Title: An investigation into the physical determinants of a change of direction task

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Abstract

Agility is an important attribute for many sports and is believed to be influenced by a variety of physical factors. However, there is a lack of consensus as to which physical attributes relate to agility. The aim of this study was to examine the relationship of several physical attributes to agility. Thirty-eight subjects (mean ± SD: age, 21.5 ± 3.8 years; height, 1.77 ± 0.07 m; mass, 77.5 ± 13.9 kg) undertook tests of speed, agility, strength and power. Running speed was assessed via a 25 metre sprint with split times taken at 5, 20 and 25m. Agility was assessed by a 505 test, which involves measuring the time to complete a 5 m out and back course. The strength and power tests included unilateral isokinetic concentric and eccentric knee extensor and flexor strength at 60°/s and bilateral leg press, countermovement and drop jumps. Pearson's product moment correlation and co-efficients of determination were used to explore relationships amongst all variables. Multiple regression was used to determine the combined effects of significantly correlated variables on agility. Stepwise multiple regression revealed that running speed explained 58% of the variance in agility ($F_{1,33}$ = 45.796, p<0.001) with the addition of eccentric knee flexor strength raising the value to 67% ($F_{1,32}$ = 8.781, p = 0.006). The results suggest that for basic improvements in agility, athletes should seek to maximise their sprinting ability and enhance their eccentric knee flexor strength to allow effective neuromuscular control of the contact phase of the agility task.

Keywords: agility, change of direction speed, speed, eccentric strength

INTRODUCTION

Agility is an important component of many sports and may be defined as 'a rapid whole-body movement with change of direction in response to a stimulus' (1). In recent studies, agility has been considered to be dependent on 2 sub-components, a) perceptual and decision making factors, and b) to factors related to the actual mechanics of changing direction (2, 1, 3). In light of this, many tests of agility and training exercises that do not involve a decision-making aspect are considered to be assessing or training change of direction speed (2,1,3). For the purpose of this study, tests of agility that do not include a perceptual or decision making component will be referred to as measures of change of direction speed (CODS) and can be defined as the ability to decelerate, reverse or change movement direction and accelerate again.

Successful CODS is thought to be influenced by a number of physical and technical attributes, including straight sprinting speed/acceleration, eccentric and concentric strength and power and reactive strength (2).

Previous research has found significant but low correlations between 20m sprint and the Illinois agility test as well as no relationship between 20m sprint and the 505 agility test (4). The Illinois agility test involves a sprint from a start line to a 2nd line 9.1 m away, a turn and sprint back to the start line followed by a turn to weave down and back through a series of cones down the same 9.1 m course and then finally a repeat of the sprint from the start line to the second line and back again (reference?), The 505 test involves a 15 m sprint with a set of timing lights set at 10m to a turning point where the subject performs a 180^{o} turn and a 5 m sprint back through the timing lights. The time from passing the timing lights until returning through them is the measure of agility performance (Reference). In contrast to the previous findings, Graham-Smith and Pearson (18) reported a co-efficient of determination of 65.6% between a 15 m sprint and a similar 180^{o} turn task. Other studies investigating relationships between speed and CODS have involved CODS tasks with multiple turns and less sharper changes of direction. Buttifant *et al.* (5) found weak correlations between a zig-zag agility test with undefined magnitudes of the turns involved and straight sprint performance. Similarly, non-significant low correlations between 20m sprint and similar zig-zag tests with 90º and 120º changes of direction have been reported (6). A small difference was reported by Little and Williams (7) who found small to moderate correlations and coefficients of determination between acceleration (10m sprint) and agility (4 × 5m 100º zig-zag sprint) together with maximum speed ('flying' 20m sprint) and agility. These results indicate that straight sprinting speed is not strongly related to agility performance. Indeed, Young *et al* (8) have shown that straight sprint training does not improve performance in sprints with change of direction and vice versa. Thus, these studies support the notion that each component must be considered independently when designing training programmes.

