower body power, performance forms part of the multi-factorial relationship contributing to sprint performance. Due to the high SDD (16.36%) for the DDJ-RSI test, strength and conditioning coaches should be cautious when using such methods of assessment to determine fatigue and readiness to train and are advised to determine the SDD for their own squad of athletes, to permit them to make focussed and informed decisions from such data. It is worth noting that Markwick et al.[19] reported excellent reliability of DDJ-RSI in basketball players, but this may be attributed to their much greater familiarity with jumping tasks.

CONCLUSION

The results of this study demonstrate that vertical jump performance is related to 20 m sprint performance in first-class county cricketers, with a strong inverse relationship observed between CMJ height and 20 m sprint time. Additionally, while DDJ-RSI demonstrated a moderate (although non-significant) association with 20 m sprint time, this was the weakest relationship observed in the present study and demonstrated the lowest reliability of the jumping parameters assessed. DDJ-RSI values also demonstrated the largest between-session SDD (16.36%) in this population, therefore limiting the possible application of this task to identify small changes in neuromuscular fatigue in cricketers.

These results imply that the acceleration phase of a sprint involves the use of the long SSC to a greater extent than the short SSC. Strength and conditioning coaches should, therefore, spend time developing sprint athletes' strength and explosive strength qualities and should view resistance training as multi-dimensional, focussing on force production and long SSC actions to improve the acceleration phase of a sprint. In addition, when identifying performance changes in CMJ height and 5, 10 and 20 m sprint times, changes of >5.26%, 5.80%, 2.98%, and 2.72%, respectively, signify a meaningful change.

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