DETERMINING THE RELIABILITY AND USABILITY OF CHANGE OF DIRECTION SPEED TESTS IN ADOLESCENT FEMALE SOCCER PLAYERS: A SYSTEMATIC REVIEW

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ABSTRACT

INTRODUCTION: This review aimed 1) to describe the most common tests used for assessing change of direction (COD) performance; 2) to detail the reliability of current COD tests; 3) to provide an overview of current intervention strategies used to improve COD performance in adolescent female soccer players.

EVIDENCE ACQUISITION: A computerized search was conducted in the PubMed, Cochrane Plus and Web of Science (from 1995 to January 2020) for English and Spanish language and peer-reviewed investigations.

EVIDENCE SYNTHESIS: A total of 221 studies were identified, with only 16 meeting the specific search criteria. The main findings were that eleven different tests have been used to assess COD performance with intraclass correlation coefficient and coefficient of variation values between 0.72-0.99 and 1-10.6%, respectively. The number of CODs performed during each test ranged from 1 to 9 within a range of 45º to 180º and with a duration <5 s, 5-9 s and >10 s.

CONCLUSIONS: Findings indicate that the reliability of the COD tests seems to depend on: the equipment used, the surface tested on and the technical level of the soccer player. These results should be interpreted with caution as they may be influenced by the period of growth and maturation, the playing position of the player and the period of the soccer season. Finally, strength and power drills could be considered as appropriate to improve COD performance.

Key Words: Reliability, change of direction, training, youth, football

Introduction

Soccer has become increasingly popular among females worldwide and according to the Women´s Football Survey of the Fédération Internationale de Football Association (FIFA), there were more than 30 million registered women soccer players in 2014. [1] At youth standards, popularity is increasing at a rapid rate. There has been almost a 4% increase in participation in the last 5 years in youth female soccer players. [2] In 2017, over 960,000 youth female were registered in Europe, [2] which represents a huge increase in the popularity of the female game.

Historically, agility has been defined as the ability to change direction rapidly, without losing balance using a combination of strength, power and neuromuscular coordination.[3, 4] More recently, this definition has been questioned, with some suggesting that it does not really reflect the nature of true agility in a sports context. Consequently, new definitions have recognised the reactive nature of agility. Sheppard and Young[5] suggest that agility must also encompass an athlete´s perceptual and decision-making skills. However, given that these types of skills typically occur in competition, they can be extremely challenging to measure objectively. Thus, measuring performance during pre-planned movements (e.g., 5-0-5, T-test, pro-agility), may be better described as COD speed and more appropriate for practitioners to monitor reliably.[6]

The COD can be defined as the ability to decelerate, reverse or change movement direction and accelerate again and is influenced by a number of physical and technical attributes such as straight, sprinting, speed/acceleration, eccentric and concentric strength, power and reactive strength.[7, 8] In team sports, COD manoeuvres (e.g., side-step cutting) are frequently performed and can be considered as one of the most important physical qualities to develop, given the associated multi-directional nature of movement patterns seen in team sports.[9, 10] Specifically, COD ability is one of the most important fitness components in soccer[11, 12] and previous literature has highlighted that players can change direction between 1200-1400 times in a match.[13] Given the prevalence of COD in soccer, its improvement has become an important focus of training programmes.[14, 15]

It has been shown that fitness testing is fundamental for sport performance optimization.[10, 15, 16] In soccer, there is a strong interest in developing and validating COD field tests like the T-test,[17] the Illinois agility test (IAT)[14] or the sprint 9-3-6-3-8 m with 180º turns (S180º),[17] that could allow researchers, coaches and practitioners to effectively measure COD performance in soccer players.

Similar motion characteristics between the sexes at youth standards have been found.[18, 19] Buchheit et al.[20] established that the duration of sprints during a match in adolescent male soccer players is less 3 s. Typical COD tests do replicate the movement patterns of soccer; however, time to completion can range from 7-18 s. Thus, this value might not represent a sport-specific test for adolescent soccer players. In addition, these tests might be overly strenuous for adolescent players, which might also affect the validity and/or reliability of the test.[15] For these reasons, it is necessary to examine the most frequently used COD tests in female adolescent soccer players in order to provide a safe, effective and ecologically valid assessment of COD performance.

Appropriate and reliable tests are also a strong consideration for test selection. Reliability can be defined as the consistency or reproducibility of test results when carried out on more than one occasion.[21] Many influencing factors like test type, physical condition, test duration or inter-trial time are susceptible to the reliability of a test.[22, 23] Testing and monitoring players' COD performance is crucial and can have multiple purposes such as comparing between players, controlling training efficacy, talent identification and monitoring long-term player development; however, test reliability must first be considered before being informed by data. Issues surrounding named above the reliability are important to determine the integrity of a test. For the practitioner to provide meaningful results to female adolescent soccer players and the coaching staff, it is their prerogative to use testing methods regarded as possessing high levels of reliability. Furthermore, providing details about factors that may impact COD performance and how these can be improved with different intervention strategies will guide practitioners to appropriate training design and prescription.

Therefore, the aims of this systematic review were to: (1) describe the most common tests used for assessing COD performance in female adolescent soccer players, (2) detail the reliability of current COD tests, (3) provide an overview of current intervention strategies used to improve COD performance in female adolescent soccer players.