With reference to relationships between leg strength qualities and change of direction speed, the greater reliance on the eccentric-concentric reactive coupling during the braking and propulsion phases of a change of direction task provides a strong rationale for the role of reactive strength in CODS (9). Despite this rationale, previous research has produced conflicting findings. Young *et al*. (6) found no relationship between reactive strength as measured by a 30cm drop jump and lower body power (loaded and unloaded countermovement jumps) and 90º and 120º change of direction sprints. Similarly, Young *et al*. (2) reported non-significant correlations between isokinetic concentric squat power and sprints with changes of direction of various magnitudes, and only a few significantly moderate correlations with drop jump performance. In contrast, Negrete and Brophy (10) reported moderate and significant correlations between a complex lower extremity test involving multiple changes of direction and short sprints and normalised isokinetic leg press, squat and knee extension and single leg hop for distance. In accordance with the latter findings, Barnes *et al*. (11) found that countermovement jump ability was a significant predictor (34%) of the variance of an agility test that involved 4 × 5 metre sprints with 3 × 180º turns.

The discrepancy between many of these studies is partly due to a lack of consensus in the agility/CODS test used and methods of strength measurement utilised. Many of these studies used multiple turns of differing magnitude and variations in the total distance covered in the agility task. A more consistent trend may have been evident if a test that focused on one turn was used, which subsequently placed more emphasis on neuromuscular control to achieve performance. Another limitation in the abovementioned studies is that they have been restricted to single correlations and have not investigated the combined effect of the numerous physical factors by virtue of multiple regression analysis.

Therefore, the aim of this study was to examine the relationship of several physical attributes to CODS performance as measured by the '505' test (4). It was hypothesised that a large variation in CODS performance is explained by acceleration ability as well as reactive strength and eccentric knee extensor and flexor strength.

MATERIALS AND METHODS

Subjects

Thirty-eight University students participated in the study (female, n=5; male, n=33; mean ± SD: age, 21.5 ± 3.8 years; height, 177.3 ± 6.9 cm; mass, 77.5 ± 13.9 kg). The subjects had various sporting backgrounds, including individual and team sports athletes, and actively played sport at the time of the study. The study was approved by the Institutional Ethics Committee and all subjects provided written informed consent to participate.

Procedures

Testing took place over a two-day period with a) speed and agility, and b) strength and power, measured on separate days. All subjects were familiarised with the procedures prior to testing. The subjects had been instructed to refrain from strenuous exercise for forty-eight hours prior to testing and to avoid food and caffeine intake for two hours preceding the assessments. All subjects completed testing at the same time of day to avoid any circadian rhythm effects (12). Finally, all equipment utilised was calibrated according to manufacturers' standardised procedures.

Speed and agility

Speed was assessed via a 25 metre 'all-out' sprint due to limitations in available indoor space and the need to obtain measures of acceleration and maximum speed ability. Electronic timing gates (Newtest Oy, Oulu, Finland) were placed at 0m, 5m, 20m, and 25m to record split times (i.e. 0-5m, 0-20m, 20-25m). Timing gates were placed at the approximate hip height for all subjects as previously recommended (Yeadon et al., 1999) to ensure that in most cases only one body part such as the lower torso breaks the beam. The first 5m split was deemed to provide a measure of acceleration, as well as replicating the re-acceleration part of the 505 test. The 20-25m split (flying 5m) was used as a measure of maximal speed ability. Two trials were completed and the best time was recorded for each interval time from the 2 trials.

Agility was measured utilising the 505-agility test (4). The test involved placing electronic timing gates (Globus, Italy) 2m apart, 10m away from the starting line, and with the turning line marked with a painted line and 2 cones at 15 m from it (Figure 1). Timing gates were again placed at the approximate hip height for all subjects. Subjects were instructed to sprint maximally from the start line through the timing gates and then change direction via a 180° turn at the turning point on their dominant limb, before accelerating back through the timing gate. It was emphasised that execution should be made as fast as possible. The time taken to complete the 10 m distance from the timing gate to the turning point and back was recorded.

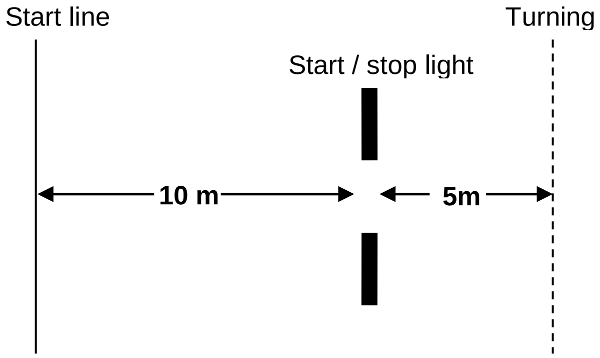

Figure 1. Equipment set up for the 505 agility test.

