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Testing variations of methodological characteristics in the 5-0-5 test: impact of the linear sprint on change-of-direction deficit in adult male soccer players

original paper
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ABSTRACT

Purpose. The study compared the change-of-direction deficit (CODD) using the first 10-m sprint of a 40-m sprint test ($CODD_{original}$), the 10-m time that precedes the 5-0-5 test ($CODD_{5\text{-}0\text{-}5start}$), and the best 10-m split of a 40-m sprint test ($CODD_{best}$).

Methods. A cross-sectional study design was applied. Twenty elite male soccer players (age: 21.6 ± 2.0 years; experience: 8.7 ± 2.3 years; body mass: 73.2 ± 6.1 kg; stature: 174.8 ± 4.5 cm) voluntarily participated in this study. They were assessed in the following tests: (i) 40-m linear sprint test and (ii) 5-0-5 test with a pre-planned 180° change-of-direction (COD) (left and right sides). CODD for both sides was calculated as the difference between average 5-0-5 and $CODD_{original}$, $COOD_{best}$, and $CODD_{5\text{-}0\text{-}5start}$.

Results. The time over 10 m during the 30–40-m split of a 40-m sprint test was significantly shorter than the first 10 m of the same sprint test (best times: $p < 0.001$, $d = -7.077$; average time: $p < 0.001$, $d = -1.140$) and the first 10-m acceleration phase of the 5-0-5 test (best times: $p < 0.001$, $d = 9.000$; average times: $p < 0.001$, $d = -8.500$). No significant differences were found between the first 10 m of the 40-m sprint test and the 5-0-5 test (best times: $p > 0.999$, $d = 0.133$; average times: $p = 0.990$, $d = 0.047$). Comparisons of CODD revealed significant differences between approaches (best times: $F = 201.7$, $p < 0.001$, $\eta_p^2 = 0.914$; average times: $F = 196.2$, $p < 0.001$, $\eta_p^2 = 0.912$). However, there were no significant correlations between any CODD outcomes and the 40-m sprint test ($p > 0.05$).

Conclusions. CODD calculated with the first 10 m and the best 10 m of a sprint test was significantly different; similarities existed between the initial 10 m of a 40-m sprint test and the 5-0-5 test. Therefore, to save time and resources, practitioners could use the first 10-m acceleration phase of the 5-0-5 since no significant differences were found between the initial 10 m of a linear sprint test.

Key words: football, exercise test, physical fitness, athletic performance

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Introduction

During soccer match play, players are often exposed to fast short accelerations, decelerations, and re-accelerations along with changing direction [1–3]. This means that they must be able not only to produce rapid linear trajectories, but also to change direction quickly [4]. Change-of-direction (COD) is a multi-dependent ability that allows athletes to perform manoeuvres such as cutting and turning to correspond to the challenges of a match [5, 6]. Previous research has even observed that rapid COD efforts are among the main actions preceding a goal in professional soccer [7].

Owing to its importance in soccer match play, COD is one of the recommended abilities to be included in a regular testing battery for the assessment of physical fitness [8, 9]. However, some of the most common outcomes extracted from COD-oriented tests can cause bias in the interpretation. For example, the time of the 5-0-5 test (which consists of performing an initial 10-m linear acceleration followed by 5-m 180° COD) is nearly perfectly correlated with linear sprint at 5, 10, and 20 m [10], implying that the test may lack the ability to discriminate COD.

However, the issue of COD time may have recently been mitigated with the suggestion of calculating a COD deficit (CODD), which is the subtraction of the linear sprint time and the time of performing the same distance with COD [11]. The authors found that CODD assessed during the 5-0-5 in comparison with one's 10-m sprint time during a 30-m sprint was able to provide a more accurate measure of COD ability. Nevertheless, it is still unclear if this methodology is transferable to multiple athletes or just those that are accustomed to 180° COD (e.g., cricketers). It is also unknown if there is any significant difference between using the first 10 m of a 30-m sprint test and the first 10-m acceleration phase of the 5-0-5 test, or if it is best to take the initial 10 m of a sprint test or the best 10-m split of a linear sprint test. Understanding if these differences exist may help practitioners in selecting their testing battery so as to choose tests that can glean accurate information on the qualities they are after without needing additional training time.

With these methodological questions on mind, the aim of this study was to compare CODD using the first 10 m of a 40-m sprint test ($\text{CODD}_{\text{original}}$) vs. CODD using the 10-m time that precedes the 5-0-5 test ($\text{CODD}_{\text{5-0-5start}}$) vs. COOD using the best 10-m split of a 40-m sprint test ($\text{CODD}_{\text{best}}$). We hypothesized that non-significant differences would be found between 10-m time speed between applying a linear sprint test and the 10 acceleration meters of 5-0-5. Moreover, we hypothesized that CODD would be significantly different between the first 10 m and the best 10 m of a linear sprint test.