Evidence acquisition

Search strategy

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guidelines (24, 25). A systematic search was undertaken to observe quality in COD tests in adolescent female soccer players within the scientific literature. A computerized search was performed in PubMed, Cochrane Plus and Web of Science (up to January 2020).

A systematic search of three electronic databases (PubMed, Cochrane Plus and Web of Science) was conducted in January 2019 and included all papers until this time. The search period ranged from 1995 to 2020. The keywords used to identify the articles and restrict the population investigated in this review were: “young”, “youth”, “adolescent”, “adolescence”, “female”, “children” and “child”, which were combined with “reliability”, “repeatability”, “smallest worthwhile change”, “reproducibility”, “minimal detectable change", "agility", "unanticipated", "cutting", "manoeuvre", "change of direction", "side-step", "side-cutting", "training", "intervention", "test", "testing", "football" and "soccer". Unpublished data or unpublished full-text reports were not included in the analysis, as well as those not published in English or Spanish.

Inclusion and exclusion criteria

Although no restrictions were made on the study design, eligibility criteria for study inclusion consisted of one of the following: (1) tests comparing results on two separate occasions under similar conditions (test-retest study design) to determine reliability, (2) at least one COD in tests, (3) tests examining factors that may affect COD performance, and/or (4) studies examining the effect of an intervention on COD performance. The principal author coded the studies according to the selection criteria. Moreover, studies were included if they: (1) were published in peer-reviewed journals, (2) used a COD test without a ball, (3) included female adolescents (using the World Health Organization´s definition of adolescent as the period of life between 10 and 19 years),[26] and (4) included soccer players. Unpublished data and studies in new-borns or infants, adults or seniors and males were subsequently excluded.

Quality assessment

Eligible studies were assessed for methodological quality using two different tools. For cross-sectional studies, the "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies" proposed by the National Hearts, Lung and Blood Institute (NIH National Heart, Lung, and Blood Institute, website) was used. This rates validity on a scale of 1-14 according to the following criteria: 1) Was the research question or objective in this paper clearly stated? 2) Was the study population clearly specified and defined? 3) Was the participation rate of eligible persons at least 50%? 4) Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants? 5) Was a sample size justification, power description, or variance and effect estimates provided? 6) For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured? 7) Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed? 8) For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome? 9) Were the exposure measures (independent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? 10) Was the exposure(s) assessed more than once over time? 11) Were the outcome measures (dependent variables) clearly defined, valid, reliable, and implemented consistently across all study participants? 12) Were the outcome assessors blinded to the exposure status of participants? 13) Was loss to follow-up after baseline 20% or less? 14) Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure(s) and outcome(s)? The scale used to assess studies interventions was adopted from a modified quality-assessment screening scoring system[8]. This scale includes a 10-item scale (range 0–20) designed for rating the methodological quality of the studies. The items are as follows: 1) Inclusion criteria were clearly stated. 2) Subjects were randomly allocated to groups. 3) Intervention was clearly defined. 4) Groups were tested for similarity at baseline. 5) A control group was used. 6) Outcome variables were clearly defined. 7) Assessments were practically useful. 8) Duration of intervention was practically useful. 9) Between-group statistical analysis was appropriate. 10) Point measures of variability.

Table I and II near here

Statistical analysis

The relative change in performance outcomes if mean and standard deviation were available was calculated by equation 1.

Equation 1: $((Mean_{post} – Mean_{pre}) / Mean_{pre}) \times 100$

$Mean_{pre}$ represents the baseline value, $Mean_{post}$ is the postintervention value.

Effect sizes (ES) were calculated according to Cohen (1988) and represent the difference between experimental and control condition means divided by the baseline standard deviation. This method permits the determination of the magnitude of the differences or the changes between the groups or experimental conditions for each study that provided absolute mean data and standard deviations. Magnitudes of change were classified as follow: ES<0.2 was defined as trivial; 0.2-0.6 was defined as small; 0.6-1.2 was defined as moderate; 1.2-2.0 was defined as large; >2.0 was defined as very large; and >4.0 was defined as extremely large.

Evidence synthesis

Literature search

The initial search procedure yielded 221 records through the electronic databases. After removing duplicates and adding additional records identified through other sources, 185 publications were retained for the article selection process. Title and abstract selection excluded 44 articles. The remaining 35 records were further examined using the specified inclusion/exclusion criteria, and 19 records were subsequently rejected. Finally, 16 studies were included in the final analysis after performing the appropriate quality assessment. A summary of the article selection process can be found in Figure 1.

Figure 1 near here

Methodological quality of studies

Seven cross-sectional studies[16,27-32] observed different factors affecting COD performance, yielding a mean score of 7/14 (range 6-7). Some of the criteria assessed were not applicable due to the type of variables measured (exposures that did not vary by amount or level, exposures measured only once over time or blinding assessors). Furthermore, some points were not reported in most of the studies, such as the rate of eligible persons or the drop-outs after baseline. Considering these difficulties, the highest achievable score was 10/14. A list of Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies scores can be found in Table I.

