Evaluating Change of Direction Ability: Part 2 The Influence of Momentum on the Change of Direction Deficit

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Headline

Studies of change of direction (CoD) ability show the importance of calculating both CoD time and CoD deficit ([CoD-D] the time taken to perform a CoD test – the time taken in a linear sprint of equivalent distance) to help provide a better profiling of an athlete's ability to change direction (1–4), with evidence that using CoD time alone could lead to misinterpretations of CoD ability (1–4). Recently, authors have drawn attention to the influence of angle and velocity on CoD biomechanics, indicating momentum (velocity x body mass) may better represent the mechanical demands associated with CoD-D than sprint velocity alone (5,6). Indeed, a 180° CoD (i.e., 505) requires greater deceleration (i.e. velocity reduction) compared to 45 and 90 degree CoD to reduce forward momentum prior to the foot plant to facilitate effective CoD (7), potentially indicating momentum to play an important role in determining CoD-D. It is possible the CoD-D could be biased towards slower, lighter athletes who have less momentum to reduce compared to faster, heavier athletes, and therefore, less deceleration requirements. A recent study by Fernandes et al. (6) found no association between momentum and CoD-D, yet when grouped by CoD-D, athletes with larger CoD-D demonstrated faster 10-m sprint times (d = 0.79) and higher momentum (d = 0.81). Furthermore, CoD time was slower in the high CoD-D subjects (d = 1.24) compared to low CoD-D subjects. As such, more research is required on how momentum influences the CoD-D.

Aim

The aim of this study was to determine if differences in sprint and CoD measures were present between high and low momentum male cricketers. Furthermore, comparisons of high and low body mass, and fast and slow subjects were performed to assist in confirming the primary findings of the study.

Design

Indpendent 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 (8). 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 (8). 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. Subjects were grouped into high (n = 11) and low (n = 11) upper and lower 50th percentiles for based on body mass and momentum, while 10-m sprint time analyses were grouped based on the fastest (n = 11) and slowest (n = 11) subjects. Independent sample

Table 1. Comparison of performance measures based on high vs. low body mass groups.

	High (n = 11)	Low (n = 11)	p	d (95%CI)
Body Mass (kg)	87.52 ± 8.32	66.38 ± 8.47	<0.001	2.25 (1.39 to 3.11)
10 m (s)	1.87 ± 0.10	1.85 ± 0.10	0.674	0.17 (-1.03 to 0.69)
Momentum (kg·m/s)	469.74 ± 52.82	359.64 ± 51.23	<0.001	1.94 (1.09 to 2.80)
Dominant 505 (s)	2.33 ± 0.15	2.33 ± 0.15	0.920	0.04 (-0.82 to 0.90)
Nondominant 505 (s)	2.43 ± 0.16	2.43 ± 0.10	0.912	-0.06 (-0.92 to 0.80)
Dominant CoD-D (s)	0.46 ± 0.11	0.48 ± 0.08	0.768	-0.17 (-1.03 to 0.69)
Nondominant CoD-D (s)	0.56 ± 0.11	0.58 ± 0.07	0.528	-0.32 (-1.18 to 0.54)

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

Table 2. Comparison of performance measures based on fast vs. slow 10-m sprint groups.

	Fast (n = 11)	Slow (n = 11)	p	d (95%CI)
Body Mass (kg)	75.91 ± 13.23	78.73 ± 14.15	0.636	-0.19 (-1.05 to 0.67)
10 m (s)	1.76 ± 0.05	1.94 ± 0.04	<0.001	-3.67 (-4.53 to -2.81)
Momentum (kg·m/s)	431.03 ± 77.29	405.28 ± 74.22	0.435	0.30 (-0.56 to 1.16)
Dominant 505 (s)	2.33 ± 0.10	2.42 ± 0.12	0.001	-1.69 (-2.55 to -0.83)
Nondominant 505 (s)	2.33 ± 0.08	2.51 ± 0.11	0.001	-1.81 (-2.67 to -0.95)
Dominant CoD-D (s)	0.46 ± 0.07	0.48 ± 0.11	0.734	-0.05 (-0.91 to 0.82)
Nondominant CoD-D (s)	0.56 ± 0.08	0.57 ± 0.10	0.872	-0.02 (-0.88 to 0.84)

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

Table 3. Comparison of performance measures based on high vs. low momentum groups.