Material and methods

Study design and setting

This study followed a cross-sectional design. All assessments were performed on a single day, between 3:00 p.m. and 6:00 p.m., on a outside synthetic soccer turf pitch. The average temperature during testing was 8°C, with a relative humidity of 56%. The wind reported was 21 km/h, and no raining conditions occurred.

Participants

Overall, 20 male soccer players (age: 21.6 ± 2.0 years; experience: 8.7 ± 2.3 years; body mass: 73.2 ± 6.1 kg; stature: 174.8 ± 4.5 cm) voluntarily participated in this study. Convenience sampling was applied as an approach for nonprobability sampling strategy. Players of the same team were invited to participate in the study protocol. The eligibility criteria were: (i) not being injured or ill in the previous 3 weeks before the physical fitness assessments; (ii) not being subjected to any drug or special supplementation in the previous 3 weeks; and (iii) not participating in structured exercise in the 48 hours preceding the assessments. The athletes were informed about the study design and protocol.

Context before physical fitness assessment

Before anthropometric and physical assessments, information regarding hours of sleep, days of rest before physical assessment, and time of latest meal was collected. Moreover, total quality recovery in a 10-point scale was applied [12]. To the question 'How recovered are you right now?,' the players could choose between 0 ('very poorly recovered / extremely tired') and 10 ('very well recovered / highly energetic'), as in the original scale. This scale was confirmed for the ability to detect changes in performance [12]. All those questions were collected 30 minutes before starting the physical fitness assessments. Additionally, the individuals were verbally asked about the hour of sleep and the hour of wake-up (aiming to obtain the number of hours of sleep) of the night before the assessments, as well as the time in which the last meal was consumed on the day of the assessment.

The participants reported their latest meal to be 4.5 ± 0.8 hours before the assessments, slept 8.5 ± 0.9 hours the previous night, had 2.4 ± 0.5 days of rest before the assessments, and felt 8.0 ± 0.8 in the total quality recovery (which means ‘well recovered / somewhat energetic’).

Anthropometric measurement

The players were firstly measured for their stature, body mass, and leg length. They were instructed to perform anthropometric measurements barefoot, wearing a T-shirt and shorts. Stature was measured with a stadiometer (SECA 213; Germany) with a technical error of 0.13 cm. Body mass was determined with a digital balance (Tanita BC 418 MA analyser; Tanita Corp., Tokyo, Japan). The leg length was evaluated from the anterior superior iliac spine to the medial malleolus on each side, by using a tape.

Protocol for physical assessment

After anthropometric measurements, the participants followed the FIFA 11+ standardized warm-up protocol (level 2), which is described in previous publications, as well as confirmed as effective for improving COD performance in soccer players [13, 14]. After finishing the warm-up, a 3-minute rest was conceded.

After random selection, half of the players performed the physical fitness assessment in the following order: (1) linear 40-m sprint test; (2) 5-0-5 test braking with left foot; and (3) 5-0-5 test braking with right foot. The other half performed testing in the inverse order: (1) 5-0-5 test braking with right foot; (2) 5-0-5 test braking with left foot; (3) linear 40-m sprint test. The athletes performed 3 trials for each of the tests, with a 5-minute rest between tests.

The 40-m linear sprint test

Players performed 3 trials of the 40-m linear sprint test. Between the trials, a 3-minute rest was conceded. The individuals were instructed to start in a staggered stance position, with their preferred foot in front. They were positioned 0.3 m from the first pair of photocells (located at the starting line), with the single-beamed photocells (SmartSpeed; Fusion Sports, Sumner, Australia) positioned 60 cm from the floor. Three pairs of photocells were used: 1 pair at the starting line (0 m), 1 at 30 m, and 1 at the finish line (40 m). The participants were specially instructed to run as fast as possible from the start to the end of the of the 40-m track and to decelerate only after crossing the 40-m line. The split times (s) of 0–30 m, 30–40 m, and 0–40 m were collected for each trial. The best trial (0–40 m) and the average of trials were considered for calculating CODD.

The 5-0-5 test

The 5-0-5 test consists of an initial acceleration of 10-m split, followed by a 5-m deceleration and 180° COD before the final 5-m acceleration. The players were familiarized with the test in a previous session (1 week before the data collection), which aims to reduce the bias associated with the learning of the test. The participants were instructed to start in a staggered stance position, with their preferred foot in front. Moreover, they were asked to perform the COD off a specific foot (e.g., left or right) on the basis of the randomization established and described above. The athletes were positioned at 0.3 m from the first pair of photocells (located at the starting line), with the single-beamed photocells (SmartSpeed; Fusion Sports, Sumner, Australia) positioned 60 cm from the floor. Three pairs of photocells were used: 1 pair at the starting line (0 m), 1 at 10 m (beginning and end of the 5-0-5 test), and 1 at the COD line (15 m). The players were instructed to run as fast as possible from the start and to only decelerate after crossing the finish line. The split times (s) of 0–10 m, 10–15 m, and 15–20 m were collected for each trial of the left (3×) and right (3×) foot. The best trial (5-0-5 time) and the average of trials were considered for calculating CODD for the left and right feet (while braking).