Nine experimental studies[33-37] examined the effects of an intervention on COD ability performance, yielding a mean score of 16/20 (range 15-19). Most studies provided detailed and repeatable descriptions of methods, clearly defined outcome variables and used appropriate statistical analyses. Some studies did not include inclusion/exclusion criteria and/or a control group, nor test-retest reliability of the methods used. Scores of experimental studies can be observed in Table II.

Cross-sectional studies

A total of 7 studies were of cross-sectional nature.[16,27-32] In total, 885 participants (mean 113, maximum 213, minimum 36) were studied. Participants' age ranged from 9 to 17 years old (median 13 years), and their playing ability varied from recreational to professional. Five studies included only females and 3 included both, males and females (Table III).

Experimental studies

A total of 9 studies were of experimental nature (Table IV).[33-41] In total, 349 participants (median 37, maximum 62, minimum 12) were studied. Participants' age ranged from 11 to 17 years old (median 14 years), and playing ability varied from recreational to professional. All studies included only females.

Study findings

ICC and coefficient of variation (CV) values ranged from 0.72 to 0.99 and 1% to 10.6%, respectively for COD tests in cross-sectional studies (Table III). ICC values for COD tests showed in experimental studies ranged from 0.80 to 0.98 (Table IV). Three experimental studies[37, 38, 41] showed CV value (1.5-5.3%) for COD tests. The average training intervention period lasted for 9 weeks (range 6-12), except for one study[39] performed a strength intervention one day per week during 3 seasons. A neuromuscular training program has been performed by 4 studies,[33, 34, 36, 38] 2 studies implemented a strength training program[39, 41] and three studies performed different training program such us, high intensity interval training program (HITT)[37], small sided game (SSG)[40] and speed.[30] Four studies have a control and experimental group[33,35,36,38,41] and 5 studies have experimental group[34,36,37,39,40]. Improvements in time to complete the COD test ranged from -2%; ES= -0.15 (neuromuscular training program) to -8.4%; ES = -1.45 (High intensity interval training program (HIIT).

Table III and IV near here

In Table V, a total of 11 different COD tests were used in female adolescent soccer players. Two methods were used to quantify the COD times. Electronic timing gates (ET) were used in 75% of the studies, 10% used a handheld stopwatch (HHS). Mainly, 2 trials were performed in each study. Diverse surfaces were used to performed COD tests like rubber/parquet indoor surface (25%) or natural/synthetic surface (50%). Seven studies did a previous familiarization test at least 1 week before.[16, 28, 29, 37, 38, 40, 41] Four, two and five tests had a short (<5 s), middle (5-9 s) and large (>10 s) duration, respectively. The number of CODs was between 1 and 9 and the angle of directional change was within a range of 45º to 180º.

Table V near here

Discussion

The purpose of this systematic review was threefold. Firstly, describe the most common tests used for assessing COD performance. Secondly, detail the reliability of current COD tests. Thirdly, provide an overview of current intervention strategies used to improve COD performance in female adolescent soccer players. Eleven COD tests within the searched scientific literature were retrieved. The reliability of the COD tests was dependent on differing factors such as the instrument used, the surface and/or the playing level of the soccer player. Finally, it is not clear what kind of training program is more beneficial to improve COD in this population, although some programs which include specific speed, COD speed or interval training have shown positive results.

Methodological quality

The mean scores of the studies when using the "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies" and the modified quality assessment were 70% (range 60-80%) and 60% (range 50-80%), respectively. All the studies showed included high scores. Some studies showed a lack of detailed description of the screening tool, which did not allow test replication. For example, information on the type of surface used[34, 37] and the number of trials performed29 were not reported, as well as a lack of previous familiarization27,[30, 32-36] and reliability of the screening tool.[27, 28, 30, 40] Therefore, practitioners should be mindful that methods sections should be written so that processes are fully repeatable should practitioners want to it. Consequently, specific detail of the test, number of trials, rest periods taken and equipment used should be clearly described for methodological transparency.

Factors affecting tests reliability

The complexity of each test can be characterized by the time to complete the test, the number of COD, the total distance covered and/or the COD angles.[9] Despite such different characteristics, it seems that reliability is similar across all the reported COD tests. Reliability may be quantified using the CV (i.e., absolute) and ICC (i.e., relative). It is worth noting to use both coefficients because of it is highly plausible that one of such coefficients may report strong reliability while the other shows unacceptable variability.[42] When they are considered together, average reliability will be considered "good" if ICC > 0.67 and CV <10%, "moderate" if ICC < 0.67 or CV >10% or "poor" if ICC < 0.67 and CV > 10%.[42] For instance, Tables I and II illustrate the ICC and CV values for COD tests which range from 0.72 to 0.99 and from 1% to 10.6%, respectively. Two studies reported both coefficients,[16, 29] while five studies reported ICC values[33-36] and only one study showed the CV value.[37] Pardos-Mainer et al., in several studies[16, 38, 41], reported good reliability (ICC = 0.75-0.93) and small variability (CV = 1-5.3%) for both the 180ºCOD and the V-cut tests. Meylan et al.[29] showed good reliability (ICC = 0.72-0.94) and acceptable variability (CV = 1.6-10.6%) for COD task, though more variation was observed in this test. Between-COD tests variations' may be due to subjects' participation in a multi-sport activity in the Meylan's study. Of all COD tests, the 180ºCOD had the greatest reliability (ICC = 0.80-0.82, CV = 1-1.7%). However, the tendency with those studies included in current review when measuring COD performance seems to be to report intraday reliability (ICC), resulting in a flawed measure of reliability as it assesses "rank-order consistency". In team sports, like soccer, players represent a homogenous sample and it means that very small changes in performance can result in player´s rank-order, changing the next test performance. When it happens, the ICC value decreases and gives a false impression of reduced reliability. Therefore, apart from reporting ICC values, measures of variability (CV) for COD tests would need to be calculated by practitioners.

