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Association between Leg Power and Sprinting Technique with 20-m Sprint Performance in Elite Junior Australian Football Players

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ABSTRACT

The main purpose of this study was to determine the association between leg power and sprint technique with 20-m sprint performance. Seventy-seven elite junior Australian Rules football players were assessed on a 20-m sprint test, a countermovement jump (CMJ) and a two bound test, and on a new method of quantifying sprint technique from simple video recordings. Technique assessment involved rating 14 points on a scale from 1-5. Players were median-split into faster and slower groups based on their 20-m times, and they were compared for differences in leg power and technique. The faster group was significantly better ($p < 0.05$) in the two-bound test (5.2%) and the technique score (8.2%), but not in the CMJ ($p > 0.05$). A multiple regression indicated that the two-bound test and technique accounted for 37.7% of the variance associated with the 20-m sprint time ($p < 0.05$). It was concluded that the technique assessment tool captured some important characteristics of 20-m sprint performance and could potentially be used to profile or monitor athletes. Further the two-bound test is a more relevant test for developing athletes because of its specificity to sprinting, compared to the CMJ.

Key words: Acceleration, Australian Football, Leg Power, Sprinting Technique, Vertical Jump

INTRODUCTION

The ability to accelerate over relatively short distances such as 20 m is important for many field sports such as the various codes of football. In Australian Rules football (ARF), analysis of running demands in games determined by Global Positioning Systems (GPS) revealed there were 74 mean sprints per game [1] and over 200 accelerations over 4 km/hr/s [2]. A 20-m sprint test using a standing start is typically used to assess short sprint abilities of elite junior ARF players for talent identification, and performance in this test has been shown to

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be a good predictor of being selected to play professionally [3]. Further, gaining more possessions in elite junior competition is associated with better performance in the multi-stage shuttle run and the 20-m sprint test [4]. Therefore it is of considerable interest to understand what factors contribute to 20-m sprint performance.

It is widely believed that explosive force production from the leg extensor muscles is crucial for acceleration performance and many studies have reported statistically significant correlations between a measure of leg power and short sprints of 40 m or less [5-12]. Therefore coaches spend considerable training time to develop leg power in the hope that it will transfer to improved sprint performance.

Leg power is typically assessed by vertical jumps using a double leg take-off such as a countermovement jump (CMJ), which could be expected to involve a different neuromuscular activation pattern to sprint running. Therefore various unilateral tests involving forward jumping movements have been employed and shown to highly correlate with acceleration performance [8]. Indeed, a study by Nesser et al. [13] showed that a 5 bound test correlated more strongly with 40-m time ($r=-0.81$) than a vertical jump test ($r=-0.46$). In contrast, research has also shown that for 30-m time [9] and 10-m time [14], the correlations were higher for a CMJ than various horizontal jumping tests. Therefore the test and muscle function that best relates to acceleration performance is not clear.

Another factor considered to be important for acceleration performance is running technique [15] since the capacity to produce high levels of power may be ineffective if forces are not directed to propel the whole body in a forward direction. Although training to enhance sprinting technique is common in track athletes, it is emphasised less in the training of team sport athletes. This may be because of the difficulty evaluating and coaching many athletes in a team training environment, and also the competing demands with many other factors that contribute to team sport performance.

Assessing sprint technique often involves a sophisticated biomechanical analysis, which may be labour-intensive, time-consuming and expensive to implement in a team sport setting. Therefore an alternative technique analysis tool that may reveal key technique strengths and weakness of team sport athletes and is relatively easy to administer would be valuable. Unfortunately most of the literature relating to sprint technique is related to track and field and to longer sprints where maximum velocity is reached [16]. There is relatively little research describing the optimum technique for acceleration sprinting, but a brief review follows.