Strength and power

Isoinertial strength is the maximum amount of force produced by a muscle or muscle group when accelerating a constant external load. Isoinertial strength was assessed using a Concept II dynamometer (Concept II Ltd, Nottingham, UK). Each subject performed 3 repetitions of bilateral leg press. The dynamometer measures force by monitoring the acceleration of a flywheel of a known resistance. Execution form was maintained the same for all the subjects and trials. The subjects were seated and arms grasping handles attached to the seat. The range of motion was from full knee extension to approximately 90º of knee flexion. The score (in kg) from the monitor was recorded for each repetition in each exercise with the best score used in the analysis.

Knee flexor and extensor muscle strength of the dominant leg, was assessed at 60º/s. The subject seated with the hip joint at 90º (supine position = 0º), using an isokinetic dynamometer (Contrex, Switzerland). The center of rotation of the knee was aligned with the dynamometer axis while extraneous movement was prevented by straps, positioned at the hip, shoulders and tested thigh. Measurements were corrected for gravity and peak torque was obtained from 4 repetitions for both concentric and eccentric contractions, as previously recommended (13). Peak torque was taken from 0 to 90º of knee flexion (full knee extension = 0º). The order of tests was concentric extensor, concentric flexor, eccentric extensor, eccentric flexor. Absolute strength scores for leg press and isokinetic variables were normalised to bodyweight (BW), using $BW^{0.67}$ and BW^{1}, respectively, as suggested by Jaric (14).

Slow and fast reactive strength was assessed by the countermovement jump (CMJ) and drop jump from 30 cm (DJ), respectively. Each subject performed 3 trials for each jump, whilst maintaining hands on hips to isolate the contribution from the leg muscles (15). For the DJ's, subjects were requested to step off (and not jump) from the raised platform, to ensure a homogeneous drop distance on each trial. Furthermore, they were instructed to perform a 'bounce' drop jump whereby, the subject was requested to jump for maximum height and minimum contact time. Previous research (16) has shown that instructions on the execution of drops jumps can have implications on the actual strength quality being measured. Jump height and flight time for both jumps, as well as contact time for DJ, were determined using a jump mat (Newtest Oy, Oulu, Finland). Additionally, reactivity index (jump height/contact time) was determined for DJ's.

Statistical Analysis

Normality of data was confirmed using a Shapiro-Wilk test, with the exception of the reactivity index. Therefore, Pearson's product moment correlation and co-efficients of determination were used to explore relationships amongst all variables, while Spearman's rho was used to investigate relationships with the reactivity index. Stepwise multiple regression was used thereafter to determine the combined effects of significantly correlated variables on CODS. Significance was set at $P < 0.05$. Data is presented as mean ± SD. Statistical analysis was conducted using SPSS v14 (Chicago, USA).

RESULTS

Descriptives for all variables can be found in Table I. Significant correlations were observed between the 505 test and flying 5 m, 5 m sprint, leg press, concentric knee extensor strength, eccentric knee extensor strength, concentric knee flexor strength, eccentric knee flexor strength and CMJ height. All Pearson correlations and their significance can be found in Table II. Correlations between CODS and normalised strength scores (Table III) are similar to the relationships observed with the absolute strength scores. The Spearman's correlation between the 505 test and DJ reactivity index showed a low non-significant relationship (ρ = -0.296, df = 35, p = 0.076).

From the co-efficients of determination (Table IV), flying 5m time accounted for the largest variance in CODS performance (60.4% variance explained). Of the strength variables, eccentric knee flexor strength had the highest co-efficient of determination (39.2% variance explained), closely followed by the other isokinetic variables (see Table IV).

In the stepwise multiple regression, flying 5 m was entered first and explained 58% of the variance in CODS performance ($F_{1,33}$ = 45.796, $p<0.001$). Eccentric knee flexor strength was entered second and explained a further 9% ($F_{1,32}$ = 8.781, p = 0.006). Greater CODS was associated with greater linear sprinting speed and eccentric hamstring strength. Addition of the other isokinetic variables, 5 m sprint and CMJ height provided no significant elevation of explained variance in CODS performance.

DISCUSSION

The aim of the present study was to examine the relationship of CODS with a number of speed and strength qualities. The findings suggest that linear sprinting ability is highly related to CODS. This relationship has been explored considerably in the literature and has produced broad and contradictory findings (4, 6, 5, 8, 7, 17).