Time measurement devices included ET[16, 27-29, 33, 35, 38, 41] and HHS.[31, 34] Two studies[31, 34] used HHS tools and reported a high ICC (0.89-0.90) whereas the rest of studies used ET and also showed a high ICC (0.72-0.99). Hetzler et al.[43] compared those times obtained by HHS with ET during a 200 m sprint in trained runners (8 males, 10 females). It was concluded that on the basis of the absolute error between HHS and ET, when greater precision is required, ET is more reliable method than HHS because the absolute error if it is less. Therefore, it is advisable to use ET to record COD times.

It is fundamental to understand the normal growth and maturation process of female soccer players for the systematic evaluation of the potential effects of regular physical activity.[44] Youth soccer, like many sports, is organized into annual age groups according to chronological age. Unfortunately, players can have an advantage or disadvantage when performing tests due to their maturity status and relative age (born earlier or later in the year),[45] as chronological age and biological maturity rarely progress at the same rate.[45-47] As such, these variables should be included to better understand either those changes reported in adolescents or a greater performance achieved in some players. Furthermore, basic improvements in one physical component (e.g., speed) during the early stages of maturation and growth may enhance performance in another one (e.g., COD speed)[47, 48] However, the majority of research studies have not reported the maturity status of adolescent soccer players; there are only six studies that have taken this into account.[16, 29, 37-39, 41] These studies concluded that maturity should be taken into account when interpreting explosive and COD performance of adolescent female soccer players. Thus, the disruption of motor coordination, which is usually observed before peak height velocity,[49,50] might be a consideration in terms of the reliability of physical performance measures. Test familiarization is an important point to provide an accurate assessment of reliability.[21, 51, 52] In the current review, seven studies reported a familiarization period before testing with high ICC values (0.75-0.99).[16, 28, 29, 37-39, 41] On the other hand, the rest of studies did not take this into consideration; however, ICC values were also high (0.72-0.98). Thereby, there is a lack of information regarding the procedures undertaken during the familiarization period for reliability establishment in COD testing, specifically concerning adolescent female soccer players of the studies. Given the aim is to reduce the risk of intra-participant variability, it is suggested that all players conduct familiarization sessions prior to data collection, even if they have performed the test protocols on multiple occasions.

In relation with the type of surface, both artificial turf and rubber/parquet indoor surface have shown similar high ICC values (>0.70).[16, 29, 31, 33, 35, 36] Artificial turf is developed to improve performance, provide more natural field and grass characteristics and reduce injuries.[53] So that, artificial turf surface characteristics are more related with soccer´s demands than rubber or parquet indoor. Moreover, the changes in surface characteristics may affect kinetic patterns of players, potentially perturbing their technical performance of skill specific activities during competition.[54] Hence, it seems necessary to performance COD tests on artificial turf to reflect accurately how quickly players can actually change of direction.

Finally, some studies have shown an improvement in COD performance as the season progressed,[55, 56] attributing these increases to the training and match play. In addition, COD performance also showed significant decreases during the off-season period.[55, 57]

These findings may indicate that soccer players are less fit at the beginning of the season which could affect the reliability values. Therefore, any changes in performance throughout the season should be accompanied by further data analysis. The smallest worthwhile change can be calculated by multiplying the standard deviation by 0.2[58] and if such values are used in conjunction with absolute reliability data such as the CV or standard error of the measurement, this will enable practitioners to distinguish between which changes are 'real' and changes inside the error of the test.[58]

Characteristics of different COD speed tests

Table III shows the COD tests included in this review. The tests aiming to assess COD can be grouped according to the time to complete the test and the number and type of COD involved.[9]

The duration and intensity of the COD tests are determined by the relative contribution of the energy system involved in performance.[9] The anaerobic energy system uses phosphocreatine for the first 5-10 s of exercise.[59, 60] In this regard, the pro-agility test, 180ºCOD, 5-0-5 test and the 15 m agility run test last less than 5 s. The rest of the COD tests last approximately 5-9 s or > 10 s; from then, the aerobic system starts releasing energy.[59] Although the tests with duration of more than 5 s might be chosen in relation to the energetic system used in soccer, the selection of a COD test should be based on the movement patterns and requirements presented in soccer rather than in the energetic system used. Given previous research has highlighted that soccer players can change direction every 2-4 s,[13] it seems prudent to suggest that COD tests should err on the side of shorter durations.

