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Reliability and validity of a modified Illinois change-of-direction test with ball dribbling speed in young soccer players

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ABSTRACT: The purpose of this study was to assess test-retest reliability, discriminative and criterion-related validity of the modified Illinois change-of-direction (CoD) test with ball dribbling-speed (ICODT-BALL) in young soccer players of different biological maturity and playing levels. Sixty-five young male soccer players (11.4 ± 1.2 years) participated in this study. The participants were classified according to their biological maturity (pre- and circum-peak height velocity [PHV]) and playing-level (elite and amateur players). During the test-retest time period of two weeks, the following tests were performed during week one and as retest during week two: ICODT-BALL, ICODT, 4 × 9-m shuttle-run, countermovement-jump, triple-hop-test, maximum-voluntary isometric-contraction of back-extensors, Stork, Y-Balance, 10 and 30-m sprints. The ICODT-BALL showed excellent relative ($r = 0.995$, $p < 0.001$; ICC = 0.993) and absolute (SEM < 5%; SEM < $SWCs_{(0.2, 0.6, 1.2)}$) reliability. The circum-PHV (22.8 ± 1.7-s) and elite (22.5 ± 0.9-s) players showed better ICODT-BALL performance than their pre-PHV (24.2 ± 2.5-s) and amateur (25.1 ± 2.8-s) counterparts (p = 0.028 and p < 0.001, respectively). The ICODT-BALL showed "very good" (AUC = 0.81) discriminant validity when comparing the elite and amateur players, and "moderate" (AUC = 0.67) discriminant validity when compared to pre-PHV and circum-PHV boys. ICODT-BALL demonstrated "large" positive associations with the ICODT ($r = 0.65$; 41.8% shared-variance) and sprint tests ($r \geq 0.52$; 27.3 to 34.8% shared-variance). In addition, results showed "moderate" negative associations between ICODT-BALL and strength, and power measures, as well as a "small" negative relationship with balance tests. In conclusion, the ICODT-BALL is a valid and reliable test to evaluate the ability to quickly change directions while ball dribbling in young soccer players. Therefore, practitioners can use the ICODT-BALL as a tool for talent identification.

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INTRODUCTION

The ability to quickly change directions has been considered an important physical quality, related to success in youth soccer [1–4]. When analyzing movement tasks and patterns within each phase of the soccer game, initiation or change of movement in various directions occurs both with and without the ball. Therefore, players need to be able to apply effective change of directions (CoD) when in possession of the ball and when moving off the ball [5]. In particular, the ability to quickly CoD with the ball evading opposing players into an opponent's territory is a hallmark of gifted players [6] and offers a strong tactical advantage [7, 8]. Accordingly, development and monitoring of players' ability to carry out CoD with specific tasks while moving with the ball at speed should also be an important part of a soccer CoD ability evaluation and development program [9].

With the lack of an accepted gold standard test, a plethora of CoD speed tests are used in youth soccer for performance assessment [1, 10]. However, ball dribbling speed elements are rarely incorporated within a CoD assessment. Previous research have examined the reliability of the dribbling square speed test (ICC = 0.71) [11], zig-zag with ball test (ICC = 0.81) [12], shuttle dribble test (ICC = 0.74) [7], T drill kicking ball (ICC = 0.88) [13], UGent slalom dribbling test (ICC = 0.81) [14] and slalom dribbling test (ICC = 0.78–0.99) [15–18]. Furthermore, the construct validity of 15-m ball dribbling [3], slalom dribbling test [15, 16, 19] and T drill kicking ball [13] soccer players have been demonstrated.

Based on the recently published systematic review of Altmann et al. [10], the ball dribbling speed tests can be categorized into slalom, shuttle run or zig-zag test types. In this context, Mirkov et al. [12] assessed the dribbling ability speed on a zigzag course. However, this test can be criticized for its reliance CoD with the ball rather than relying on slalom actions around cones, which diminishes its ecological validity. Moreover, Huijgen et al. [19] evaluated the dribbling speed ability in a slalom fashion. However, the evaluation of the CoD ability with pre-planned close maneuvers with the ball is not represented in this test [3, 7, 15, 16]. Kutlu et al. [13] reported the validity and reliability of a new test based on the T-drill test. Although the protocol cited [13] was valid for measuring speed with CoD and kicking stationary the balls to the goal, no information was provided on the dribbling speed ability with the ball.

Generally, players in highly ranked professional soccer teams covered greater distances with the ball at high speed than their counterparts from lower-ranked teams [9, 20]. Thus, professional players performed faster times (trivial to large) in the dribbling speed test compared to amateur [10, 13, 15, 16] and semi-professional players [21]. Therefore, it is not surprising that CoD with ball dribbling speed has been shown to be a more construct valid test that can discriminate between potential elite and amateur youth soccer players [3, 15, 16, 19]. The difference in CoD performance between the two leagues could possibly demonstrate the need for the application of the modified Illinois change-of-direction test with ball dribbling speed (ICODT-BALL). This test can be used to differentiate between the playing levels of soccer athletes. Pre-adolescent soccer players usually compete in groups according to chronological age. At this stage of puberty, players of similar chronological age might differ with regards to their biological maturity status [22]. Previous literature reported that biological maturity influences physical fitness test performance [23, 24]. However, previous cross-sectional reports demonstrated that maturity status did not have an impact on dribbling speed ability [11, 14].

In the sport science community, the paradigm of speed development is undergoing changes, and a greater emphasis is being placed not just on acceleration, top speed and speed endurance training, but also on speed drills including CoD [4] as is the case in dribbling [6]. In view of the previous protocols [7, 12, 13], there is a lack of new tests integrating both these components (slalom and CoD) to evaluate the dribbling speed performance among young soccer players. These tests are considered to have "low" construct validity to prescribe while they assess the soccer players' ability to slalom and quickly CoD while ball dribbling. To go beyond this limitation and meet the specific demands of the modality, it is necessary to develop tests with specific motor actions. Indeed, the modified Illinois change-of-direction test with ball dribbling speed (ICODT-BALL) could be used to determine the players' CoD ability with the ball, and slalom at different angles. Therefore, it can be postulated that the inclusion of these characteristics could improve the ecological validity of the ICODT-BALL as a talent-identification test that has the potential to discriminate between future elite and amateur soccer players.