Previous research involving the 505 test or a similar 180º change of direction have produced conflicting findings. Draper and Lancaster (4) found no relationship between the 505 test and 20 m sprint performance, whereas Graham-Smith and Pearson (18) reported co-efficients of determination of 65.6% between a 15 m sprint and a similar 180º turn task. Our findings concur with the latter findings, supporting that linear speed is more highly related to CODS performance than previously suggested. Research involving different change of direction tasks generally show a lack of a relationship between speed and change of direction ability. Young et al., (6) found low-non significant correlations of 0.27 and 0.19 between 20 m sprints and 3 × 90º and 3 × 120º, respectively, whilst Buttifant *et al*. (5) found low co-efficient of determination (5-10%) between 20 m sprint and similar zig-zag agility tests. In addition, Little and Williams (7) between a flying 20 m sprint and a zig-zag agility task ($r = 0.458$, $r^2 = 0.209$) in professional soccer players. However, more recent findings by Vescovi and McGuigan (17) indicate some moderately strong correlations between various standing (18.3, 27.4 and 36.6 m) and flying sprint (9.1 and 18.3 m) tasks and the Illinois and pro-agility tests (some $r > 0.7$)..

Several methodological differences can explain the broad range of results found in the literature, such as type of speed and CODS tests used, sample size and the subjects used in each study. Vescovi and McGuigan (17) used a high number of college and high school soccer and lacrosse players, whilst Graham-Smith and Pearson (18) used sports students. The present study also used University level sports performers, which could explain the similarity in the results to the aforementioned studies. In contrast, other studies using higher-level sports performers have found lower or non-significant relationships between speed and agility / CODS. Little and Williams (7) used professional football players, Draper and Lancaster (4) studied state hockey and Australian football players, Buttifant *et al*., (5) used junior national and state soccer players, whilst Young *et al*., (6) used a small band of Australian rules football players. The results suggest that at low levels of performance and during the early stages of athlete development, a basic improvement in speed may lead to an improvement in CODS performance.

It was expected that acceleration ability could account for variation in CODS performance, as a major aspect of the 505 test is the re-acceleration from the 180º turn. A significant moderate correlation was observed in the present study, but following multiple regression analysis acceleration ability could not explain any further variance in turn time after speed and eccentric knee flexor strength. Similar findings have been reported between a 10 m sprint and a 3 × 100º zigzag test (7) with a lower significant correlation (r = 0.346) and co-efficient of determination (r^2 = 0.119) than in the present study (r=0.518 and r^2=0.269, respectively). Vescovi and McGuigan (17) also found weak to moderate correlations between 9.1 m sprint and Illinois and Pro-agility tests (r = 0.297 to 0.671). In addition, they found that stronger relationships were evident with longer sprints (r = 0.460 to 0.831) and flying sprint times (r = 0.583 to 0.771), which may indeed suggest that speed is more strongly related to CODS than acceleration.

It is proposed that the inconsistency of the relationships found between acceleration ability and CODS performance, are due to the different mechanical requirement of the execution of the various tasks. In 'linear' acceleration, the subjects are facing the direction of movement, which is not the case for the 're-acceleration' part of the 505 or any other turning task, when the subject initially is facing the original forward direction they were travelling in and then has to turn the head and then shoulders and hips before the first step to accelerate in to the new direction. This would lead to a technically different execution of the first stride, potentially affecting the final acceleration.

It was expected that reactive and eccentric strength may be important strength qualities to account for the variance in CODS, due to the eccentric-concentric reactive coupling acting during the contact phase of a CODS task (9). However, the present study found very low non-significant correlations between DJ rebound height and reactivity index with the 505-test performance. A moderate significant correlation (r = 0.50) between CMJ height and 505 test performance was observed, suggesting that slow reactive strength is more closely related to CODS than fast reactive strength. It is worth noting that typical movement times for a CMJ are approximately 0.5 s or greater and thus may be more likened to CODS contact times. Although change of direction contact times were not measured in the present study, previous research has found mean contact times to be greater than 0.4 s (11, 18). Mean ± SD DJ contact times in this study were 0.27 ± 0.1 and subjects are instructed to aim for short contact times. Furthermore, as demonstrated in the correlation matrix (Table II), DJ rebound height (r = -0.36), reactivity index (r = -0.55) and CMJ height (r = -0.64) showed improved correlation coefficients with linear speed performance, and it could be postulated that this is due to ground contact times during linear sprinting being similar to the contact or movement times during the jump tests.