The number of COD varies among tests, from 1 to 9. Certain tests (pro-agility test, 180º COD, 5-0-5 test, agility test, 15 m agility run) have 1, 2 or 3 directional changes, while others like the MIT includes 9 COD. Barnes et al.[61] reported that in team sports, players are mostly subjected to sharp COD (e.g., 180º turn) during sprints of 5 m, involving only one COD. As a consequence, tests including a COD with large angle changes could be considered the most appropriate. This is further supported in recent research from Dos'Santos et al.[62] who highlighted a trade-off between velocity and the angle when changing direction. It was suggested that angles < 45° require minimal braking, which enables velocity to be maintained. Thus, in order to truly test the transition from braking to propulsive force actions during COD tests, larger COD angles might be a strong consideration for test selection.[9]

The sharp 90º and 135º COD require the players to adapt a sideways learning posture in order to apply enough lateral force to the ground to successfully change direction at high speed.[63] Players are also likely to require adjustments to the stride pattern when decelerating and accelerating around each stick.[63] In the current review, 8 studies (16, 29-32, 35, 38, 41) indicated angle of directional change within a range of 45 to 180º. It is important to acknowledge that the majority of COD-runs in soccer matches occur within a range of 0 to 90º (64). Therefore, COD tests require > 90º angles which will need pre-test familiarisation to improve reliability values.

Training

Nine studies investigated training influences on COD. Five studies[34, 35, 37, 39, 41] have reported improvements in COD performance after different training programs, two studies reported a decline in COD performance[36, 38] and another one did not report any change.[33] It is well known that strength and power development may have a positive impact on COD performance.[65] For this reason, training programs should focus on working strength and power development. Three studies[34, 36, 38] investigated the effects of a neuromuscular training program on the 180ºCOD, the V-cut test, the MIT and the T-test. Theses training programs included core stability, balance, lower-limb strength and flexibility exercises. The only difference between them was that two studies used the program as a warm up (15 min; 11 weeks; 2 days per week),[36] while the other used to program as main sessions (90-120 min; 6 weeks; 3 days per week).[34] The warm up training protocol did not improve the MIT performance (0.4%; ES = 0.08) while the control group that did not perform the training program, improved such performance (-1.1%; ES = -0.26).[36] In relation with these results, Pardos-Mainer et al. neither showed improvements in the 180ºCOD (0-4%; ES = -0.01; -0.59).[38] This could indicate that the neuromuscular program used like a warm up did not provide sufficient stimulus to improve COD performance. In contrast, Noyes et al.[34] found different results in the T-test duration with a neuromuscular training protocol (-6.14%; ES = 0.43). This may be due to different factors like duration, frequency and the number of training sessions per week.

Vescovi et al.[33] investigated the effects of 12 weeks of 3 days per week of the Prevent Injury Enhance Performance program in the MIT and PAT tests. They observed a decline on performance in both the experimental and the control group. Similar results were found by Lindblom et al.[36] In this regard, while the control group improved their performance, the performance of the experimental group declined. Due to these reasons, we hypothesize that these may be due to intervention programs where warm-ups were performed regularly prior to scheduled practices and has a short duration of 15-20 min.

Mathisen et al.,[35] Pardos-Mainer et al.[41] and Wright et al.[37, 39] investigated the effects of speed, agility, strength and interval training with the agility test, the 180ºCOD, the V-cut test and the MTT, respectively and all reported significant improvements. The female players in the study of Mathisen et al.[35] performed speed training for 8 weeks and reported a significant improvement in the agility test (-5.2%; ES = -1.38) compared with the control group (-1.1%; ES = -0.26). Pardos-Mainer et al.[41] performed a CSPT in 36 adolescent female soccer players. They observed improvement in the 180ºCOD (-7; -2%; ES = -0.52; -0.15) and the V-cut test (-2.4%; ES = -0.58) after 8 weeks. Against, the control group did not show positive results (-2;4%; ES = -0.28;0.23). Wright et al.[37] also reported a significant improvement in the MTT duration (-8.37%; ES = -1.45) after 8 weeks of HIIT, concretely in after-PHV players. In other study, the same author showed positive results after a strength training program in 180ºCOD (-1.9; -8.3%; ES = -2.09; -0.45) during 3 years one day per week.[39] Both studies had not a control group. According to these results and previously commented, it seems to be that strength and power drills have a positive impact on COD performance.

Limitations of the present review and directions for future research

This systematic review provides some practical guidelines and considerations to be used when performing COD ability tests in female adolescent soccer players; however, there are some significant limitations that require acknowledgement.

The present review is focused in COD speed and not in agility because some scientist evidences show that many true agility tests are not actually reliable.[66] Furthermore, the maturational status, the menstrual cycle, the time of the day, the training block, the period of the season and the playing position of the participants was not always reported. In relation with menstrual cycle, some studies have observed the effects of the phase of the menstrual cycle on performance,[67, 68] and the findings in the literature are equivocal. There have been no studies of this review examining the impact of the menstrual cycle phase on COD performance. Therefore, this factor would be beneficial to observe to aid the understanding of whether the menstrual cycle phase significantly effects on COD performance; thus, affecting the reliability values. Then, further research should be done to evaluate COD in each soccer playing position with their specified test and the effects of the phase of the menstrual cycle on COD performance. In addition, prospective studies in adolescent female soccer players are necessary to make well-oriented recommendations to trainers and coaches. Ideally, they should include large sample sizes and report reliability values from each test used. Finally, considerations concluded in the present review are really interesting in adolescent female soccer players. Although it is possible that some of them, such us characteristics of COD tests or factors that affect test reliability, can be informative to adolescent male soccer. However, it is necessary to be very caution in interpreting this information.