The ICODT-BALL was also previously applied in youth elite [25], amateur [26], semi-professional [21] and para-soccer players [27]. To the authors' knowledge, only two previous studies have investigated the reliability of ICODT-BALL, with excellent values (ICC = 0.985) found in 11- to 12-year-old soccer players [28] and good values (ICC = 0.84) were found in 19-year-old soccer players [27]. Accordingly, the current study is one of the first to examine the construct-discriminant and criterion-related validity of the dribbling speed test in young soccer players of different biological maturity and playing levels. Therefore, the purpose of this study was to: (a) examine the reliability and validity of the ICODT-BALL; (b) establish its relationship with CoD, linear sprint, muscle strength, power and balance capabilities; and (c) assess whether this soccer-specific test is sensitive and can discriminate between young soccer players with different biological maturity and playing levels. With reference to the relevant literature [1, 11, 19, 25], we hypothesize that the ICODT-BALL shows high test-rest reliability, sensitivity, and validity, as well as a significant association with proxies of athletic performance.

MATERIALS AND METHODS

Subjects

Sixty-five young male soccer players from the Esperance Football Academy (an elite soccer club in Tunisia, and Middle East and North Africa [MENA] region) volunteered to participate in this study during the mid-season period. The physical characteristics of the participants are presented in Table 1. All participants had a similar socioeconomic status and the same daily school and soccer team-training schedules. Players trained three-to-four times a week (90-min per session) on synthetic surfaces with a match during the weekend. To estimate the participants' biological maturity status, a maturity index (timing of maturation) was calculated [29]. This assessment is a non-invasive and practical method of predicting years from peak height velocity (PHV) as a measure of maturity offset using height and age as variables (PHV = -7.999994 + [0.0036124 × age (years) × height (cm)]). In this study, children and adolescents can be classified into two categories according to their biological maturity status: pre-PHV velocity (-3 years to > -1 years from PHV) or circum-PHV (-1 to +1 years from PHV) [28]. The participants were assigned according to their playing level: elite and amateur youth teams players (Table 1). The elite players train to play in the highest division corresponding to their age-category level in Tunisia. Amateur players train to play friendly matches. Years of soccer experience were obtained from their medical sports monitoring files. Parents or legal representatives and participants provided written informed consent after a thorough explanation of the objectives and scope of this project and the procedures, risks, and benefits of the study. The study was conducted according to the Declaration of Helsinki and the protocol was fully

TABLE 1. The sample characteristics.

	Chronological age (years)	Predicted PHV (years from PHV)	Age at PHV (years)	Height (cm)	Body mass (kg)	BMI (kg·m⁻²)	Experience (years of play)	Weekly training sessions
All subjects (n = 65)	11.4 ± 1.18	-1.9 ± 0.95	13.3 ± 0.40	147.8 ± 8.72	38.1 ± 9.14	17.3 ± 2.64	2.4 ± 1.24	3.5 ± 0.50
All subjects divided into maturity-based groups								
Pre-PHV group (n = 54)	11.0 ± 0.68	-2.2 ± 0.46	13.2 ± 0.37	145.1 ± 6.10	35.7 ± 7.09	16.9 ± 2.55	2.4 ± 1.27	3.6 ± 0.50
Circum-PHV group (n = 11)	13.6 ± 0.65	-0.1 ± 0.70	13.7 ± 0.32	160.8 ± 8.02	50.2 ± 8.74	19.3 ± 2.17	2.5 ± 1.13	3.3 ± 0.47
p value of pre-PHV group vs. circum-PHV group	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.626	0.054
All subjects divided into expertise level of the players								
Elite players (n = 35)	11.0 ± 0.73	-2.2 ± 0.61	13.2 ± 0.30	145.8 ± 7.25	34.9 ± 6.04	16.3 ± 1.76	2.7 ± 1.36	4.0 ± 0.00
Amateur players (n = 30)	12.0 ± 1.38	-1.5 ± 1.12	13.4 ± 0.46	150.1 ± 9.79	41.9 ± 10.67	18.4 ± 3.08	2.1 ± 0.98	3.0 ± 0.00
p value of elite players vs. amateur players	0.003	0.003	0.036	0.093	0.005	0.002	0.047	< 0.001

Means ± standard deviations (SD) provided; PHV: peak height velocity; BMI: Body mass index.

approved by the Ethics Committee of the National Centre of Medicine and Science of Sports of Tunisia (CNMSS) before the assessments began.

Procedures

Players were classified into two groups according to their biological maturity (pre- and circum-peak height velocity [PHV]) and playing level (elite and amateur players). Before the commencement of the study, all of the players completed a two-week orientation period (two sessions/week) to become familiar with the general environment, equipment, form and technique of each fitness test as well as minimize learning effects during the course of the experiment. Researchers demonstrated the proper form and mechanics of movement for the execution of all tests and explained the key technical features. Players were allowed to practice the ICODT-BALL task until they felt comfortable. Verbal instruction regarding technique and turning direction was kept to a minimum in order to elicit a 'natural' ICODT-BALL performance from each player. Overall, during the familiarization period, participants repeated each test at least 6–8 times. However, no more than 10 practice trials were realized by any of the players. Anthropometrical measurements were also determined for each participant two days before the start of the experiment. Body mass was measured to the nearest 0.1 kg using an electronic scale (LifeSource Model UC-321P; A&D Company, Tokyo, Japan). Height and sitting-height were measured to the nearest 0.1 cm using a wall-mounted stadiometer (Easy Glide Stadiometer; Perspective Enterprises, Portage, MI, USA).