In a block start, force production variables on the blocks and the velocity generated in the first two steps highly correlates with time to 20 m [17], suggesting that an effective start is important for acceleration performance. Approximately 90 degrees at the knee of the front leg and 120-140 degrees at the knee of the back leg are recommended for a block start [18]. Although the optimum joint angles for the standing start are not known, similar angles may be expected to be effective. The capacity to produce high acceleration from a standing start is dependent on a forward orientation of the body [19], and premature raising of the body can be considered a fault [15]. In the first two steps, the centre of gravity of the body should be ahead of the contact foot and as the sprint progresses, step length and step rate increase while ground contact time gradually decreases [20]. A near complete extension of the hip, knee and ankle joints is desirable for high force output [18], but should not be at the expense of a high step frequency, which is particularly important for acceleration performance [21]. The trunk should be straight so there is no "rounding" of the back [15]. Typically a 90 degree angle at the elbows is recommended during a vigorous arm swing that should be in forward and backward direction rather than across the body [22].

A purpose of this research was to develop a new technique analysis tool that could be applied to the 20-m sprint in team sport athletes. The main purpose was to determine if leg power and sprint technique (using the new instrument) were associated with 20-m sprint performance. It was hypothesised that these two factors would distinguish faster and slower sprint athletes and together, account for a large proportion of the 20-m time.

METHOD

EXPERIMENTAL APPROACH TO THE PROBLEM

In order to assess running technique during a 20-m sprint, a new instrument was developed that was intended to be user-friendly for coaches. To achieve this goal, it was designed to use readily available equipment and require minimal biomechanical expertise. A review of coaching and research literature was conducted to reveal key technique factors considered important for short sprints up to 40 m from a stationary start. It must be noted that much of the biomechanical research relates to such issues as the relationship between various kinetic variables (forces) or joint angles (kinematics) and sprint performance, with few clear implications for technique analysis. Nevertheless we have attempted to develop a checklist of observable technical points and a corresponding level of importance to acceleration performance. The rationale for the technique scoring instrument used in this study was outlined briefly in the Introduction section.

With an assessment tool that requires a score to be allocated on technique factors, it is important to know if similar scores are achieved when rated by different individuals. Therefore to determine the inter-rater reliability, a club fitness coach not involved in the study was given the technique evaluation list (Table 1), and asked to score one randomly selected sprint trial from 31 participants. The intra-class correlation was calculated and produced a reliability coefficient of 0.861, indicating that the test was objective. The mean difference in scores between the two raters was 1.2 out of 44, and the difference in the total score was 0-2 in 65 % of the cases. The coefficient of variation (90 % CI) was 4.2 % (3.5-5.3).

With the constraint of limited clear evidence about the important technique points for acceleration performance, a checklist was developed that included 14 attributes which were given a points value between 1-5, based on their perceived relative importance to 20-m sprint performance (Table 1). Participants were also assessed on two tests of leg power, a CMJ (bilateral and vertical) and a two-bound test (unilateral and horizontal). The association between the leg power tests, the technique score and 20-m sprint performance could then be observed.

SUBJECTS

The subjects were 77 male elite-junior ARF players from one club squad aged between 16-18 years, and had a mean $\pm$ SD height and weight of 180.8 ± 6.1 cm and 74.0 ± 7.5 kg respectively. Testing was conducted on the whole squad from this elite-level under-18 club just prior to the start of the season, and some of the players were subsequently cut to form the final team. After the competitive season, some players were recruited to play for professional ARF clubs. Consent was provided by the participants or if less than 18 years of age, by a guardian, and the study was approved by the University's Human Research Ethics Committee.

PROCEDURES

On a single day, three tests were conducted in a counterbalanced order and were conducted indoors on a sprung wooded floor. Prior to testing, a group warm-up was conducted by the club fitness staff lasting about 20 minutes and consisted of jogging, dynamic stretches and

activities and run-throughs of gradually increasing intensity.