CODD

CODD was calculated with the subtraction of the 10-m sprint time and the 5-0-5 time [11]. However, the 10-m sprint time was also obtained and used for calculating CODD in the following ways: (1) $CODD_{original}$: using the first 10 m of the 40-m sprint test; (2) $COOD_{best}$: using the best 10-m split in the 40-m sprint test; and (3) $CODD_{5\text{-}0\text{-}5start}$: using the 10-m time that precedes the 5-0-5 test (for the left and right sides).

Monitoring peak speed

During peak speed measurement, the players wore a Polar Team Pro device (Polar Electro, Kempele, Finland) sampling at 10 Hz in a specialized pocked on their upper backs. For each trial of the 40-m sprint test and 5-0-5 test, peak speed was obtained and collected. The concurrent validity and reliability of detecting peak speed with these devices was described in a previous publication [15].

Statistical procedures

Descriptive statistics are presented in the form of the average and standard deviation. Within-test variability of data (between the trials) is shown as the percentage of the coefficient of variation. Data were tested for the assumptions of normality and homogeneity by using the Shapiro-Wilk and Levene's tests. After checking the absence of significant outliers and the confirmation of normality ($p > 0.05$) and homogeneity ($p > 0.05$) of the sample, repeated measures ANOVA was conducted to analyse the variation of COD performance between $CODD_{original}$, $COOD_{best}$, and $CODD_{5\text{-}0\text{-}5start}$. Partial eta squared () was executed to calculate the effect size. The Bonferroni test was used as the post-hoc test after repeated measures ANOVA, with Cohen's *d* applied to calculate the effect size between pairs with the formula with pool standard deviations. The magnitude of effect size (*d*) was considered on the basis of the following thresholds [16]: 0.0–0.2, trivial; 0.2–0.5, small; 0.5–0.8, medium; > 0.8, large. The comparisons between COD left and right were made with the paired *t*-test. Correlation between outcomes and performance in sprint time and COD time were tested by using the Pearson-product moment correlation. The magnitude of correlation was considered on the basis of the following thresholds [16]: 0.0–0.1, trivial; 0.1–0.3, small; 0.3–0.5, medium; and 0.5–1.0, large. The statistical procedures were executed in the SPSS software, version 28.0.0.0 (IBM, USA) for $p < 0.05$.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the scientific council of Escola Superior de Desporto e Lazer (approval No.: CTC-ESDL-CE002-202).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

Table 1 presents the descriptive statistics of the players' performance in the 40-m sprint test and 5-0-5 test. The coefficient of variation of the pooled outcomes (considering the 3 trials performed) exhibited values between 1.63% and 6.65%, which suggests good quality of data and reliability.

Table 2 depicts the repeated measures ANOVA with the consideration of the best 10-m time recorded during the 40-m sprint test (0–10 m and 30–40 m) and 5-0-5 test (first 10-m acceleration phase). Significant differences were found between the outcomes for the best times ($F = 358.2$; $p < 0.001$; = 0.950) or the average times ($F = 439.4$; $p < 0.001$; = 0.959). The time of the 10-m split during the 30–40-m portion of the 40-m sprint test was significantly shorter than the first 10-m time of the same sprint test (best times: $p < 0.001$, $d = -7.077$; average time: $p < 0.001$, $d = -1.140$) and the first 10-m acceleration phase of the 5-0-5 test (best

Table 1. Descriptive statistics (mean, standard deviation, and coefficient of variation) of 40-m sprint and 5-0-5 tests

Test	Split and measure	Trial 1 (mean ± *SD*)	Trial 2 (mean ± *SD*)	Trial 3 (mean ± *SD*)	CV%
40-m sprint test	0–10 m (s)	1.70 ± 0.10	1.71 ± 0.09	1.71 ± 0.11	3.05 ± 2.86
40-m sprint test	30–40 m (s)	1.21 ± 0.04	1.24 ± 0.16	1.21 ± 0.04	2.35 ± 6.42
40-m sprint test	0–40 m (s)	5.44 ± 0.17	5.45 ± 0.13	5.51 ± 0.20	1.63 ± 1.32
40-m sprint test	Peak speed (km/h)	29.33 ± 0.83	28.883 ± 0.90	28.89 ± 0.67	1.80 ± 1.09
5-0-5 test (L)	0–10 m (s)	1.73 ± 0.09	1.74 ± 0.10	1.84 ± 0.08	2.26 ± 2.05
5-0-5 test (L)	10–15 m (s)	1.29 ± 0.07	1.28 ± 0.12	1.37 ± 0.09	5.14 ± 3.53
5-0-5 test (L)	15–20 m (s)	1.35 ± 0.07	1.36 ± 0.10	1.50 ± 0.14	6.65 ± 4.23
5-0-5 test (L)	10–20 m (s)	2.64 ± 0.10	2.64 ± 0.16	2.87 ± 0.18	5.39 ± 2.98
5-0-5 test (L)	Peak speed (km/h)	19.00 ± 0.91	18.84 ± 0.65	18.58 ± 0.65	2.36 ± 1.29
5-0-5 test (R)	0–10 m (s)	1.74 ± 0.09	1.73 ± 0.08	1.72 ± 0.10	2.69 ± 2.29
5-0-5 test (R)	10–15 m (s)	1.37 ± 0.14	1.37 ± 0.14	1.39 ± 0.16	4.11 ± 3.75
5-0-5 test (R)	15–20 m (s)	1.39 ± 0.12	1.39 ± 0.15	1.38 ± 0.23	5.71 ± 4.50
5-0-5 test (R)	10–20 m (s)	2.76 ± 0.18	2.76 ± 0.23	2.77 ± 0.31	4.40 ± 3.60
5-0-5 test (R)	Peak speed (km/h)	18.82 ± 0.82	18.93 ± 0.61	18.70 ± 0.58	1.97 ± 1.12