Participants performed tests during week one and retests during week two. The same test battery was applied in test and retest. During each week, the tests were conducted on three days with a recovery period of 48 h in between. Testing was always realized at the same time of day (i.e., between 4 pm and 6 pm) and with the same test sequence, at the same location (Esperance Club in Tunis, Tunisia), by the same investigators and with similar environmental conditions (i.e., temperature ≈25° C and ≈63% humidity). On day 1, participants completed the triple-hop-test, the 30-m linear sprint [30-m] and 4 × 9-m shuttle run tests. On the second day, each player completed the Y-balance test [YBT], the countermovement jump test [CMJ], the 10-m linear sprint test [10-m], and the Illinois change-of-direction speed test without the ball [ICODT]. The remaining tests were conducted on day 3 (maximum voluntary isometric contraction of the back extensors [BE-MVIC], stork balance test, and ICODT with ball dribbling [ICODT-BALL]. The rest intervals between each test and within each test session were at least 5 minutes to allow adequate recovery. All test sessions were preceded by a standardized 15-minute warm-up that included 5-min of submaximal running followed by a 5-min series of dynamic stretching (i.e. hip flexion/extension, hip abduction/adduction); low-intensity forward, sideways, and backward running; several acceleration runs; jumping at a progressively increased intensity; and mobility exercises that provided appropriate activation of the lower-limbs muscles. Players performed a set of two sub-maximal repetitions of each test to get prepared for the test. During all tests, instructor-to-participant ratio was 1:1. Uniform verbal encouragement was offered to all participants.

Measurements

CoD speed was assessed with the 4 × 9-m shuttle run test and the ICODT without the ball as previously described by Hachana et al. [1] and Negra et al. [30].

ICODT-BALL was similar to the ICODT, which involves placing 4 cones to indicate a square area that is 10-m long and 5-m wide. In the center of the area, 4 poles were placed 3.3-m apart. The players were required to dribble a soccer ball while performing the test (Figure 1). Each participant had to move the ball with their feet as quickly as possible from the start gate, follow a planned route and slalom through the markers, and then dribble the ball to the finish gate. The objective was to complete the drill in the fastest time possible by controlling the ball only with the feet. The time for each trial was recorded with photoelectric cells. The participants performed two maximal attempts with at least 3-min of rest between trials. The faster time was recorded in seconds [25, 28].

The players' *linear sprint performance* was assessed using 10- and 30-m sprints [31].

Muscle strength was assessed with maximum voluntary isometric contraction of the back extensor (BE-MVIC) and measured in kilograms using a back dynamometer (Takei, Tokyo, Japan) according to the procedures described previously [28, 32, 33]. During recent years, BE-MVIC testing has become a regular part of testing with youth, team sport athletes during recent years, particularly in soccer [34, 35]. Indeed, optimal back extensor strength may contribute to core stability by stiffening the torso. Particularly in football, players may benefit from core stability in high impact situations such as during acceleration and deceleration, changes of direction, and tackles [34]. In a previous study from our laboratory, we observed a significant medium-to-large sized correlation between balance measures with back extensor strength ($r = 0.486–0.791$, all $p < 0.001$) with a mean r-value of $r = 0.645$ and an explained variance of 42% in youth soccer players [32]. Some soccer-specific actions are performed under unstable conditions with high speed dynamic contractions performed within a more limited base of support (e.g., single leg hop jump test) or with the center of gravity being moved outside the base of support (SLJ), which affords core stability and thus back extensor strength.

Muscular power was assessed using the countermovement jump (CMJ) without arm swing and three consecutive maximal hops forward on the same leg (triple-hop-test) to reach the maximal horizontal distance. The CMJ was performed using an Ergo jump system (Ergojump apparatus; Globus Italia, Codogne, Italy) according to the procedures described by Chaouachi et al. [36]. For each muscular power test, three trials were performed with approximately 2-min passive recovery and the best result was used for further analysis.

Static balance was assessed utilizing the stork balance test and *dynamic balance* was tested using the Y balance test composite score (YBT CS) as described by Makhlouf et al. [28]. For each balance test, players performed three trials (~ 2-min between-trial passive recovery) with the best measure used for further analysis.

Statistics

Two statistical software packages, SPSS 20 (for Windows, Inc., Chicago, IL, USA) and MedCalc (Version 14.8-1993-2014 MedCalc Software) were used for data analyses. Data are presented as means, standard deviations (SD) and 95% confidence intervals (95% CI).

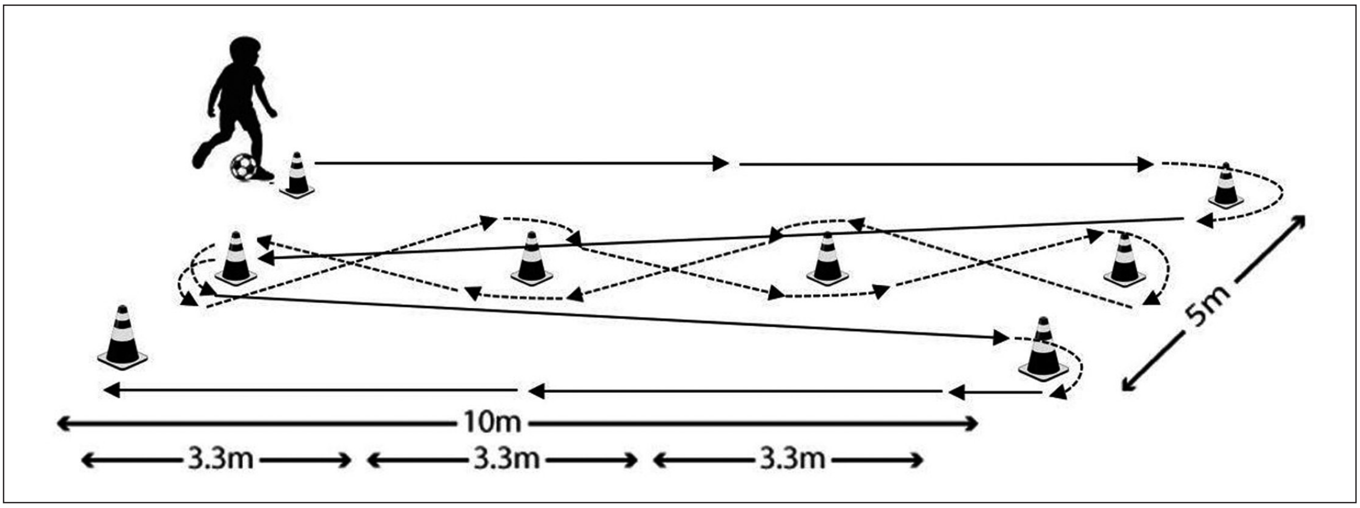

FIG. 1. The Illinois change-of-direction test with ball dribbling speed (ICODT-BALL) procedures.