	High (n = 11)	Low (n = 11)	p	d (95%CI)
Body Mass (kg)	86.96 ± 9.07	67.40 ± 9.51	<0.001	1.90 (1.04 to 2.76)
10 m (s)	1.83 ± 0.10	1.89 ± 0.08	0.050	-0.64 (-1.50 to 0.22)
Momentum (kg·m/s)	475.72 ± 45.26	356.12 ± 47.13	<0.001	2.33 (1.47 to 3.19)
Dominant 505 (s)	2.30 ± 0.14	2.37 ± 0.11	0.039	-0.57 (-1.43 to 0.29)
Nondominant 505 (s)	2.40 ± 0.16	2.46 ± 0.08	0.031	-0.51 (-1.37 to 0.35)
Dominant CoD-D (s)	0.47 ± 0.11	0.48 ± 0.06	0.487	-0.21 (-1.08 to 0.65)
Nondominant CoD-D (s)	0.57 ± 0.11	0.57 ± 0.06	0.560	-0.09 (-0.96 to 0.77)

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

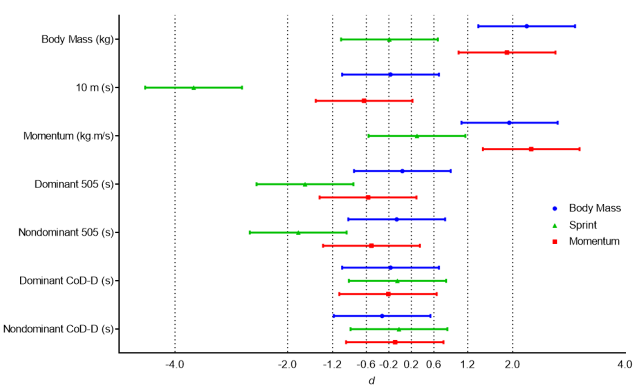

Fig. 1. Standardized comparisons of performance measures when grouped by body mass, 10-m sprint and momentum.

t-tests were performed to determine differences in body mass, 10-m sprint, momentum, 505 times and CoD-D times between groups. The magnitude of differences between group mean values was also expressed as effect size (d) according to the scale by Hopkins (9). The criterion for statistical significance for all tests was set at p ≤0.05.

Results

Differences in performance measures between high and low body mass, fast and slow 10-m sprint, and high and low momentum groups are presented in Tables 1-3. Standardized comparisons (d) of performance measures between groups are shown in Figure 1.

Discussion

The aim of this study was to determine if differences in sprint and CoD measures were present between high and low momentum subjects, and to discover the additional influence of its sub-components (body mass and sprint time). The primary findings of this study are that (a) momentum was very largely influenced by body mass and moderately by 10-m sprint time, influencing 505 times, but not CoD-D, (b) 10-m sprint time impacts 505 time, but not CoD-D, and (c) body mass largely influenced momentum, with trivial-to-small impact on 10-m sprint or CoD measures. These findings may help us to understand the role of momentum in monitoring 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.

Unsurprisingly, differences in momentum were observed between high and low groups (d = 2.33). These differences are likely attributed to differences in larger body mass values (d = 1.90) and moderately faster 10-m sprint times (d = -0.64). The results revealed small differences in 505 time on both dominant (d = -0.57) and nondominant limbs (d = -0.51) between high and low momentum subjects, but no differences in CoD-D (d = -0.21 to -0.09). Fernandes et al. (6) showed male soccer players who had lower CoD-D (d = -3.60) also demonstrated faster 505 times (d = -1.24), compared to slower subjects. Although not a primary aim of their study, these results also revealed faster subjects demonstrated moderately lower momentum (d = -0.81), likely due to moderately slower 10-m sprint times (d = 0.79), compared to slower subjects. Furthermore, Freitas et al. (10) found greater momentum (d = 1.76) was observed in rugby forwards compared to backs, but did not yield differences in CoD-D, likely due to the forwards being largely slower (d = 1.37). In this study, the high momentum group demonstrated very large differences (20 kg, d = 1.90) in body mass, as compared to low momentum subjects; thus, greater momentum values are attributed to greater body mass values to a greater extent than sprint times, in spite of moderate differences in 10-m sprint time being revealed (d = -0.64). Yet, the greater momentum was not detrimental to either 505 time or CoD-D, likely due to heavier (greater momentum) players in this study possessing superior relevant muscle strength qualities (i.e., eccentric strength) or desired technical proficiency (5,7,11).

