Evaluating Change of Direction Ability: Part 1 Application of the Change of Direction Deficit

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Headline

Although change of direction (CoD) time (time taken to complete a given CoD test) may serve as the primary performance measure of CoD ability, previous studies have indicated the CoD deficit (CoD-D) may be a practical tool to better isolate an athlete's CoD ability, given only approximately 31% of the time in a 505 test is spent changing direction (1–4) and therefore, is biased towards athletes with superior linear speed. Briefly, the CoD-D can be calculated as the time taken to perform a CoD test – the time taken in a linear sprint of an equivalent distance (i.e., 505 time – 10-m sprint time). As such, we evaluated whether the CoD-D identified a different or more isolated measure of CoD ability compared with 505 time.

Aim

The primary aim of this study was to determine the associations between linear speed, momentum, body mass and 505 time and CoD-D. A secondary aim was to quantify between-limb differences using 505 time and CoD-D, and to determine its influence on the profiling of CoD ability.

Design

Single group, cross-sectional study. Data was collected during a single testing session as part of regular performance monitoring. All participants were familiar with testing procedures and performed a standardised warm-up prior to testing.

Participants

Twenty-three male cricketers (age = 18.7 ± 2.7 years; height = 1.87 ± 0.09 m; mass = 81.6 ± 10.5 kg) from a professional academy participated in this study. All subjects read and signed a written consent from before participation, with consent from the parent or guardian of all subjects under the age of 18. Approval for the study was provided by the institutional ethics committee, in line with the Declaration of Helsinki.

Sprint Testing

The 20-m sprint test was administered as a test of acceleration and short-sprint ability on a third-generation artificial rubber crumb surface (Mondo, SportsFlex, 10 mm; Mondo America Inc., Mondo, Summit, NJ, USA). Prior to maximal effort trials, subjects performed 2 warm-up trials at 50 and 75% maximum effort. All subjects performed three maximal effort trials, with two minutes' rest between trials using single beam (accuracy to 1/1000th of a second) Brower photocell timing gates (model number BRO001; Brower, Draper, UT, USA) setup at 0-, 5-, 10- and 20-m. Timing gates were placed at the approximate hip height for all athletes, to ensure that only one body part, such as the lower torso, breaks the beam (5). Participants started 0.5 m behind the first gate, to prevent any early triggering of the initial start gate, from a two-point staggered start. The best performance from each of the three trials of 0-10 m was used for further analysis. Momentum was calculated as the average velocity obtained over 0-10 m multiplied by body mass (kg·m/s) to reflect the momentum attained in the initial 10 m of a 505 test.

Change of Direction Speed

After sprint testing participants were provided with 5 minutes' rest before commencing the CoD speed test. Change of direction speed was assessed utilising a 505 test on the same surface as the sprint testing, with each subject performing 2 warm-up trials (in each direction) at 50 and 75% maximum effort before beginning maximal effort trials. Participants started 0.5 m behind the photocell gates, to prevent any early triggering of the initial start gate, from a two-point staggered start. Participants were instructed to sprint to a line marked 15 m from the start line, placing either left or right foot on the line, depending on the trial, turn 180° and sprint back 5 m through the finish. If the subject changed direction before hitting the turning line, or turned off the incorrect foot, the trial was disregarded, and the subject completed another trial after the rest period. All participants performed three trials on each leg, in a randomized and counterbalanced order, with a two-minute rest between trials. Timing gates were again placed at the approximate hip height for all athletes (5). The best performance from each of the three trials was used for further analysis. Change of direction deficit was calculated using the formula: 505 time – 10-m sprint time.

Statistical Analyses

Data are presented as either mean ± SD or mean with 95% confidence intervals (95% CI) where specified. Relationships between variables were determined using Pearson's product-moment correlation and evaluated as per Hopkins (6). Differences between left and right and dominant and nondominant sides were assessed using paired sample t-tests and Cohens d effect sizes (d) (6). Percentage imbalances between limbs were calculated using the formulae: (right limb – left limb) / right limb) * 100 and (dominant limb – nondominant limb) / dominant limb) * 100 (7). Additionally, using a similar method to previous authors (1,3), Z-scores were calculated to examine whether 505 times and CoD-D provided different indicators of CoD ability via the formula: Z-score = (subjects score – group mean)/SD. Worthwhile differences were also calculated (differences in Z-scores for 505 time and CoD-D) by methods described previously (1,3), with both analyses comparing dominant and nondominant limbs separately. For all analyses, the dominant limb was defined as the fastest 505 time and shortest CoD-D. The criterion for statistical significance for all tests was set at $p \leq 0.05$.