TABLE 2. Reliability results of the physical tests.

	Test (mean ± SD) (95% CI)	Retest (mean ± SD) (95% CI)	Mean difference ± SD (95% CI)	Cohen's d (95% CI)	*r* (95% CI)	ICC magnitude (95% CI)	α magnitude	SEM	SWC (0.2, 0.6, and 1.2)	MDC95%
ICODT-BALL (s)	23.755 ± 2.390 (23.162 to 24.347)	24.073 ± 2.430 (23.471 to 24.675)	-0.318 ± 0.248 (-0.379 to -0.257)	0.12, very small (-0.35 to 0.62)	0.995** (0.992 to 0.997)	0.993 excellent (0.871 to 0.998)	0.997 excellent	0.02	0.48, 1.45, 2.89	0.058
ICODT (s)	18.163 ± 0.804 (17.964 to 18.362)	18.405 ± 0.832 (18.199 to 18.612)	-0.242 ± 0.304 (-0.318 to -0.167)	0.29, small (-0.19 to 0.78)	0.931** (0.890 to 0.958)	0.943 excellent (0.767 to 0.977)	0.964 excellent	0.07	0.16, 0.49, 0.98	0.201
4 × 9-m shuttle run (s)	10.457 ± 0.463 (10.342 to 10.571)	10.575 ± 0.486 (10.454 to 10.695)	-0.118 ± 0.098 (-0.142 to -0.094)	0.25, small (-0.24 to 0.74)	0.980** (0.967 to 0.988)	0.974 excellent (0.669 to 0.992)	0.989 excellent	0.01	0.09, 0.28, 0.57	0.028
10-m linear sprint (s)	2.194 ± 0.156 (2.155 to 2.233)	2.226 ± 0.157 (2.187 to 2.265)	-0.032 ± 0.028 (-0.039 to -0.025)	0.20, small (-0.28 to 0.69)	0.985** (0.975 to 0.991)	0.982 excellent (0.780 to 0.995)	0.992 excellent	0.004	0.03, 0.09, 0.19	0.010
30-m linear sprint (s)	5.427 ± 0.347 (5.341 to 5.513)	5.481 ± 0.372 (5.389 to 5.574)	-0.054 ± 0.060 (-0.069 to -0.039)	0.15, very small (-0.34 to 0.64)	0.989** (0.981 to 0.993)	0.988 excellent (0.921 to 0.996)	0.993 excellent	0.007	0.07, 0.22, 0.43	0.018
BE-MVIC (kg)	56.069 ± 13.360 (52.759 to 59.380)	51.338 ± 14.866 (47.655 to 55.022)	4.731 ± 6.203 (3.194 to 6.268)	0.33, small (-0.82 to 0.15)	0.909** (0.854 to 0.944)	0.923 excellent (0.720 to 0.968)	0.949 excellent	1.72	2.82, 8.47, 16.94	4.771
CMJ (cm)	21.052 ± 4.860 (19.848 to 22.256)	20.381 ± 4.810 (19.189 to 21.573)	0.671 ± 1.001 (0.423 to 0.919)	0.14, very small (-0.63 to 0.35)	0.979** (0.965 to 0.987)	0.985 excellent (0.950 to 0.993)	0.989 excellent	0.12	0.97, 2.90, 5.80	0.340
Triple-hop-test (cm)	505.015 ± 53.494 (491.760 to 518.270)	493.369 ± 52.877 (480.267 to 506.472)	11.646 ± 9.305 (9.341 to 13.952)	0.22, small (-0.71 to 0.27)	0.985** (0.975 to 0.991)	0.981 excellent (0.709 to 0.994)	0.992 excellent	1.28	10.64, 31.91, 63.82	3.555
Stork balance test (s)	4.655 ± 2.746 (3.975 to 5.335)	4.137 ± 2.472 (3.524 to 4.749)	0.518 ± 0.528 (0.387 to 0.649)	0.20, small (-0.69 to 0.29)	0.985** (0.975 to 0.991)	0.980 excellent (0.850 to 0.993)	0.990 excellent	0.07	0.52, 1.57, 3.13	0.207
YBT CS (s)	89.910 ± 11.670 (87.019 to 92.802)	91.889 ± 12.529 (88.784 to 94.994)	-1.978 ± 5.409 (-3.319 to -0.638)	0.16, very small (-0.32 to 0.65)	0.902** (0.844 to 0.940)	0.942 excellent (0.896 to 0.966)	0.947 excellent	1.30	2.42, 7.26, 14.52	3.611

BE-MVIC: back extension maximum voluntary isometric contraction; YBT CS: Y balance test composite score; ICODT: Illinois change of direction speed test; CMJ: countermovement jump; SD: standard deviation; 95% CI: 95% confidence interval; *r*: Pearson's *r*-values; ICC: intraclass correlation coefficient; α: Cronbach's alpha coefficients; SEM: standard error of measurement; SWC (0.2, 0.6, and 1.2): smallest worthwhile change with various effect sizes (0.2, 0.6, and 1.2); MDC95%: minimal detectable change at the 95% CI. **: $p < 0.001$.

To compare the characteristics (anthropometrics, playing level, etc.) and performance variables of the biological maturity-based groups (pre-PHV vs. circum-PHV groups) and competitive standard of the players (elite vs. amateur players) two tests were used. An independent *t*-test was used when parametric assumption (normality) was confirmed and the non-parametric Mann-Whitney U test was used when the assumption of normality was not fulfilled. Effect sizes for significant pairwise comparisons were calculated using Cohen's *d* [37] and interpreted as d (0.01) = "very small", d (0.2) = "small", d (0.5) = "medium", d (0.8) = "large", d (1.2) = "very large", and d (2.0) = "huge"[38].