L – braking with left foot, R – braking with right foot, CV% – coefficient of variation as percentage

Table 2. Descriptive statistics (mean and standard deviation) of the best and average 10-m time of the 40-m sprint test (splits at 0–10 and 30–40 m) and the first 10 m of the 5-0-5 test

Result	40-m sprint test (0–10 m)	40-m sprint test (30–40 m)	5-0-5 test (0–10 m)	F | p |
Best times (s)	1.66 ± 0.09^{b}	$1.20 \pm 0.04^{a,c}$	1.65 ± 0.06^{b}	358.2 | < 0.001 | 0.950
Average times (s)	1.71 ± 0.8^{b}	$1.22 \pm 0.06^{a,c}$	1.73 ± 0.06^{b}	439.4 | < 0.001 | 0.959

[a] significantly different from 40-m sprint test (0–10-m best)
[b] significantly different from 40-m sprint test
[c] significantly different from 5-0-5 test (0–10-m best) at $p < 0.05$

Table 3. Descriptive statistics (mean and standard deviation) of CODD

Result	$CODD_{original}$ (L)	$CODD_{best}$ (L)	$CODD_{5\text{-}0\text{-}5start}$ (L)	$CODD_{original}$ (R)	$CODD_{best}$ (R)	$CODD_{5\text{-}0\text{-}5start}$ (R)	F | p |
Best times (s)	$0.94 \pm 0.15^{b,c,e}$	$1.39 \pm 0.14^{a,c,d,f}$	$0.45 \pm 0.06^{a,b,d,e,f}$	$1.01 \pm 0.19^{b,c,e}$	$1.46 \pm 0.19^{a,c,d,f}$	$1.02 \pm 0.21^{b,c,e}$	201.7 | < 0.001 | 0.914
Average times (s)	$1.02 \pm 0.17^{b,e}$	$1.52 \pm 0.14^{a,c,d,f}$	$0.99 \pm 0.14^{b,e}$	$1.08 \pm 0.22^{b,e}$	$1.58 \pm 0.21^{a,b,c,d,f}$	$1.05 \pm 0.20^{b,e}$	196.2 | < 0.001 | 0.912

CODD – change-of-direction deficit, L – braking with left foot, R – braking with right foot
$CODD_{original}$ – CODD using the first 10 m of the 40-m sprint test (best value among trials)
$CODD_{best}$ – CODD using the best split (30–40 m) of the 40-m sprint test (best value among trials)
$CODD_{5\text{-}0\text{-}5start}$ – CODD using the 10-m acceleration step of the 5-0-5 test (best value among trials)
Values significantly different from: [a] $CODD_{original}$ (L), [b] $CODD_{best}$ (L), [c] $CODD_{5\text{-}0\text{-}5start}$ (L), [d] $CODD_{original}$ (R), [e] $CODD_{best}$ (R), [f] $CODD_{5\text{-}0\text{-}5start}$ (R) at $p < 0.05$

times: $p < 0.001$, $d = 9.000$; average times: $p < 0.001$, $d = -8.500$). However, no significant differences were found between the first 10 m of the 40-m sprint test and the first 10-m acceleration phase of the 5-0-5 test (best times: $p > 0.999$, $d = 0.133$; average times: $p = 0.990$, $d = 0.047$).

Comparisons between 5-0-5 COD time performance with COD with the left and right legs were also performed. The best 5-0-5 COD left times were 2.59 ± 0.12 s, while the average times of the trials equalled 2.73 ± 0.12 s. The best 5-0-5 COD right times were 2.66 ± 0.17 s, while the average times of the trials equalled 2.78 ± 0.18 s. The paired t-test revealed significantly better performance in left leg COD than in right leg COD (best times: $t = -2.095$, $p = 0.050$, $d = -0.468$; average times: $t = -1.902$, $p = 0.072$, $d = -0.333$).