20-m Sprint Test. The participant adopted a standing start with the toe of the front foot on the start line which was directly under the start beam. He was allowed to start when ready and the first forward movement started the timing, with the time stopped at the 20-m mark. Timing was conducted with a dual beam infra-red timing system capable of recording time to 0.01 s (Swift performance Equipment, Brisbane, Australia). Two trials were performed with approximately one min recovery, and the best of the trials was retained for analysis. The sprints were recorded with two digital video cameras (JVC HD operating at 50 fields.s⁻¹) mounted on tripods and positioned side-on (in-line with the 5-m mark and 15 m back from the running lane), and front-on to the running direction (10 m beyond the finish line). Video footage was later analysed so that slow-motion and freeze-frame features allowed one of the researchers to evaluate and score the sprint technique. The side-on view was used to evaluate all technique points whereas the front-on view was mainly used to evaluate points 2 and 14 (Table 1). The time taken to evaluate each athlete's technique was typically about 10 minutes. After scoring each item, the total score was the sum of the 14 technique points, and this was retained to represent technique for each player.

Table 1. Assessment sheet for scoring 20m sprint technique

Attribute	Description	Points weighting
Start position		
1. Knee angles	<ul style="list-style-type: none"> • Approx 90-100 degree knee bend of lead leg • Approx 120-140 degree bend of back leg 	3
2. Foot positioning	<ul style="list-style-type: none"> • Feet approximately hip width apart while in start position • Feet should be pointing towards the target 	3
3. Arm positioning	<ul style="list-style-type: none"> • Arm opposite to lead leg is held forward 	1
4. Weight distribution	<ul style="list-style-type: none"> • Athlete leans forward while in starting position • Positions centre of mass over front foot 	3
Running		
5. Forward lean	<ul style="list-style-type: none"> • Significant forward lean during initial steps of exercise • Approximately 45-55 degrees of forward lean 	5
6. Centre of mass under hips	<ul style="list-style-type: none"> • Initial ground contact during first 3-4 steps is made at a point which is close to the line of the hip 	3
7. Triple extension at toe-off	<ul style="list-style-type: none"> • Near full extension of hip, knee and ankle joints of support leg at toe off throughout exercise 	5
8. Neutral spine	<ul style="list-style-type: none"> • No rounding of back throughout exercise 	3
9. Trunk extension	<ul style="list-style-type: none"> • Gradual decrease in forward lean • Upright trunk by approximately 10-15 metre mark 	3
10. Upper body movement	<ul style="list-style-type: none"> • Elbows remain at approximately 90 degrees during upper arm motion • Upper arm/shoulder rotate forward to approx 30 degrees and backward to approx 90 degrees 	3
11. Ankle during swing phase	<ul style="list-style-type: none"> • Ankle remains at approx 90 degrees during swing phase (no plantar flexion) until just before ground contact 	1
12. Knee lift during swing phase	<ul style="list-style-type: none"> • Angle of hip during swing phase reaches 90 degrees or less at smallest point • "Angle of the hip" refers to the angle between the trunk and the thigh. 	5
13. Ground contact after 10m	<ul style="list-style-type: none"> • Initial ground contact should not be made with the heel of the foot • Contact should be made with the ball or mid foot to reduce breaking forces 	5
14. Undesirable rotations	<ul style="list-style-type: none"> • Arms and legs should not cross midline of the body • Knees and shoulders should always be facing target • Should be viewed from in front of the participant. 	1

CMJ. This is a widely-used test to assess leg power by jumping without the assistance of an arm swing [12, 23]. Jump height and peak power were obtained by an integrated system comprising a linear position transducer, a force platform and associated computer software (Ballistic Measurement System, Fitness Technology, Australia). Peak power was expressed in absolute terms (W) as well as relative to body mass (W/kg). The best of three trials was used for analysis. The inter-day reliability for this test has previously been shown to be good, with a coefficient of variation of less than 10% [24].