Table 1. Correlations for the dominant and nondominant limbs between 505 time, CoD-D, 10-m sprint, momentum and body mass.

	505 time vs. CoD-D	505 time vs. 10-m sprint	505 time vs. Momentum	505 time vs. Body mass	CoD-D vs. 10-m sprint	CoD-D vs. Momentum	CoD-D vs. Body mass
Dominant							
r	0.72	0.78	–0.32	–0.08	0.13	–0.21	–0.17
95% CI	0.43 to 0.87	0.55 to 0.90	–0.64 to 0.11	–0.47 to 0.35	-0.30 to 0.51	–0.57 to 0.23	–0.55 to 0.26
r^2	0.52	0.61	0.10	0.01	0.02	0.04	0.03
p	<0.001	<0.001	0.142	0.732	0.560	0.347	0.430
Nondominant							
r	0.66	0.76	–0.25	–0.01	0.01	-0.08	–0.07
95% CI	0.34 to 0.84	0.50 to 0.89	-0.60 to 0.18	–0.42 to 0.41	-0.41 to 0.42	–0.47 to 0.35	–0.47 to 0.36
r^2	0.44	0.58	0.06	0.00	0.00	0.041	0.00
p	<0.001	<0.001	0.252	0.968	0.970	0.734	0.761

CoD-D = change of direction deficit; CI = confidence interval.

Table 2. Left vs. right comparisons for 505 time and CoD-D.

	Left	Right	% Imbalance	p	d (95% CI)
505 time (s)	2.40 ± 0.14	2.34 ± 0.15	2.85 ± 4.39	0.011	-0.47 (-0.79 to -0.15)
CoD-D (s)	0.55 ± 0.09	0.49 ± 0.10	16.61 ± 24.55	0.006	-0.73 (-0.95 to -0.51)

CoD-D = change of direction deficit; CI = confidence interval.

Table 3. Dominant vs. nondominant comparisons for 505 time and CoD-D.

	Dominant	Nondominant	% Imbalance	p	d (95% CI)
505 time (s)	2.32 ± 0.14	2.42 ± 0.13	4.24 ± 3.03	<0.001	-0.76 (-1.28 to -0.24)
CoD-D (s)	0.47 ± 0.09	0.57 ± 0.09	22.93 ± 19.00	<0.001	-1.19 (-1.59 to -0.80)

CoD-D = change of direction deficit; CI = confidence interval.

Results

The correlation data with 95% CI are presented for the dominant and nondominant limbs in Table 1. Between-Limb comparisons for left vs. right, and dominant vs. nondominant limbs are shown in Table 2. Figure 1 illustrates the z scores for 505 time and CoD-D for each subject. Figure 2 displays the difference in Z scores (CoD-D – 505 time) for dominant vs. nondominant limbs for each subject. Figure 3 shows an overview of between-limb percentage imbalances for both left vs. right, and dominant vs. nondominant limbs.

Discussion

The results of this study show that, with the exception of 505 time, CoD-D failed to demonstrate any significant associations to measures of sprint, momentum and body mass in male academy cricketers. In this study, standardizing 505 time and CoD-D performances revealed 35-43% of subjects demonstrated opposite CoD abilities, whereas 83% of subjects CoD ability was overestimated or underestimated. These findings may help us to understand the role of momentum in 505 and CoD-D performance, and the practical use of the CoD-D as a more specific measure of CoD ability to aid monitoring and training interventions.

The primary findings of this study were that large positive associations were observed between 505 times and CoD-D on the dominant limb (r = 0.76, p <0.001), while moderate associations were revealed for the nondominant limb (r = 0.66, p <0.001). Furthermore, large positive associations were demonstrated between 505 times and 10-m sprint times on both dominant (r = 0.78, p <0.001) and nondominant limbs (r = 0.76, p <0.001). In accordance with the present results, previous studies have demonstrated 505 times to associate with CoD-D (1–4,8). Additionally, studies using other CoD tests (i.e., zigzag, 90° cut, and pro-agility) have also revealed similar findings (4,8,9). Thus, performances on CoD tests are associated with lower (faster) CoD-D. Yet, whilst CoD time and CoD-D may be associated, these measures are not synonymous. Previous work has shown the CoD-D provides practitioners with more information regarding an athletes CoD ability than CoD time alone (3,4). Future studies on the current topic are therefore recommended.