Conclusions

Change of direction ability in female adolescent soccer players can be evaluated with different tests, however the 180ºCOD seems to be the most appropriate to replicate the movement patterns of soccer. The reliability of the COD ability tests depends on the instruments used such as electronic timing gates, the surface and/or the playing level of the soccer player. Test results should be interpreted with caution as they may be influenced by the period in growth and maturation, the playing position of the player and the period of the soccer season. Specifically, strength and power drills can improve change of direction ability in adolescent female soccer players whereas results on neuromuscular training need further investigation. Finally, the characteristics of an ideal test to assess the COD ability in soccer should be only one COD with a duration of less than <5 s and at a COD angle within a range <90º.

NOTES

Conflict of interests

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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TABLES

Table I. — Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies scores for the cross-sectional studies.

Studies	Item														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Score
Emmonds et al. (2018)[32]	+	+	+	-	+	NA	NA	NA	+	NA	+	-	NA	+	7
Hirose et al. (2015)[31]	+	+	-	+	+	NA	NA	NA	+	NA	+	-	NA	+	7
Mathisen et al. (2014)[30]	+	-	-	-	+	NA	NA	+	+	NA	+	-	NA	+	6
Meylan et al. (2014)[29]	+	+	-	-	+	NA	NA	NA	+	NA	+	-	NA	+	6
Mujika et al. (2009)[28]	+	+	-	-	+	NA	NA	+	+	NA	+	-	NA	+	7
Pardos-Mainer et al. (2019)[16]	+	+	-	+	+	NA	NA	NA	+	NA	+	-	NA	+	7
Vescovi et al. (2008)[27]	+	+	-	+	+	NA	NA	NA	+	NA	+	-	NA	+	7

Note: += yes; - = no; NA= Not applicable

Table II.— Modified quality-assessment screening scoring system scores for the intervention studies.

Studies	Item										
	1	2	3	4	5	6	7	8	9	10	Score
Lindblom et al. (2012)[36]	-	++	-	++	++	++	++	-	++	++	17
Mathisen et al. (2015)[35]	-	-	-	++	++	++	++	-	++	++	16
Noyes et al. (2013)[34]	-	/	++	++	++	++	++	++	++	-	16
Pardos-Mainer et al. (2019)[38]	/	++	++	++	++	++	++	++	++	++	19
Pardos-Mainer et al. (2019)[41]	/	++	++	++	++	++	++	++	++	++	19
Pérez et al. (2019)[40]	/	-	++	++	-	++	++	++	++	++	15
Vescovi et al. (2010)[33]	-	++	-	++	++	-	++	++	++	++	17
Wright et al. (2016)[37]	-	/	++	++	/	++	++	++	++	++	15
Wright et al. (2019)[39]	-	/	++	++	++	++	++	++	++	++	17

Note: ++ = Clearly yes; - = Clearly no; / = Maybe

Table III. — Cross-sectional studies characteristic regarding the reliability of COD speed tests in adolescent female soccer players.

Study	Population				Test and description	Reliability	QA
	Subjects	Age	Level	Sport			
Emmonds et al. (2018)[32]	157F	U-10: 9.25 ± 0.58 U-12: 11.41 ± 0.98 U-14: 13.22 ± 0.65 U-16: 15.05 ± 0.64	Highly trained	S	**5-0.5 test:** Players were placed 10m front the start point. Each player sprinted from the start, turning 180º at the 15m mark and sprinted back through the finish line.	CV: 2.2%	7
Hirose et al. (2015)[31]	135M/F	16.5 ± 0.5	Highly trained	S	**10m x 5COD:** 2.5 round trips between 2 lines drawn 10m apart, which necessitated four 180º turns alternating between the left and right foot, followed by a sprint for 10m in a straight line.	ICC: 0.89	7
Mathisen et al. (2014)[30]	36F	CG: 13.6 ± 0.2 TG: 13.7 ± 0.3	Trained	S	**Agility test:** 20 m, starting with 5m straight line sprint followed by a 90° turn, 2.5m straight-line sprint followed by a 180° turn, 5m slightly curved sprint followed by a 180° turn, 2.5m straight-line sprint followed by a 90° turn and 5m straight-line sprint. Best of two trials was recorded using photocells.	NS	6
Meylan et al. (2014)[29]	113M/F	F: 11.3 ± 0.9	Recreational	S, B, W, FH, R, N, SLS, A, C	**COD task:** 10m with two 100° turns, 2 m straight sprint section, a turn into backwards running section (4m), 2x2m side steps sections with two 100° turns, and a 1m straight sprint section. Finally, 10m straight sprint.	ICC: 0.72-0.94 CV: 1.6-10.6%	6