Two-Bound Test. As there is no standardized unilateral horizontal leg power test, we chose a test requiring two bounds. It was believed that more than two bounds would allow the accumulation of relatively long horizontal distances which would be expected to induce large impact and eccentric loads, which the participants were not accustomed to and is not a characteristic of acceleration running. The participant placed the toe of the left foot on a start line with the other foot off the floor, then jumped for maximum horizontal distance to land on the other foot, and then immediately bounded forward to finally land with both feet together. This was repeated starting on the right foot after a 30 s rest, and the mean of the two jumps was retained for analysis. Distance was measured with a metal ruler from the toe to the heel of a foot closest to the start line at landing. Distance was expressed in absolute terms (m) as well as relative to standing height (distance/height) to account for individual differences in height and leg length.

STATISTICAL ANALYSES

To determine the association between 20-m time and the technique and leg power variables, the whole group was median-split to form two groups based on their 20-m times, which created a “faster” and a “slower” group. Independent t-tests were then conducted to determine if there were any significant differences ($p < 0.05$) between the two groups. To describe the magnitude of the differences between the groups, effect sizes were calculated and interpreted as 0-0.2=“trivial”, 0.2-0.6=“small”, 0.6-1.2=“moderate”, 1.2-2.0=“large”, 2.0-4.0=“very large” [25]. To determine how much variance associated with 20-m sprint performance was explained by a combination of the technique and leg power variables, a stepwise multiple regression was performed with statistical significance set at $p < 0.05$. To determine the relationship between the CMJ and two bound test, a Pearson correlation was conducted.

RESULTS

The mean $\pm$ SD for all tests are shown in Table 2. Due to very minor injury concerns such as muscular soreness, some players did not perform all tests. There was a very large and statistically significant difference between the groups in 20-m time, indicating the split was successful in creating distinctly faster and slower groups. There were some moderate and statistically significant differences between the groups with the faster group displaying better performance in the two-bound test (distance/height)(5.2%) and the technique analysis score (8.2%). However, there were small to trivial non-significant ($p > 0.05$) differences between the groups for height, weight and the CMJ variables (Table 2).

There was a significant regression ($p < 0.05$) for predicting 20-m time and the variables selected by the multiple regression model were technique and two bound distance/height ($R^2 = 0.377$), indicating that 37.7% of the variance associated with 20-m time was explained by these variables. The correlation between the two bound test (distance/height) and the CMJ (power/weight) was $r = 0.106$, $p = 0.498$.

Table 2. Mean $\pm$ SD results for faster and slower groups

	All (n=77)	Faster (n=39)	Slower (n=38)	% difference from slower	Effect size	P value
20m time (s)	3.14 $\pm$ 0.09	3.06 $\pm$ 0.05	3.22 $\pm$ 0.06	-5.0	2.90 (very large)	<0.001
Height (cm)	180.8 $\pm$ 6.1	180.5 $\pm$ 6.2	181.2 $\pm$ 6.1	-0.4	0.11 (trivial)	0.622
Weight (cm)	74.0 $\pm$ 7.5	73.8 $\pm$ 7.6	74.3 $\pm$ 7.5	-0.7	0.07 (trivial)	0.757
Technique analysis (TA)	36.7 $\pm$ 3.8	38.1 $\pm$ 3.7	35.2 $\pm$ 3.4	8.2	0.82 (moderate)	0.001
CMJ jump height (cm)	42.4 $\pm$ 0.5	42.9 $\pm$ 0.05	41.9 $\pm$ 0.05	2.4	0.20 (small)	0.530
CMJ peak power (W)	1839 $\pm$ 525	1791 $\pm$ 474	1887 $\pm$ 579	-5.1	0.18 (trivial)	0.543
CMJ peak power/weight (W/kg)	24.3 $\pm$ 5.9	23.8 $\pm$ 5.3	24.9 $\pm$ 6.6	-4.4	0.18 (trivial)	0.527
Two-bound distance (cm)	431.7 $\pm$ 24.5	441.4 $\pm$ 23.3	421.7 $\pm$ 21.6	4.7	0.88 (moderate)	<0.001
Two-bound distance/height (cm/cm)	2.38 0.14	2.44 $\pm$ 0.13	2.32 $\pm$ 0.12	5.2	0.96 (moderate)	<0.001

DISCUSSION

An important and novel finding of this study was that the new technique assessment score was associated with better 20-m time, suggesting that the assessment instrument captured some relevant characteristics of sprint acceleration performance. To our knowledge, this is the first evidence-based tool to achieve this. Another key finding was that there was also a significant association between the two bound test and 20-m sprint performance, since the faster athletes were superior in this leg power test.