The relative reliability was assessed using Pearson's correlation (*r*) and intraclass correlation coefficient (ICC) between tests and retests. An ICC < 0.40 was considered as "low", between 0.40 and 0.70 as "acceptable", between 0.70 and 0.90 as "good", and > 0.90 as "excellent" [39]. Cronbach's alpha reliability coefficients (α) were used to determine the between-subjects reliability classified as "unacceptable" = < 0.5, "poor" = 0.51–0.60; "questionable" = 0.61–0.70, "acceptable" = 0.71–0.80, "good" = 0.81–0.90, and "excellent" = > 0.91 [40].

Absolute reliability was analyzed by calculating the standard error of measurement (SEM) as follows: $SEM = SD \times \sqrt{1 - ICC}$. The smallest worthwhile change (SWC) was assumed by multiplying the between-subject SD by either 0.2 ($SWC_{0.2}$), indicating the typical small effect or 0.6 ($SWC_{0.6}$), showing an alternative medium effect or 1.2 ($SWC_{1.2}$), representing an alternative large effect. The usefulness of each test was assessed by comparing the SWC score with the SEM [41]. The ability of the test to detect a change was rated as "good," "satisfactory," or "marginal" when the SEM was below, similar, or higher than the SWC, respectively. The minimal detectable change (MDC95%) of physical tests, which represent 95% confidence interval (CI) of the difference in the score between paired observations was determined as $MDC95\% = 1.96 \times SEM \times \sqrt{2}$. This indicator is interpreted as the minimal change required for a given variable so that sufficient confidence for a practically relevant change is provided [41].

The criterion-related validity was established by assessing the relationship between ICODT-BALL and the other tests (ICODT, 4 × 9-m shuttle run, 10-m, and 30-m sprint, BE-MVIC, CMJ, triple-hop-test, stork balance test and YBT CS) using Pearson's product moment correlation coefficient (*r*). The following criteria were adopted to interpret the magnitude of the correlation: "trivial" ($r < 0.1$), "small" ($0.1 \le r < 0.3$), "moderate" ($0.3 \le r < 0.5$), "large" ($0.5 \le r < 0.7$), "very large" ($0.7 \le r < 0.9$), "nearly perfect" ($0.9 \le r < 1$), and "perfect" ($r = 1$) [39]. In line with this scale, criterion validity was accepted when a "large" value (or above) was observed between the ICODT-BALL and ICODT. Coefficient of determination (R^2) was used to interpret the meaningfulness of the relationships between ICODT-BALL and other outcomes.

The discriminant validity of the ICODT-BALL was analyzed using the receiver operator characteristics (ROC) curve [42] with analyses of the area under the curve (AUC). The ROC curve analysis determined the sensitivity and specificity of a tool to evaluate the ability of the different tests to discriminate individuals with different biological maturity (pre-PHV vs. circum-PHV group) and playing level (elite vs. amateur players) levels. The cut-off value for a "good" discriminative ability was 0.70 [42]. The significance level was set at $p < 0.05$.

RESULTS

Comparison of the anthropometric characteristics and playing experience of the players

Significant differences ($p \le 0.002$) were found when the group was split by biological maturity for chronological age, predicted PHV, age at PHV, height, body mass, and body mass index (BMI), with higher values in the circum-PHV group. These two groups (pre-PHV vs. circum-PHV group) were not significantly different for experience and weekly training sessions.

Regarding the comparison between the playing levels of the players (elite vs. amateur players), significant differences ($p \le 0.047$) occurred only for chronological age, predicted PHV, age at PHV, body mass, BMI, experience, and weekly training sessions. Notably, the differences were (a) higher chronological age, predicted PHV, age at PHV, body mass, and BMI of the amateur vs. elite players ($p \le 0.036$), and (b) higher experience and weekly training sessions of the elite vs. amateur players ($p \le 0.047$). However, there were no significant difference between the two groups (elite vs. amateur players) for height. The results are reported in Table 1.

Relative and absolute reliability of the physical tests

The relative and absolute reliability outcomes of the ICODT-BALL, ICODT, 4 × 9-m shuttle run, 10-m, and 30-m sprint, BE-MVIC, CMJ, triple-hop-test, stork balance test, and YBT CS are displayed in Table 2. All of the measurements were not significantly different between the test and retest and showed a significant relationship ($r > 0.90$, $p < 0.001$) and an excellent relative reliability (ICC and $\alpha > 0.90$). The estimated Cohen's *d* effect sizes were in the range of "very small" to "small" for all test outcomes. The SEM values for all of the tests' measurements were relatively "low" (< 5%). The SEMs was less than $SWCs_{(0.2,\ 0.6,\ 1.2)}$ for all of the variables. The MDC95% limits of agreement were "small" for all of the variables.

Criterion validity of the ICODT-BALL

The correlation coefficient, confidence interval, and magnitude between the players' measurements recorded during the ICODT-BALL and their performance during the other tests (ICODT, 4 × 9-m shuttle run, 10-m, and 30-m sprint, BE-MVIC, CMJ, triple-hop-test, stork balance test and YBT CS) are summarized in Table 3. Without division by biological maturity and playing level groups, the ICODT-BALL was significantly correlated (rated between "moderate" and "large") to the ICODT, 4 × 9-m shuttle run, 10-m, and 30-m, CMJ, triple-hop-test ($p < 0.001$) and BE-MVIC ($p = 0.003$) (Table 3). A "low" correlation was found between the ICODT-BALL and stork balance test ($p = 0.059$) and the YBT CS ($p = 0.029$) (Table 3).

Analysis of common variance using the coefficient of determination (R^2) revealed that ICODT-BALL performance had shared variance with the ICODT (41.8%), 30-m (34.8%), 10-m (27.3 %), triple-hop-test (23.9 %), CMJ (21.5%), 4 × 9-m shuttle run (17.1%), BE-MVIC (13.4%), YBT CS (7.3%) and stork balance test (5.5%).