Mujika et al. (2009)[28]	68M/F	JF: 17.3 ± 1.6	Highly trained	S	**15m agility run:** Athletes started running 3 m behind the initial set of gates. After 3 m of line running, players entered a 3 m slalom section marked by three sticks 1.6 m high and placed 1.5. m apart, and then cleared a 0.5 m hurdle placed 2 m beyond the third stick, finally players ran 7 m.	NS	7
Pardos-Mainer et al. (2019)[16]	68 F	U-16: 14.2 ± 1.6 U-18: 17.1 ± 0.79	Trained	S	**180º COD:** Each player sprinted from the start/finish line, completely crossed the 5 m line with either right or left foot, and turned 180º to sprint back to the start/finish line. **V-cut test:** A 25 m sprint with four CODs of 45º 5 m each.	180ºCOD ICC: 0.80 to 0.82 CV: 1-1.7% V-cut test ICC: 0.75 to 0.76 CV: 2.1-2.2%	7
Vescovi et al. (2008)[27]	213F	HS: 15.1 ± 1.6	Recreational	S, L	**Modified Illinois test:** Athletes sprinted 9.1m from the start position to the second corner cone, turned to weave down and back through the centre line of cones, made one final change of direction at the third corner code, and finished with another sprint (9.1m) across the finish line. **Pro-agility test:** Athletes sprinted maximally from the starting line to the cone at the other end (9.1m), touched the ground with one hand, changed direction, sprinted back to the star line, again touched the ground with one hand, made a final change of direction to sprint through the finish line at the centre cone (4.6m).	NS	7

HS = High school; F = Female; M = Male; CG = Control group; TG = Training group; U = Under; COD = Change of direction; JF = Junior female; S = Soccer; B = Basketball; W = Waterpolo; FH = Field Hockey; R = Rugby; N = Netball; SLS = Surf lifesaving; A = Athletics; C = Cricket; L = Lacrosse; ICC = Intraclass correlation; CV = Coefficient of variation; QA = Quality assessment; NS = Non stated

Table IV. — Experimental studies characteristics regarding the reliability and results (effect size) of COD speed tests in adolescent female soccer players.

Study	Population				Weeks of intervention	Test and description	Reliability	Effects of intervention	QA
	Subjects	Age	Level	Sport					
Lindblom et al. (2012)[36]	52F	CG: 14.2 ± 1.1 IG: 14.2 ± 0.7	Trained	S	11	**MIT:** Athletes sprint 10 m, turns and returns back the starting line, then, he swerves in and out of four markers, completing two 10 m sprints to finish the agility course	ICC: 0.89	Neuromuscular warm-up 0.4% (ES: 0.08) CG -1.1% (ES: -0.26)	17
Mathisen et al. (2015)[35]	23F	CG: 15.1 ± 0.5 EG: 15.5 ± 0.7	Trained	S	8	**Agility test:** 20m, starting with 5m straight line sprint followed by a 90° turn, 2.5m straight-line sprint followed by a 180° turn, 5m slightly curved sprint followed by a 180° turn, 2.5m straight-line sprint followed by a 90° turn and 5m straight-line sprint.	ICC: 0.81	Speed training -5.2% (ES: -1.38) CG -0.3% (ES: -0.21)	16
Noyes et al. (2013)[34]	62F	15 ± 1	Recreational	S	6	**T-test:** Athletes sprinted from a standing point in a straight line to a cone placed 9.14 m away. Then, athletes shuffled to their left without crossing their feet to another cone placed 4.57 away. After touching this cone, the shuffled to their right to a third cone placed 9.14 m away, shuffled back to the middle cone, and then ran backwards to the starting position.	ICC: 0.90	Neuromuscular training program -6.14% (ES: 0.43)	16

Pardos-Mainer et al. (2019)[38]	36F	CG: 12.5 ± 0.4 EG: 13.1± 0.3	Trained	S	10	**180º COD:** Each player sprinted from the start/finish line, completely crossed the 5 m line with either right or left foot, and turned 180º to sprint back to the start/finish line. **V-cut test:** A 25 m sprint with four CODs of 45º 5 m each.	ICC 0.83-0.93 CV: 1.5-5.3%	Neuromuscular training program 180ºCOD right: 4% (ES: 0.32) 180ºCOD left: 0% (ES: -0.01) V-cut: 2% (ES: 0.59) CG 180ºCOD right: 5% (ES: 0.53) 180ºCOD left: -9% (ES: 0.28) V-cut: 6.6% (ES: 0.70)	19
Pardos-Mainer et al. (2019)[41]	37F	CG: 16.2 ± 0.9 EG: 15.6 ± 0.9	Trained	S	8	**180º COD:** Each player sprinted from the start/finish line, completely crossed the 5 m line with either right or left foot, and turned 180º to sprint back to the start/finish line. **V-cut test:** A 25 m sprint with four CODs of 45º 5 m each.	ICC: 0.80-0.86 CV: 2.4-2.5%	CSPT 180ºCOD right: -2% (ES: -0.15) 180ºCOD left: -7% (ES: -0.52) V-cut: -2.4% (ES: -0.58) CG 180ºCOD right: 4% (ES: 0.23) 180ºCOD left: -2% (ES: -0.28)	19