The finding that the two bound test was associated with 20-m time, but the CMJ variables were not, is consistent with the research of Nesser et al. [13], and may be explained by the greater specificity of the unilateral horizontal test. However, some research has shown CMJ to correlate more strongly with sprint performance than a horizontal leg power test [9, 14], which may be explained by differences in the particular tests uses as well as the athlete groups. The athletes in the present study were not highly resistance-trained or experienced with CMJ movements. The limited number of bounds may have suited these athletes as impact loads would likely be relatively small. The low and statistically non-significant correlation between the CMJ and two-bound test ($r=0.106$) indicates these tests of leg power have very little in common (1% common variance). Although it can be assumed they both assess some characteristics of leg power, their neuromuscular and biomechanical expression appears to be very different. One difference between the tests is the range of motion at the knees, with observations indicating less knee flexion in the two-bound test.

Since both technique and leg power were significantly associated with 20-m sprint performance, we wanted to know how well these qualities in combination predicted acceleration performance. Despite a statistically significant multiple regression, only 37.7% of the variance of 20-m time could be explained by these two qualities. This suggests that other factors besides technique and leg power that were not assessed (perhaps flexibility, maximum strength or reactive strength), contribute to performance as measured by 20-m time. Alternatively, there may be characteristics of the technique analysis and the leg power tests that did not fully capture the demands of the 20-m sprint test.

PRACTICAL APPLICATIONS

The results of this study suggest the new technique analysis instrument may be potentially useful for coaches to assess 20-m sprint performance. The process involves videotaping and analysing key technique points which are easily visible from a side-on and front-on view, and

is relatively time-efficient (about 10 minutes per player). The score may be used to decide how much training time to devote to enhancing sprint technique for individual athletes. If such assessment is conducted in conjunction with a test of physical qualities such as leg power, an athlete profile can be generated that reveals strengths and weaknesses. If an athlete scores relatively poorly in any of the tests, training can be directed to overcoming the athlete's specific weakness while at least maintaining the strengths. Further, the specific technique points that scored relatively poorly could be the focus of training to enhance acceleration technique. If the athlete is re-tested after a period of training, the test could potentially be used to monitor technique development.

In general, the inter-rater reliability was shown to be good, and therefore the technique analysis does not have to be performed by the same person to generate similar results for an individual athlete. As new evidence emerges about the importance of various technique points for acceleration performance, the instrument should be modified to more accurately represent acceleration performance.

The significant association between two-bound performance and 20-m time suggests that this test can potentially be used to assess leg power as it relates to acceleration, and this unilateral horizontal test may be preferable to a CMJ, at least for athletes with limited experience with the CMJ movement. As the two-bound test is unique, future research should establish its inter-day reliability before it can be confidently recommended for routine athlete assessment. Another implication of the findings is that unilateral horizontal training exercises like bounding and speed-bounding may be more productive for such athletes than vertical jumping exercises for enhancing acceleration performance.

CONCLUSION

Faster junior athletes (based on a 20-m sprint test) were found to possess significantly better technique as well as leg power, as measured by the two bound test, but were not better than slower athletes in the CMJ. It was concluded that the technique assessment tool captured some important characteristics of 20-m sprint performance and could potentially be used by coaches for athlete assessment. Also the two bound test is a more relevant test than the CMJ for developing athletes because of its specificity to sprinting.

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