This study did not find any associations between 10-m sprint times and CoD-D on either dominant or nondominant limbs. These findings are in agreement with some (2–4,8,10) but in contrast to others (1,8,11). This result might be explained by the fact that the CoD-D eliminates the contribution of linear speed and may therefore provide a more isolated measure of CoD ability. A note of caution is due here since some studies did find associations between 10-m sprint times and CoD-D. Specifically, Dos'Santos et al. (1) found a significant negative association between the measures, indicating faster sprint times were associated with longer CoD-D. Also, Cuthbert et al. (8) found 10-m sprint times to moderately associate with CoD-D on the right limb, yet no further associations were evident across three sprint tests (5-, 10- and 20-m) and two CoD tests (505 and 90° cut) in left and right directions. Lastly, Pereira et al. (11) did find a large association (r = 0.80) between 10-m velocity and CoD-D during the zigzag CoD test which may be attributed to a shorter entry distance (5 m) to the CoD. As such, based on these results, the CoD-D offers an isolated measure of CoD ability which is not confounded by linear speed in male academy cricketers.

As shown in Figure 1, calculated Z scores for 505 time and CoD-D revealed 10 of 23 subjects (43% - dominant limb) and 8 of 23 (35% - nondominant limb) subjects demonstrated opposing CoD abilities (i.e. a faster 505 times, but worse CoD-D,

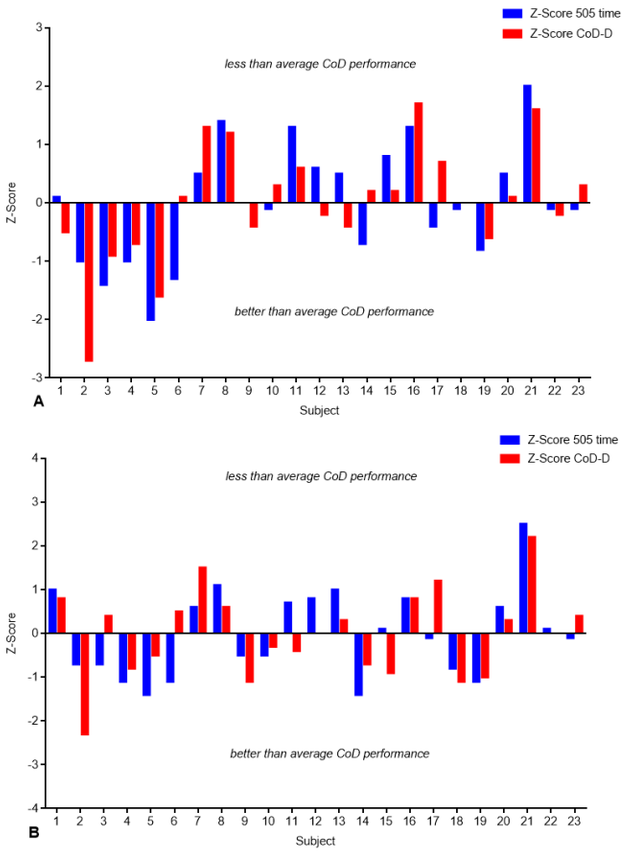

Fig. 1. Z-scores of the 505 times and CoD-D for each subject for the (A) dominant limb and (B) nondominant limb.

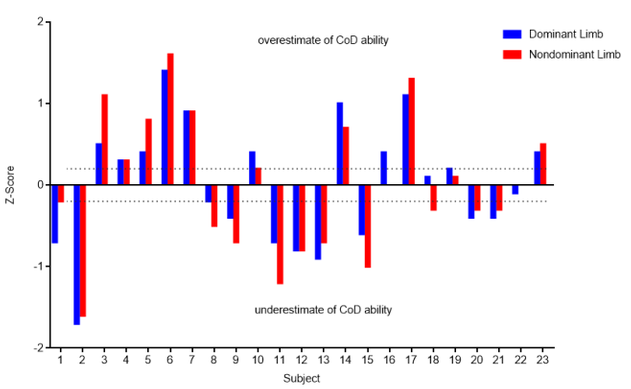

Fig. 2. Difference in Z-scores (CoD-D – 505 time) for each subject. The smallest worthwhile change is represented by horizontal dotted lines.

or vice versa). It can be seen from the data in Figure 2 that worthwhile differences were present, resulting in overestimations or underestimations in COD ability. Specifically, 19 of 23 subjects (83%) had their CoD ability overestimated or underestimated for the dominant limb, and this finding remained true for the nondominant limb (19 of 23 subjects; 83%). These results are consistent with the data obtained by Dos'Santos et al. (1) who reported 9 of 43 subjects (21%) displayed opposing CoD abilities (for both dominant and nondominant limbs) when comparing 505 time and CoD-D Z scores in female net-