Indeed, it may therefore be the case that CoD-D is influenced by neuromuscular qualities due to the eccentric-concentric coupling action during the plant phase of CoD tasks (11-13). Jones et al. (11) found eccentrically stronger athletes can approach the CoD with a higher instantaneous velocity, display greater reductions in velocity, while subsequently achieving faster times in the 505. Furthermore, recent work by Dos'Santos et al. (14) demonstrated faster athletes in the 505 demonstrated greater instantaneous velocities and reductions in velocity, likely contributing to shorter ground contact times during the final foot contact. Taken together, these findings highlight the technical and physical factors to effectively change direction. Additional work by Thomas et al.(15) found greater reactive strength index-modified in the countermovement jump was associated with lower CoD-D, while Lockie et al. (16) found greater lateral jump distances to associate with lower CoD-D. It is possible, therefore, that slow stretch-shortening cycle activities may influence CoD-D more so than fast stretch-shortening cycle activities. However, it could be argued that these findings are due to the actions inherent within the 505 test (180° turn) and it is unknown whether this argument pertains to other CoD tasks (45 or 90° cuts).

As expected, there was a difference in sprint times between fast and slow 10-m sprint groups (d = -3.67). Furthermore, this study found the faster sprint group demonstrated faster 505 times on both dominant (d = -1.69) and nondominant limbs (d = -1.81), compared to the slower 10-m sprint group. Yet, no differences in CoD-D times existed between groups (d = -0.05 to -0.02). Freitas et al. (10) found players with faster 10-m sprint times demonstrated higher CoD-D compared to their slower counterparts. Likewise, faster players showed larger CoD-D than slower players in elite soccer (17) and handball (18) athletes. Thus, it could be suggested faster athletes are not capable of tolerating the high approach velocities in CoD. Yet, in the current study, 10-m sprint time was unable to discriminate between smaller or larger CoD-D, potentially indicating the importance of technique and relative strength to perform direction changes, specifically during the 505 in male cricketers. 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, as shown previously in a similar cohort (3). In general, therefore, it seems that separating male cricketers by 10-m sprint time might not be sensitive enough to discriminate between players of different CoD abilities. Therefore, practitioners are encouraged to assess CoD ability using CoD time and the CoD-D; and subsequently, apply analyses relative to momentum (including the interaction of body mass and linear running speed) to better identify player-specific training needs.

It is believed that for a given body mass, faster athletes carry greater momentum into a CoD; thus, must therefore exert a larger braking impulse over a series of steps to decelerate and, consequently, is likely to demonstrate higher ground reaction forces over shorter contact times during antepenultimate and penultimate foot contacts. When comparing high vs. low body mass subjects (d = 2.25), differences in momentum were also evident with higher body mass subjects demonstrating greater momentum (d = 1.94), compared to low body mass subjects. Additionally, small differences in 10-m sprint, 505 time, or CoD-D performances existed between groups (d = -0.32 to 0.17). Thus, greater momentum values can be attributed to greater body mass values which were not detrimental to 10-m sprint and CoD performance in the current cohort. It is important to note that mass positively affects momentum but negatively affects velocity. The findings from the current study indicate subjects with greater mass demonstrated similar sprint and CoD performances as lighter subjects, counterbalancing any negative effects of increased mass. Taken together, it appears the interaction between mass, linear running speed and momentum on COD ability (CoD time and CoD-D) seems specific to each sport. Thus, evaluating these aspects is important to evaluate athletes COD capabilities against their specific sport demands to develop individualised intervention strategies to improve COD performance.

Practical Applications

- The CoD-D does not appear to be biased towards body mass, sprint time or momentum, and thus may provide a more specific measure of CoD ability than CoD time alone to aid the training and monitoring of these qualities.
- 505 time appears to be influenced mostly by sprint time and resultant momentum, yet these measures had little impact on CoD-D.
- In addition to CoD-D, coaches should consider body mass, sprint times (average velocity), and subsequently momentum when evaluating and making decisions regarding an athlete's ability to change direction.

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).
- We only determined momentum from average velocity during 0-10 m sprint and did not directly assess peak velocity or momentum. Likewise, this study did not assess instantaneous velocity during the COD task, which would be more accurate.

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