CODD was calculated for the left and right legs COD by using the 40-m sprint test (0–10 m and 30–40 m, best times) and the 5-0-5 acceleration phase (0–10 m, best time). The results of repeated measures ANOVA and post-hoc comparisons can be observed in Table 3. Significant differences were found between particular CODD calculations (best times: $F = 201.7$, $p < 0.001$, = 0.914; average times: $F = 196.2$, $p < 0.001$, = 0.912).

Table 4 presents the correlation coefficients between CODD outcomes and the performance at the 40-m sprint test and 5-0-5 time for COD with the left and right feet. All the CODD results were independent of the 40-m sprint performance ($p > 0.05$).

Table 5 depicts the descendent ranking of players, which can provide information about the real impact of considering different approaches while calculating CODD.

Discussion

The results of this study revealed that the time collected in the first 10-m acceleration phase of the 5-0-5 test produced similar results to the initial 10-m time of the 40-m linear sprint test. This indicates that there is no need to run 2 tests for calculating CODD as previously reported, but the CODD calculated from a 5-0-5 test can provide an accurate measure of COD performance.

Utilizing CODD has become well-accepted in the strength and conditioning community, namely because the outcome presents trivial correlations with linear sprint in short (e.g., 10-m) and medium (e.g., 30/40-m) sprint distances [5, 17, 18]. This means that CODD mitigates the bias promoted by COD time (typically used in COD test), which is highly influenced by linear sprinting in specific COD tests with some distances [10]. In our study, CODD (independently of how it was tested) was isolated from the 40-m sprint test, which confirms that any of the CODD measures can be applied as an independent evaluation of COD performance.

Our research tested the methodological approach of not using 2 tests (sprint test and COD test) for extract-

Table 4. Correlation (*r*) coefficients between CODD outcomes and performance at 40-m sprint test and 5-0-5 COD time (for averages and for the best times)

Measurement	Outcome	40-m sprint test (best times)	5-0-5 COD time (L) (best times)	5-0-5 COD time (R) (best times)
Best times	$CODD_{original}$ (L)	$r = 0.067$ [–0.388; 0.494] $p = 0.779$	$r = 0.858$ [0.658; 0.940] $p < 0.001$**	$r = 0.365$ [–0.101; 0.691] $p = 0.113$
Best times	$CODD_{best}$ (L)	$r = 0.105$ [–0.356; 0.521] $p = 0.659$	$r = 0.963$ [0.904; 0.985] $p < 0.001$**	$r = 0.525$ [0.094; 0.780] $p = 0.017$**
Best times	$CODD_{5\text{-}0\text{-}5start}$ (L)	$r = 0.090$ [–0.370; 0.510] $p = 0.707$	$r = 0.175$ [–0.294; 0.570] $p = 0.460$	$r = –0.117$ [–0.530; 0.346] $p = 0.624$
Best times	$CODD_{original}$ (R)	$r = 0.019$ [–0.428; 0.457] $p = 0.938$	$r = 0.456$ [0.005; 0.742] $p = 0.043$*	$r = 0.915$ [0.785; 0.965] $p < 0.001$**
Best times	$CODD_{best}$ (R)	$r = 0.043$ [–0.409; 0.475] $p = 0.859$	$r = 0.480$ [0.035; 0.755] $p = 0.032$*	$r = 0.983$ [0.955; 0.993] $p < 0.001$**
Best times	$CODD_{5\text{-}0\text{-}5start}$ (R)	$r = 0.016$ [–0.430; 0.455] $p = 0.947$	$r = 0.405$ [–0.057; 0.713] $p = 0.077$	$r = 0.958$ [0.889; 0.983] $p < 0.001$**
Measurement	Outcome	40-m sprint test (average times)	5-0-5 COD time (L) (average times)	5-0-5 COD time (R) (average times)
Average times	$CODD_{original}$ (L)	$r = –0.143$ [–0.548; 0.323] $p = 0.548$	$r = 0.871$ [0.685; 0.946] $p < 0.001$**	$r = 0.635$ [0.252; 0.836] $p = 0.003$**
Average times	$CODD_{best}$ (L)	$r = –0.165$ [–0.563; 0.303] $p = 0.487$	$r = 0.936$ [0.835; 0.973] $p < 0.001$**	$r = 0.709$ [0.373; 0.872] $p < 0.001$**
Average times	$CODD_{5\text{-}0\text{-}5start}$ (L)	$r = –0.231$ [–0.607; 0.241] $p = 0.327$	$r = 0.906$ [0.764; 0.961] $p < 0.001$**	$r = 0.697$ [0.352; 0.866] $p < 0.001$**
Average times	$CODD_{original}$ (R)	$r = –0.056$ [–0.485; 0.398] $p = 0.814$	$r = 0.711$ [0.376; 0.873] $p < 0.001$**	$r = 0.938$ [0.840; 0.974] $p < 0.001$**
Average times	$CODD_{best}$ (R)	$r = –0.059$ [–0.487; 0.395] $p = 0.806$	$r = 0.714$ [0.381; 0.874] $p < 0.001$**	$r = 0.985$ [0.960; 0.994] $p < 0.001$**
Average times	$CODD_{5\text{-}0\text{-}5start}$ (R)	$r = –0.099$ [–0.517; 0.361] $p = 0.678$	$r = 0.659$ [0.290; 0.848] $p = 0.002$**	$r = 0.960$ [0.895; 0.984] $p < 0.001$**