								V-cut: 1% (ES: -0.02)	
Pérez et al. (2019)[40]	12F	11.5 ± 0.5	Trained	S	14 sessions	**Agility test:** 20m, starting with 5m straight line sprint followed by a 90° turn, 2.5m straight-line sprint followed by a 180° turn, 5m slightly curved sprint followed by a 180° turn, 2.5m straight-line sprint followed by a 90° turn and 5m straight-line sprint.	NS	SSG MIT: -9% (ES: NS)	15
Vescovi et al. (2010)[33]	58F	CG: 16.8 ± 0.4 EG: 15.7 ± 1.2	Trained	S	12	**MIT:** Athletes sprinted 9.1m from the start position to the second corner cone, turned to weave down and back through the centre line of cones, made one final change of direction at the third corner code, and finished with another sprint (9.1m) across the finish line. **PAT:** Athletes sprinted maximally from the starting line to the cone at the other end (9.1m), touched the ground with one hand, changed direction, sprinted back to the star line, again touched the ground with one hand, made a final change of direction to sprint through the finish line at the centre cone (4.6m).	ICC MIT: 0.98 PAT: 0.94	PEP program MIT: NS PAT: NS	17
Wright et al. (2016)[37]	37F	13.4 ± 1.5	Highly trained	S	8	**MTT:** Athletes sprinted from a standing point in a straight line to a cone placed 5 m away. Then, athletes shuffled to their left without crossing their feet to another cone placed 2.5 away. After touching this cone, the shuffled to their right to a third cone placed 5 m away, shuffled back to the middle cone, and then ran backwards to the starting position.	CV: 2%	HIIT -8.37% (ES: -1.45)	17

Wright et al. (2019)[39]	32F	12.1 ± 0.9	Trained	S	3 years	**180º COD:** Each player sprinted from the start/finish line, completely crossed the 5 m line with either right or left foot, and turned 180º to sprint back to the start/finish line.	NS	Strength training Year 1 and 2: -6.5% (ES: -1.63) Year 2 and 3: -1.9% (ES: -0.45) Year 1 and 3: -8.3% (ES: -2.09)

F = Female; IG = Intervention group; CG = Control group; MIT = Modified Illinois test; PAT = Pro-agility test; TE = Typical error; MTT = Modified T-test; HIIT = High intensity interval training program; PEP = Prevent injury enhance performance program; CSPT: Combined strength and power training; SSG: Small sided game; ICC =Intraclass correlation; CV: Coefficient of variation; S = Soccer; ES = Effect size; QA = Quality assessment; NS = Non stated

Table V. — Characteristics of the different COD speed tests commonly used.

Study	Test	Trials	Surface	Instrument	Familiarization	Period season	Time (sec)	No. CODs	ADC
Emmonds et al. (2018)[32]	5-0-5 test	3	Indoor	Electronic timing gates	NS	During season	0-5	1	180º
Hirose et al. (2015)[31]	10m x 5COD	2	Artificial turf	Handheld stopwatch	NS	NS	>10	5	180º
Lindblom et al. (2012)[36]	MIT	2	Indoor	Electronic timing gates	NS	March-June	>10	9	NS
Mathisen et al. (2014) (2015)[30]	Agility test	2	Parquet floor	Electronic timing gates	NS	Preseason	5-9	3	90º; 180º
Meylan et al. (2014)[29]	COD task	NS	Rubber indoor surface	Electronic timing gates	Yes	NS	>10	5	100º
Mujika et al. (2008)[28]	15-m agility run	2	Synthetic football pitch	Electronic timing gates	Yes	Precompetitive	0-5	3	NS
Noyes et al. (2013)[34]	T-test	2	NS	Handheld stopwatch	NS	NS	>10	4	NS
Pardos-Mainer et al. (2018) (2019) (2020)[16,38,41]	180ºCOD	2	Artificial turf	Electronic timing gates	Yes	Pre- and midseason	0-5	1	180º
	V-cut	2	Artificial turf	Electronic timing gates	Yes		5-9	4	45º
Perez et al. (2019)[40]	Agility test	2	Artificial turf	NS	Yes	NS	5-9	3	90º; 180º
Vescovi et al. (2008)[27]	MIT	2	Rubbers indoor surface or artificial turf	Electronic timing gates	NS	NS	>10	9	NS
	PAT	2	Rubbers indoor surface or artificial turf	Electronic timing gates	NS		0-5	2	NS

Vescovi et al. (2010)[33]	MIT	2	Natural turf	Electronic timing gates	NS	NS	>10	9	NS
	PAT	2	Natural turf	Electronic timing gates	NS		0-5	2	NS
Wright et al. (2016)[37]	MTT	2	NS	Electronic timing gates	Yes	Preseason	5-9	4	NS
Wright et al. (2017)[39]	180ºCOD	2	NS	Electronic timing gates	NS	Pre, mid and postseason	0-5	1	180º

MIT = Modified Illinois test; PAT = Pro-agility test; MTT = Modified T-test; NS = Non stated; ADC = Angle of direction change; 180ºCOD = 180º change of direction test

TITLE OF FIGURES

Figure 1. — Flow-diagram of study identification and exclusion process.