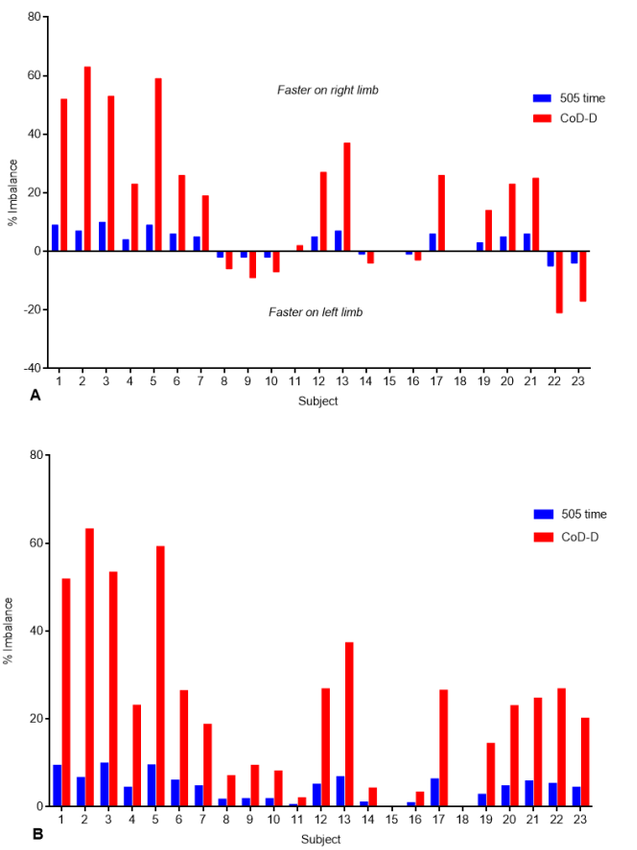

Fig. 3. Individual imbalances in 505 times and CoD-D for the (A) left and right and (B) dominant and nondominant limbs.

ballers. Similarly, Nimphius et al. (3) found 5 of 17 male cricketers to display opposing CoD abilities in 505 time and CoD-D. Furthermore, Nimphius et al. (3) reported worthwhile differences between 505 and CoD-D in 94% and 88% of subjects for the preferred and non-preferred limb, respectively. Similarly, Dos'Santos et al. (1) found 32 of 43 (74%) and 34 of 43 (79%) subjects had their CoD ability overestimated or underestimated on the dominant and nondominant limbs, respectively. These findings suggest that the CoD-D is a more isolated measure of CoD ability and thus, failure to apply to the 505 may lead to misinterpretations of an athletes CoD ability and subsequent training prescription.

The results from this study indicate significant small differences ($p = 0.011$, $d = -0.47$) in 505 times were evident between left and right limbs. Also, significant moderate differences ($p = 0.006$, $d = -0.76$) in CoD-D were observed between left and right limbs. Another important finding was the moderate differences in 505 time ($p < 0.001$, $d = -0.73$) and CoD-D ($p < 0.001$, $d = -1.19$) between dominant and nondominant limbs. In accordance with the present results, previous studies have demonstrated between-limb differences in CoD time and CoD-D (1,2,7,12–15). Like the aforementioned studies, greater mean percentage imbalances were demonstrated in CoD-D (16.61-22.93%) compared to 505 time (2.85-4.24%). As such, it appears male academy cricketers demonstrate superior CoD time towards a particular direction, yet this magnitude between limbs may be increased (and potentially in the opposite direction) when comparing CoD-D. Therefore, practitioners are recommended to evaluate between-limb imbalances

in both CoD time and CoD-D to aid in athlete profiling for CoD ability. Performing such analyses will provide further insight into diagnosing an athlete's strengths and weaknesses, so that training interventions are designed appropriately. Future studies on the use of the CoD-D as a training recommendation are therefore recommended to better understand its usage in training and monitoring.

Practical Applications

- Coaches are encouraged to perform CoD tests on both limbs to establish directional dominance and CoD asymmetries in their athletes.
- Quantifying asymmetries based on CoD time produces substantially lower percentage imbalances, which could mask deficiencies in COD ability and could lead to misinterpretations of an athlete's CoD ability.
- The CoD-D does not appear to be biased towards faster or slower athletes, thus may provide a more specific measure of CoD ability than CoD time alone.

Limitations

- Since this study is limited to the 505 CoD test, the findings should be interpreted accordingly.
- This study should be repeated using different angled CoD tests such as 45, 90 and 135° and or different sports populations, particularly in sports where size maybe considered important to increase momentum when playing certain positions (i.e., rugby forwards or American football defensive linemen and line-backers).
- The results of this study are only representative of the time testing took place (preseason) and therefore may fluctuate at different points throughout the training year, as recently shown with between-limb differences (16).
- This study did not include any qualitative video analysis, three-dimensional motion analysis, strength and power assessments to identify the causes of such percentage imbalances in CoD-D.

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