COD – change-of-direction
CODD – change-of-direction deficit, L – braking with left foot, R – braking with right foot
$CODD_{original}$ – CODD using the first 10 m of the 40-m sprint test (best value among trials)
$CODD_{best}$ – CODD using the best split (30–40 m) of the 40-m sprint test (best value among trials)
$CODD_{5\text{-}0\text{-}5start}$ – CODD using the 10-m acceleration step of the 5-0-5 test (best value among trials)
* significant at $p < 0.05$, ** significant at $p < 0.01$

Table 5. CODD (using the best times) descendent ranking of participants regarding the different methodological approaches tested

$CODD_{original}$ (L)		$CODD_{best}$ (L)		$CODD_{5\text{-}0\text{-}5start}$ (L)		$CODD_{original}$ (R)		$CODD_{best}$ (R)		$CODD_{5\text{-}0\text{-}5\ start}$ (R)	
ID	CODD (s)	ID	CODD (s)	ID	CODD (s)	ID	CODD (s)	ID	CODD (s)	ID	CODD (s)
ID002	0.71	ID002	1.09	ID019	0.35	ID008	0.79	ID007	1.21	ID007	0.68
ID004	0.78	ID003	1.16	ID020	0.36	ID010	0.82	ID003	1.22	ID003	0.82
ID008	0.78	ID005	1.26	ID003	0.40	ID015	0.83	ID008	1.28	ID008	0.86
ID012	0.79	ID012	1.26	ID006	0.40	ID012	0.85	ID005	1.31	ID010	0.86
ID003	0.80	ID008	1.27	ID008	0.42	ID003	0.86	ID012	1.32	ID002	0.87
ID005	0.81	ID004	1.28	ID015	0.42	ID005	0.86	ID015	1.33	ID005	0.88
ID015	0.82	ID015	1.32	ID011	0.42	ID011	0.87	ID010	1.33	ID009	0.90
ID011	0.84	ID011	1.36	ID012	0.42	ID007	0.90	ID002	1.34	ID012	0.90
ID018	0.87	ID013	1.37	ID005	0.43	ID009	0.90	ID009	1.35	ID015	0.91
ID001	0.90	ID018	1.42	ID018	0.43	ID002	0.96	ID011	1.39	ID013	0.95
ID006	0.94	ID007	1.43	ID009	0.45	ID004	0.98	ID013	1.40	ID011	0.97
ID010	0.95	ID001	1.44	ID013	0.45	ID014	1.02	ID016	1.46	ID004	0.98
ID014	1.01	ID006	1.44	ID002	0.47	ID016	1.08	ID004	1.48	ID016	0.98
ID009	1.05	ID010	1.46	ID010	0.47	ID001	1.08	ID019	1.58	ID001	1.04
ID019	1.06	ID019	1.46	ID016	0.48	ID013	1.10	ID014	1.60	ID014	1.10
ID013	1.07	ID009	1.50	ID017	0.49	ID006	1.14	ID001	1.62	ID019	1.23
ID017	1.11	ID020	1.50	ID004	0.50	ID019	1.18	ID006	1.64	ID006	1.24
ID007	1.12	ID016	1.58	ID014	0.50	ID018	1.22	ID018	1.77	ID017	1.29
ID020	1.14	ID014	1.59	ID007	0.53	ID017	1.30	ID017	1.78	ID018	1.34
ID016	1.20	ID017	1.59	ID001	0.58	ID020	1.50	ID020	1.86	ID020	1.50

CODD – change-of-direction deficit, L – braking with left foot, R – braking with right foot
$CODD_{original}$ – CODD using the first 10 m of the 40-m sprint test (best value among trials)
$CODD_{best}$ – CODD using the best split (30–40 m) of the 40-m sprint test (best value among trials)
$CODD_{5\text{-}0\text{-}5start}$ – CODD using the 10-m acceleration step of the 5-0-5 test (best value among trials)
ID – code number of the player

ing data to calculate CODD and applying only a single test. In this case, and along with the previous research design, we employed the 5-0-5 test since it has a preliminary 10-m acceleration phase, which is a good point to collect data of linear sprinting. Moreover, as in a 20- or 30-m sprint test, the 5-0-5 test does not stop after crossing the first 10-m barrier, which means deceleration it unlikely to occur and compromise the maximum linear effort performed. This expectation was confirmed in our results as there were no significant differences found between the 10-m time of the 40-m linear sprint test and the 10-m acceleration phase of the 5-0-5 test for best or average times.