The results from the present study did demonstrate some similarity with previous research findings. Barnes *et al*. (11) found a significant moderate correlation (-0.58) between CMJ height and a 4 by 5 metre sprint with 3 × 180º turns and that CMJ ability to be a significant predictor (34%) of the variance of the agility task. In this study DJ rebound height had a low non-significant correlation of -0.32 with the agility task. Vescovi and McGuigan (17) found significant moderate correlations ranging from -0.477 to -0.698 for the Illinois tests and -0.358 to -0.613 for the pro-agility test with CMJ performance in different groups of soccer and lacrosse players. Other research (6) found low non significant findings between CMJ (r = -0.1), loaded-CMJ (r = 0.01) and DJ (r =0.3) performance and a 3 × 90º sprint task, and the same 3 variables (r = -0.2, r = -0.04, r = 0.15) and a 3 × 120º sprint task, respectively. Only

Young *et al*., (2) have found some significant moderate correlations between bilateral DJ performance and agility.

As expected, eccentric strength proved to be an important strength quality for good CODS performance. However, it was the eccentric knee flexor strength that demonstrated a greater relationship to CODS performance than knee extensor performance. It was expected that eccentric quadriceps strength would be important in a 180º turn in order to control knee flexion during ground contact, when the ground reaction force acting through the lower limb is high. Nevertheless, the finding that eccentric hamstring strength is more related to CODS performance than eccentric quadriceps strength is also plausible in order to help generate eccentric hip extensor torque to maintain trunk position during deceleration and control knee flexion simultaneously during the turn. Fewer studies have investigated relationships between agility and isokinetic strength. Graham-Smith and Pearson (18) using a similar 180º turn task, found co-efficients of determination for concentric 43.3% and eccentric 42.1% isokinetic knee extensor strength that were considerably higher than in the present study, 29.6 and 27.9%, respectively. However, this study is only presented in abstract form, therefore a greater insight into the methods to rationalise the differences cannot be attained. Negrete and Brophy (10) found a significant moderate correlation ($r = -0.537$) between isokinetic concentric knee extensor strength and a rather complex functional test that incorporated changes of direction, substantiating the present findings ($r = -0.544$).

A limitation of the present study was the choice of linear speed used. The flying 5 m split time used to estimate subjects maximum speed ability was measured between 20-25m, since novice sprinters reach peak speed much earlier than elite sprinters (between 20 and 40 m; 9). A true estimate of peak speed would need to involve prolonging the sprint, as better standard sprinters would have achieved peak speed later in the sprint, and therefore, there may be an underestimation of maximum speed ability. Hence, the present study suggests that the observation that sprinting ability had some influence on CODS performance, needs to be confirmed with higher level performers.

An important aspect of the current study over previous research was that the combined effects of the various physical factors measured were investigated via multiple regression. The results of the present study suggest that to enhance agility performance, the development of basic linear sprinting speed will provide some assistance, however, performers should also aim to improve neuromuscular control of the turn through enhancing eccentric strength of the knee flexor muscles muscles. In addition, future research needs to revisit these parameters using elite performers to develop a better understanding of how the range of physical factors influences speed and agility performance. In considering elite performers, who can move faster, a greater demand on neuromuscular control during the turn may be placed. This would provide a greater understanding of the design of conditioning programmes for sports with great demands on speed and agility performance.

Future research should also investigate the combined effect of anthropometric, technical and physical factors, as well as the decision-making abilities, on CODS. Currently, no research has investigated CODS technique for performance and injury prevention, which is somewhat surprising given that as a form of speed training, this would be the primary way to develop an individual's agility performance (9). Sheppard and Young (1) and Young and Farrow (3) in their reviews of agility presented a deterministic model of agility and suggested that the technical component of CODS could be dependent on foot placement, adjustment of strides to accelerate and decelerate and body lean and posture. However, to the authors' knowledge, only one study has investigated the influence of these technique factors on CODS (18), and this was limited to a 2 dimensional analysis.

CONCLUSION

In summary, the present study investigated the relationships between various speed and strength qualities on CODS speed. Sprinting speed was the most important physical factor in CODS performance followed by eccentric knee flexor strength and explained a large proportion of the variance in CODS performance. Other factors such as isokinetic knee concentric extensor and flexor strength, eccentric extensor strength, countermovement jump performance and acceleration ability all showed significant moderate correlations with CODS performance, highlighting that CODS performance is a function of several different physical attributes. The results suggest that for basic improvements in CODS performance, athletes should seek to maximise their sprinting ability and enhance their eccentric knee flexor strength to allow effective neuromuscular control of the contact phase of the CODS task. Future research needs to validate such findings on elite performers in sports with high demands on agility.