Discriminant validity of the ICODT-BALL

The ICODT-BALL performance of the players divided into biological maturity-based groups (pre-PHV vs. circum-PHV groups) and playing level (elite vs. amateur players) are summarized in Table 4. The unpaired sample *t*-test revealed that the circum-PHV group had significantly better performance during ICODT-BALL than the pre-PHV group ($p = 0.028$; amplitude = 6.4%; Cohen's $d = -0.60$) and the elite players had significantly better performance ($p < 0.001$) than the amateur players during the same test ($p < 0.001$; amplitude = 11.5%; Cohen's $d = 1.29$).

The ICODT-BALL was considered to have "moderate" discriminant validity when comparing the pre-PHV to the circum-PHV group (the AUC was 0.67 [standard error = 0.092; 95% CI: 0.54–0.78, $p = 0.062$]) (Figure 2-A) and "very good" discriminant validity when comparing the elite to the amateur players (the AUC was 0.81 [standard error = 0.060; 95% CI: 0.69–0.90, $p < 0.001$]) (Figure 2-B). The cut-off performances for discriminating between the pre-PHV and circum-PHV players was ≤ 22.97-s (sensitivity of 63.6% [95% CI = 30.8–89.1] and specificity of 64.8% [95% CI = 50.6–77.3]) (Figure 2-A), and between the elite and amateur players was > 23.21-s (sensitivity of 80% [95% CI = 61.4–92.3] and specificity of 80% [95% CI = 63.1–91.6]) (Figure 2-B). This indicates that the ICODT-BALL had "good" discriminative ability, especially when the classification of players was based on their playing level (elite vs. amateur players).

TABLE 3. Correlation between the ICODT-BALL, CoD, linear sprint, balance, strength, and power measures (n = 65).

	Mean ± SD	***r* (95% CI)**	magnitude	***p* value**
ICODT-BALL (s)	23.755 ± 2.390	-	-	-
ICODT (s)	18.163 ± 0.804	0.65 (0.48 to 0.77)	large	< 0.001
4 × 9-m shuttle run (s)	10.457 ± 0.463	0.41 (0.19 to 0.60)	moderate	< 0.001
10-m linear sprint (s)	2.194 ± 0.156	0.52 (0.32 to 0.68)	large	< 0.001
30-m linear sprint (s)	5.427 ± 0.347	0.59 (0.41 to 0.73)	large	< 0.001
BE-MVIC (kg)	56.069 ± 13.360	-0.37 (-0.56 to -0.13)	moderate	0.003
CMJ (cm)	21.052 ± 4.860	-0.46 (-0.64 to -0.25)	moderate	< 0.001
Triple-hop-test (cm)	505.015 ± 53.494	-0.49 (-0.66 to -0.28)	moderate	< 0.001
Stork balance test (s)	4.655 ± 2.746	-0.23 (-0.45 to 0.01)	small	0.059
YBT CS (s)	89.910 ± 11.670	-0.27 (-0.48 to -0.03)	small	0.029

BE-MVIC: back extension maximum voluntary isometric contraction; YBT CS: Y balance test composite score; ICODT: Illinois change of direction speed test; CMJ: countermovement jump; SD: standard deviation; 95% CI: 95% confidence interval; *r*: Pearson's *r*-values.

TABLE 4. Comparison of ICODT-BALL measures between young soccer players (pre-PHV vs. circum-PHV group) and (elite vs. amateur players).

	Mean ± SD	**Mean difference ± SD (95% CI)**	**Δ (%)**	***p* value**	**Cohen's d (95% CI) magnitude**
All subjects divided into maturity-based groups					
Pre-PHV (n = 54)	24.248 ± 2.535	1.458 ± 0.615 (0.176 to 2.739)	6.4	0.028	-0.60 (-1.259 to 0.054) medium
Circum-PHV (n = 11)	22.790 ± 1.690				
All subjects divided into expertise level of the players					
Elite players (n = 35)	22.555 ± 0.929	-2.599 ± 0.535 (-3.685 to -1.514)	11.5	< 0.001	1.29 (0.752 to 1.824) very large
Amateur players (n = 30)	25.154 ± 2.799				

PHV: peak height velocity; ICODT-BALL: Illinois change-of-direction test with ball dribbling speed; SD: standard deviation; 95% CI: 95% confidence interval;