The construct of comparing the 10-m initial acceleration phase of a linear sprint test and the initial 10-m acceleration of a test with a COD (e.g., 5-0-5 test) was also aplied in the previous research that initially presented the concept of CODD [11]. Although our study is comparable (e.g., comparing the initial 10-m acceleration of a linear test and initial 10-m acceleration of a COD test), we also tested the hypothesis of using the best 10-m split in the 40-m linear sprint test. In this case, the split was significantly different (and smaller) than the 10-m initial acceleration of both tests. This unsurprisingly impacted on the final results of CODD since $CODD_{original}$ and $CODD_{5\text{-}10\text{-}5start}$ were significantly smaller than $CODD_{best}$ (which used the best 10-m split in the 40-m linear sprint test). Naturally, the kinematics of sprinting allows a better performance in 30–40 m than in initial 10 m since in the former case, the peak horizontal propulsive force, stance phase, and swing phase are significantly larger than in the acceleration phase [19]. Thus, considering that in a COD test like the 5-0-5 test, the participant spends around 31% of the time changing directions [20], it is expected that there would be a gap to the linear sprint time and larger CODD calculation during the best 10-m split. However, it is expected that faster players will also present greater CODD, a hypothesis based of a previous study [21]. In this study, the authors found that players with greater acceleration in initial 10 m were the same as those with greater CODD [21]. Nevertheless, in this study, the best players were not always included in the top-five among the different approaches. As an example, player ID002 was the best in $\text{CODD}_{\text{original}}$ left and $\text{CODD}_{\text{best}}$ left, but not in the top-5 of $\text{CODD}_{\text{5-0-5start}}$ left, $\text{CODD}_{\text{original}}$ right, or $\text{CODD}_{\text{best}}$ right, which indicates that faster athletes were not always those with greater acceleration. This further supports our results suggesting that calculating CODD by using the first 10 m and the best 10 m of a sprint test is quite different and that CODD should be calculated with either the initial 10 m of a 40-m sprint test or the 5-0-5 test.

Our research also revealed that COD with the left or right foot does not result in the same final outcomes. As previously demonstrated, COD asymmetries are natural and present in players [18], with both sides recommended to be tested and used when calculating CODD. The differences between feet can be due to the laterality profile of athletes and the greater ability to produce force or perform a task on one of the sides of the body [17, 22]. Therefore, CODD will be different for the left and right COD, which influences the final CODD calculation when using the 5-0-5 test.

There are limitations for this study that should be acknowledged. While previous research investigated cricketers, our study population were soccer players, which confirms the results in different populations. However, both studies only utilized one 180° COD. This may mean that CODD may only be specific to this angle of directional change. Future research should investigate CODD over a variety of angles and continue to determine CODD with the 5-0-5 test in different athletic populations. It is also still unknown what influence both the acceleration technique and COD technique have on CODD. This study looked to add to the current literature and provide further practical information for testing and training practitioners. The study originality consists in identifying that the 5-0-5 test can be used for assessing 10-m acceleration and COD performance simultaneously. This will provide coaches with confidence about using the 5-0-5 test for monitoring CODD without adding a linear sprint test, which means time efficiency. Future research should investigate relationships between CODD and entry and exit velocities when changing direction in athletes to gain more detailed technical information.

Conclusions and practical applications

The originality of this study lies in showing that the 5-0-5 test can serve as a single-to-use test to calculate CODD, which means that there is no need to assess the first 10-m sprint in a linear sprint test. The first 10-m acceleration phase of the 5-0-5 can be used for calculating CODD since no significant differences were found between the initial 10 m of the linear sprint test and the 10-m acceleration phase of the 5-0-5 test. For the right leg COD, no significant differences were observed between CODD using the original methodological approach or using the 10-m linear time of the 5-0-5 test. However, large differences were revealed for calculating CODD with the first 10 m or the best 10 m of the 40-m linear sprint test. If practitioners want to compare COD time with the best sprint time, it is recommended to collect the split time of the 30–40-m test for an integrated CODD calculation.

Disclosure statement
No author has any financial interest or received any financial benefit from this research.

Conflict of interest
The authors state no conflict of interest.