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Table I. Descriptives for all measured variables

Variable	Mean (SD)
505 agility test (s)	2.34 (0.12)
5 m sprint (s)	1.08 (0.07)
‘Flying’ 5 m (s)	0.65 (0.05)
Leg Press (kg)	190.74 (41.5)
Normalised Leg Press (kg/bw$^{0.67}$)	10.3 (1.6)
Isokinetic Con Ext (Nm)	203.58 (48.4)
Normalised Isokinetic Con Ext (Nm/bw^{1})	2.64 (0.47)
Isokinetic Ecc Ext (Nm)	232.95 (62.72)
Normalised Isokinetic Ecc Ext (Nm/bw^{1})	3.04 (0.69)
Isokinetic Con Flex (Nm)	148.40 (32.66)
Normalised Isokinetic Con Flex (Nm/bw^{1})	1.93 (0.33)
Isokinetic Ecc Flex (Nm)	175.06 (37.62)
Normalised Isokinetic Ecc Flex (Nm/bw^{1})	2.28 (0.42)

CMJ Height (cm)	38.75 (7.41)
DJ Height (cm)	36.69 (8.20)
DJ Reactivity Index (cm/s)	159.47 (78.8)

Note: Con Ext = concentric extensor peak torque, Ecc Ext = eccentric extensor peak torque, Con Flex = concentric flexor peak torque, Ecc Flex = eccentric flexor peak torque, CMJ = countermovement jump, DJ = drop jump.

Table II. Correlations between all measured variables

	505 test	5m sprint	Flying 5m	Leg Press	Con Ext	Ecc Ext	Con Flex	Ecc Flex	CMJ height	DJ height
505 test	1									
5 m sprint	0.518**	1								
Flying 5 m	0.777**	0.592**	1							
Leg Press	-0.371*	-0.310	-0.320	1						
Con Ext	-0.544**	-0.362*	-0.494**	0.648**	1					
Ecc Ext	-0.529**	-0.347*	-0.467**	0.568**	0.801**	1				
Con Flex	-0.549**	-0.459**	-0.534**	0.628**	0.759**	0.618**	1			
Ecc Flex	-0.626**	-0.398*	-0.494**	0.508**	0.805**	0.739**	0.777**	1		
CMJ height	-0.498**	-0.520**	-0.637**	0.150	0.301	0.159	0.435**	0.317	1	
DJ height	-0.291	-0.477**	-0.550**	0.158	0.230	0.107	0.311	0.258	0.749**	1

Note: Con Ext = concentric extensor peak torque, Ecc Ext = eccentric extensor peak torque, Con Flex = concentric flexor peak torque, Ecc Flex = eccentric flexor peak torque, CMJ = countermovement jump, DJ = drop jump.

*** $p < 0.05$**

**** $p < 0.01$**

Table III. Correlations between change of direction speed and strength scores normalised to bodyweight.

Variable	r
Normalised Leg Press	-0.446**
Normalised Isokinetic Con Ext	-0.568**
Normalised Isokinetic Ecc Ext	-0.506**
Normalised Isokinetic Con Flex	-0.560**
Normalised Isokinetic Ecc Flex	-0.592**

Note: Con Ext = concentric extensor peak torque, Ecc Ext = eccentric extensor peak torque, Con Flex = concentric flexor peak torque, Ecc Flex = eccentric flexor peak torque.

**** $p < 0.01$**

Table IV. Co-efficients of determination of relationships between change of direction speed and the sprint and strength variables.

Variable	R^2
Flying 5 m	0.604
Isokinetic Ecc Flex	0.392
Normalised Isokinetic Ecc Flex	0.350
Normalised Isokinetic Con Ext	0.323
Normalised Isokinetic Con Flex	0.314
Isokinetic Con Flex	0.301
Isokinetic Con Ext	0.296
Isokinetic Ecc Ext	0.279
5 m sprint	0.269
Normalised Isokinetic Ecc Ext	0.256
CMJ height	0.248
Normalised Leg Press	0.199
Leg Press	0.138
DJ height	0.085
DJ Reactivity index	0.052

Note: Con Ext = concentric extensor peak torque, Ecc Ext = eccentric extensor peak torque, Con Flex = concentric flexor peak torque, Ecc Flex = eccentric flexor peak torque, CMJ = countermovement jump, DJ = drop jump.