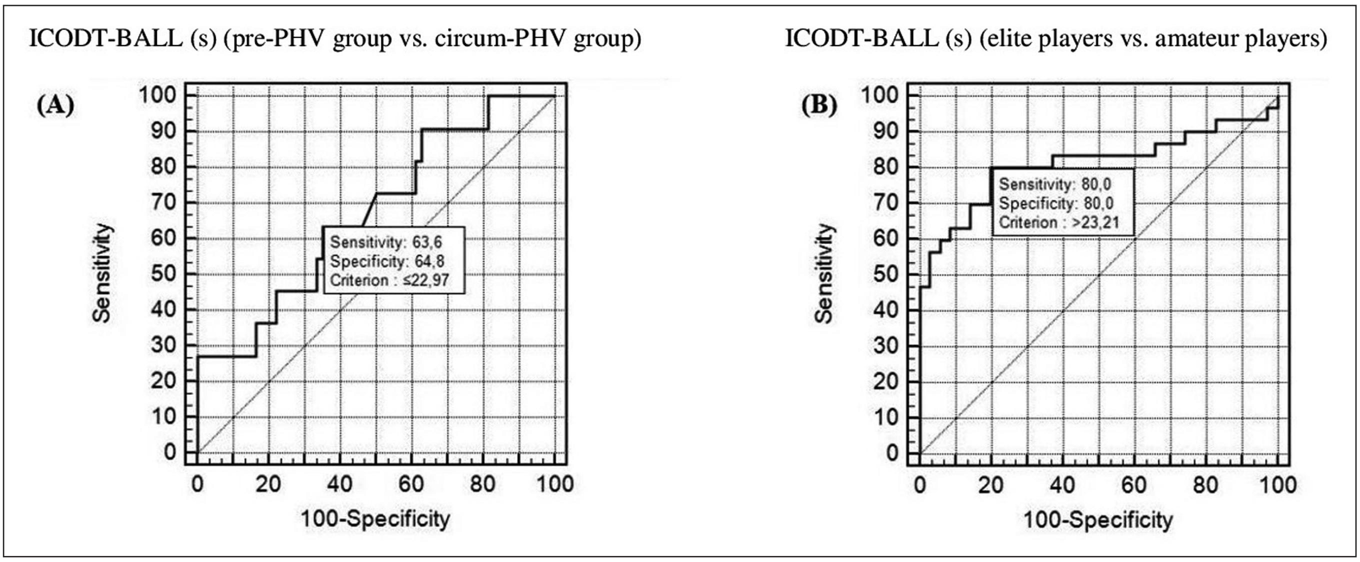

FIG. 2. Receiver operating characteristics (ROC) curves for the ICODT-BALL performance of soccer players. A: Pre-PHV group vs. circum-PHV group. B: Elite players vs. amateur players.

DISCUSSION

This study aimed i) to examine the reliability and validity of the modified Illinois CoD test with ball dribbling speed, ii) to establish its relationship with CoD, and linear sprint speed, muscle strength, power, and balance in young soccer players of different biological maturity status and playing levels. The main findings of this study demonstrated: (a) that the ICODT-BALL showed a high test-retest reliability; (b) large association with the CoD and sprint tests; (c) moderate association with the isometric strength and power measure; (d) small correlation with the dynamic balance performance; (e) very good discriminatory capability between young soccer players of different playing level; and (f) moderate discriminatory capability between players of different biological maturity level.

The results of the present study showed that the ICODT-BALL had a high level of reliability between the test and retest (ICC = 0.993) for young soccer players. Similar reliability (ICC = 0.985) was demonstrated in 11- to 12-year-old soccer players [28]. The ICC found in the present study was higher than the one (ICC = 0.84) observed in the same test for international mature para-soccer players [27]. In addition, the MDC95% was calculated to indicate the necessary variations in a given variable to detect changes larger than the measurement error [41, 43]. In the present study, MDC95% value for ICODT-BALL was 0.058 s. Therefore, to have a real improvement detected in the players' scores, the player should score above this value. This study reliability value is similar with those obtained in slalom dribbling test [15, 17] and higher than the zig-zag with ball test [12].

The reliability of a test depends on a number of factors such as the number of participants, number of performed trials, participant's skill level, and homogeneity of the sample [41]. The current study included 65 young male soccer players from an elite soccer club. This number corresponded to the number of players (n > 50) from previous studies with similar excellent relative reliability [15, 17, 18]. Good reliability has been reported in studies with a reduced number of players (n < 20) [12, 16]. In this study, we observed good ICODT-BALL reliability which can be explained by the participants' test familiarization, and the number of trials (i.e., 3 trials) performed during each session (i.e., test and retest). In addition, the players were recruited from a homogeneous group, were highly motivated, from similar socio-economic status and had the same daily school and soccer team-training schedules. Finally, the experiments were carried out in almost the same environmental conditions, and at the same time-of-day.

From previous studies, investigating the dribbling speed tests of players of different biological maturity status, early maturers tended to perform better in these tests [44, 45]. In the present study, a moderate, significant difference ($p = 0.028$; amplitude = 6.4%; Cohen's $d = -0.60$) was noted between circum-PHV and pre-PHV groups in the ICODT-BALL performance. Similar results were reported by Malina et al. [11] who found that biologically maturer boys perform slightly better in the dribbling test than less mature boys. However, Vandendriessche et al. [14] reported that the dribbling speed test did not distinguish more mature from later maturing players in both age groups. This result can been reviewed based on the methodological differences in protocol testing. The distance used between the cones ranged between 1- and 2.2-m to measure slalom rather than CoD speed. In addition, a single observer measured the time from start to finish with a handheld stopwatch [44].

Dribbling speed is more sensitive than other specific soccer test performance for detecting differences in players' level and can distinguish future professionals from amateur players as early as 12 years of age [11, 15, 16, 19, 22, 44, 46]. The results of this study found significantly higher ICODT-BALL performance in elite compared to amateur soccer players ($p < 0.001$; amplitude = 11.5%; Cohen's $d = 1.29$), although amateur players have shown significantly advanced biological maturity compared to their elite counterparts (-1.5 ± 1.12 vs -2.2 ± 0.61 years from PHV, respectively) (Table 1). Similar findings have been reported by Meylan et al. [45] who showed that elite players scored better in dribbling speed than amateur players, irrespective of their maturity status. Of interest, in the current study, the differential experience playing football ($p = 0.047$), weekly training volume ($p < 0.001$) and body mass ($p = 0.005$) between elite and amateur players (Table 1) may have contributed to the observed differences in ICODT-BALL performance between both groups. Better technical skills may also be determinants of success among elite compared to amateur players [15]. Therefore, the main reason for this difference is that technical skills influenced dribbling performance [6, 47]. Indeed, players not adequately skilled (i.e., amateur players) and unable to maintain ball control may compromise the exercise intensity of the ICODT-BALL. Faster players are able to provide dribbling technique traveling through a shorter path in a more efficient and economical style. This is accomplished through shorter and faster steps and an augmented football contacts cadence [6].

Pearson's correlation analysis in the present study revealed a "large" relationship between the ICODT-BALL and ICODT ($r = 0.65$, $p < 0.001$; with 41.8% shared variance). Corroborating the findings of Fiorilli et al. [25] who demonstrated that the ICODT-BALL was highly correlated with the ICODT in 15-year-old elite soccer players. In addition, Reina et al. [27] obtained a "large" correlation between the ICODT-BALL and ICODT in 19-year-old soccer players having 10 years' experience playing football. Mujika et al. [3] reported that 15-m slalom with a ball test was shown to be "strongly" related to 15-m CoD test. In view of the above considerations, the use of the ball during CoD tests tends to make the test more specific and creates an environment in which the test is performed less reliable and predictable than in a real soccer game [25]. The coefficients of determination showed that the ICODT-BALL and ICODT shared 41.8% common variance in young soccer players, suggesting that approximately 42% of the factors that contribute to performance success with ICODT-BALL also contribute to ICODT performance enhancement [1], these findings support the criterion validity of ICODT-BALL among young soccer players. Therefore, the ICODT-BALL is recommended more than CoD tests for talent identification and development [6, 12, 46] and for soccer-specific profiling [9, 12, 48]. Apparently, players with excellent dribbling speed ability at a younger age are more likely to be selected to play as midfielders [49].