References

1. Little T, Williams AG. Specificity of acceleration, maximum speed, and agility in professional soccer players. J Strength Cond Res. 2005;19(1):76–78; doi: 10.1519/14253.1.
2. Hasan UC, Silva R, Clemente FM. Weekly variations of biomechanical load variables in professional soccer players: comparisons between playing positions. Hum Mov. 2021;22(3):19–34; doi: 10.5114/hm.2021.100321.
3. Cruz Gonçalves LG, Clemente FM, Palucci Vieira LH, Bedo B, Puggina EF, Moura F, et al. Effects of match location, quality of opposition, match outcome, and playing position on load parameters and players' prominence during official matches in professional soccer players. Hum Mov. 2021;22(3):35–44; doi: 10.5114/hm.2021.100322.
4. Chaouachi A, Manzi V, Chaalali A, Wong DP, Chamari K, Castagna C. Determinants analysis of change-of-direction ability in elite soccer players. J Strength Cond Res. 2012;26(10):2667–2676; doi: 10.1519/JSC.0b013e318242f97a.
5. Loturco I, Nimphius S, Kobal R, Bottino A, Zanetti V, Pereira LA, et al. Change-of direction deficit in elite young soccer players. Ger J Exerc Sport Res. 2018;48(2):228–234; doi: 10.1007/s12662-018-0502-7.
6. Rauter S, Coh M, Vodicar J, Zvan M, Krizaj J, Simenko J, et al. Analysis of reactive agility and change-of-direction speed between soccer players and physical education students. Hum Mov. 2018;19(2):68–74; doi: 10.5114/hm.2018.74061.
7. Faude O, Koch T, Meyer T. Straight sprinting is the most frequent action in goal situations in professional foot-

ball. J Sports Sci. 2012;30(7):625–631; doi: 10.1080/02640414.2012.665940.
8. Turner A, Walker S, Stembridge M, Coneyworth P, Reed G, Birdsey L, et al. A testing battery for the assessment of fitness in soccer players. Strength Cond J. 2011; 33(5):29–39; doi: 10.1519/SSC.0b013e31822fc80a.
9. Križaj J. Relationship between agility, linear sprinting, and vertical jumping performance in Slovenian elite women football players. Hum Mov. 2020;21(2):78–84; doi: 10.5114/hm.2020.91281.
10. Sayers MGL. Influence of test distance on change of direction speed test results. J Strength Cond Res. 2015; 29(9):2412–2416; doi: 10.1519/JSC.0000000000001045.
11. Nimphius S, Callaghan SJ, Spiteri T, Lockie RG. Change of direction deficit: a more isolated measure of change of direction performance than total 505 time. J Strength Cond Res. 2016;30(11):3024–3032; doi: 10.1519/JSC.0000000000001421.
12. Laurent CM, Green JM, Bishop PA, Sjökvist J, Schumacker RE, Richardson MT, et al. A practical approach to monitoring recovery: development of a perceived recovery status scale. J Strength Cond Res. 2011;25(3): 620–628; doi: 10.1519/JSC.0b013e3181c69ec6.
13. Liu R, Liu J, Ma X, Li Q, An R. Effect of FIFA 11+ intervention on change of direction performance in soccer and futsal players: a systematic review and meta-analysis. Int J Sports Sci Coach. 2021;16(3):862–872; doi: 10.1177/1747954121991667.
14. Bizzini M, Impellizzeri FM, Dvorak J, Bortolan L, Schena F, Modena R, et al. Physiological and performance responses to the “FIFA 11+” (part 1): is it an appropriate warm-up? J Sports Sci. 2013;31(13):1481–1490; doi: 10.1080/02640414.2013.802922.
15. Sagiroglu İ, Akyildiz Z, Yildiz M, Clemente FM. Validity and reliability of Polar Team Pro GPS units for assessing maximum sprint speed in soccer players. Proc Inst Mech Eng P J Sports Eng Technol. 2021; doi: 10.1177/17543371211047224.
16. Cohen J. Statistical power analysis for the behavioral sciences. New York: Lawrence Erlbaum Associates; 1988.
17. Dos’Santos T, Thomas C, Jones PA, Comfort P. Assessing asymmetries in change of direction speed performance: application of change of direction deficit. J Strength Cond Res. 2019;33(11):2953–2961; doi: 10.1519/JSC.0000000000002438.
18. Dos’Santos T, Thomas C, Comfort P, Jones PA. Comparison of change of direction speed performance and asymmetries between team-sport athletes: application of change of direction deficit. Sports. 2018;6(4):174; doi: 10.3390/sports6040174.
19. Yu J, Sun Y, Yang C, Wang D, Yin K, Herzog W, et al. Biomechanical insights into differences between the mid-acceleration and maximum velocity phases of sprinting. J Strength Cond Res. 2016;30(7):1906–1916; doi: 10.1519/JSC.0000000000001278.
20. Nimphius S, Geib G, Spiteri T, Carlisle D. “Change of direction deficit” measurement in Division I American football players. J Aust Strength Cond. 2013;21(S2): 115–117.
21. Loturco I, Pereira LA, Freitas TT, Alcaraz PE, Zanetti V, Bishop C, et al. Maximum acceleration performance of professional soccer players in linear sprints: is there a direct connection with change-of-direction ability? PLoS One. 2019;14(5):e0216806; doi: 10.1371/journal.pone.0216806.
22. Dos’Santos T, Thomas C, Jones PA, Comfort P. Asymmetries in isometric force-time characteristics are not detrimental to change of direction speed. J Strength Cond Res. 2018;32(2):520–527; doi: 10.1519/JSC.0000000000002327.