Results showed a "large" relationship between ICODT-BALL and sprint tests (10- and 30-m sprint) ($r = 0.52$ and $r = 0.59$, $p < 0.001$, with 27.3% and 34.8% shared variance, respectively). Similarly, Mujika et al. [3] demonstrated a significant relationship between sprint 15-m and ball 15-m performance in professional soccer players. The shuttle dribble test in a study of Huijgen et al. [7] showed a "moderate" relationship between sprinting and dribbling. Otherwise, the correlation between the slalom dribble test and sprint test was "low" [7]. Moreover, the ICODT-BALL measures the more soccer-specific action of deceiving opponents by dribbling speed with multiple CoD.

Without division by biological maturity and playing level groups, this study showed a "moderate" relationship between the ICODT-BALL and BE-MVIC ($r = -0.37$, $p = 0.003$; with 13.4% shared variance). These findings support the relevance of BE-MVIC for ICODT-BALL signifying back extensor strength training as a relevant component to optimize soccer players' ability to slalom and quickly CoD while ball dribbling [34, 35]. Corroborating the previous findings [50] highlighting the importance of trunk stability during the braking and propulsion phases of the CoD tasks in adult soccer players. In contrast, Hammami et al. [51] found that back extensor strength did not influence CoD performance in elite male handball players aged between 14 and 18 years old. This might be explained by the ball control in soccer players that requires a forward leaning of the trunk and stabilization when they slalom or CoD through the markers [6, 25, 34, 50, 52].

The current study revealed a "moderate" relationship between the ICODT-BALL and CMJ and triple-hop-test ($r = -0.46$ and $r = -0.49$, $p < 0.001$, with 21.5% and 23.9% shared variance, respectively), demonstrating that vertical and horizontal jumping may considerably influence the CoD ability with the ball during the deceleration-acceleration transition phase in elite soccer players. This study's results seem to support the findings of previous literature highlighting the "moderate" to "large" correlations between the CoD and horizontal jump (five-jump test) in young soccer players [1, 53]. This is in disagreement with previously published studies wherein "trivial" to "small" correlations between CoD tests and vertical jump were observed in amateur and professional soccer players [4, 13]. In addition to the differences in the methodology of CoD testing applied, as well as and the age of the players in the different studies, we believe that this inconsistency is due to the higher complexity of the CoD with the ball used in this study compared with a more simple ability like CoD without the ball in others studies. One of the possible reasons for these findings is that dribbling speed with slalom and CoD includes dynamic movements requiring high muscle power [30].

This study demonstrated "low" associations between the ICODT-BALL and balance measurements, contradicting the "moderate" to "large" correlations found between CoD without the ball and balance performance in male soccer players [54]. Indeed, CoD necessitate good dynamic balance [28]. In contrast, balance during youth is not fully mature [55]. Another explanation for the weaker relationship between the ICODT-BALL and balance tests is that CoD with the ball may be considered as a technical variable probably more dependent on coordinative aspects of performance [4].

This study has some limitations that have to be addressed. First, the ability to CoD in response to a stimulus that cannot be pre-planned [4, 52] was not assessed in this study. Therefore, future investigations considering the reaction in response to the movement of an opposing player (e.g., one-versus-one situations against the same opponent) are needed [25]. Second, future research may consider measuring the dribble deficit to isolate the dribbling speed from sprinting speed across linear and CoD paths [22]. Third, it has to be emphasized that correlations do not establish cause and effect relations [1], but simply show the magnitude of the interrelation between two variables. In other words, a significant relationship between linear sprint, strength, power and the ICODT-BALL measures does not establish cause and effect relations. Therefore, the relationships between variables reported in this study should be interpreted with caution. Future studies should also adopt multiple regression analysis to estimate the best predictor model of the ICODT-BALL.

The ICODT-BALL is not time consuming, requires minimal familiarization, and is inexpensive and simple to conduct in limited spaces with sport-specific movements for young players. This soccer specific test can also be used by regional school centers and local clubs to rank young players. Furthermore, the ICODT-BALL is a valid test to evaluate the ability to quickly CoD while ball dribbling on an artificial surface. However, Andersson et al. [56] suggest that professional players who have little experience on turf found it more difficult to CoD on artificial turf than on natural grass. Whether the players' ability to CoD with the ball changes because of the surface conditions certainly warrants further investigation. Future research should be considered assessing the ICODT-BALL in both post-PHV and adult male soccer players to differentiate technical abilities among players' roles and regarding which position shows the best dribbling speed performance. Additional research is required to investigate the ICODT-BALL in other surfaces (e.g., natural grass) and other team sports (e.g., rugby and basketball).

CONCLUSIONS

The ICODT-BALL has shown excellent reliability and validity in young soccer players. Further, the ICODT-BALL can effectively discriminate either young soccer players with different biological maturity or those with different playing levels independently of maturity status. Moreover, as CoD ability, sprint time, muscle strength and power, and dynamic balance are significantly associated with ICODT-BALL, it is recommended that all-out exercises and dynamic balance be considered to develop the CoD with ball dribbling speed of young soccer players. Therefore, coaches can rely on the ICODT-BALL to routinely monitor player's adaptations to the training programs, to identify talent soccer players and to discriminate midfielders from the other positions. This could help to equalize the chances for soccer players of different biological maturity and being provided with the necessary opportunities to attain a professional career in soccer.

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Conflicts of interest

This research did not received any financial support. All authors read and approved the final version of the manuscript. The authors declare no conflict of interest.

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