Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 7), Art 215, pp. 1716- 1722., July 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Test for the improvement and evaluation of change of direction in team sports: A systematic review

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Published online: July 31, 2022
(Accepted for publication July 15, 2022)
DOI:10.7752/jpes.2022.07215

Abstract
Changes of direction (COD) are present in every type of sport there is, mainly in team sports where COD performance is particularly important because during game situations athletes frequently change speed and direction of movement as a way to avoid contact with opposing players in order to gain positional advantages that can lead to a goal or score for their team. This systematic review aimed to investigate how different types of training: strength, plyometrics, sprint, specific change of direction (COD) training or a combination of these approaches can improve COD performance. It also sought to determine what protocols or considerations should be taken into account for the improvement and assessment of COD through the different existing tests. This review included a total of 31 articles and was carried out following the recommendations of the current pre-established reporting elements for systematic reviews and meta-analyses. The following databases were consulted: *ISI Web of Science (WOS), Scopus* and *Google Scholar*. The results were presented based on two predominant themes: 1) Strength, plyometric and COD-specific training programs and 2) COD tests used for performance assessment in team sports. The most important finding of this review is that plyometric training, strength training, speed training, and specific COD training, the 505 and Illinois Test being the most used. A combination of these forms of training can be used to improve COD performance. The most important finding of this review was that plyometric training, strength training, speed training, specific training of the COD and a combination of these forms of training can all be used to develop the performance of the COD.
Keywords: literature review, sprinting, running technique, plyometrics, performance.

Introduction

Changes of direction (COD) are present in every type of sport there is (Falch et al., 2021; Freitas et al., 2022; Sugiyama et al., 2021), mainly in team sports where COD performance is particularly important because during game situations athletes frequently change speed and direction of movement as a way to avoid contact with opposing players in order to gain positional advantages that can lead to a goal or score for their team (Freitas et al., 2022). Therefore, despite the unpredictable nature of COD demands during play, in recent years sport science researchers have been interested in studying a multiplicity of pre-planned COD tests (Sugiyama et al., 2021). These assessments allow a better understanding of the physiological and mechanical bases underpinning this complex and multifaceted capacity (Hammami et al., 2017; Kalapotharakos et al., 2021; Pereira et al., 2018; Spiteri et al., 2015) (e.g., kinetic and kinematic determinants of DOC, specific biomechanical and technical aspects and strength-power qualities of top players). In field and arena sports, most game actions are performed at low intensity. Although the intensity of the work is low, a large number of actions are performed at high intensity, also known as maximal movements (Praça et al., 2020), and the ability to repeat maximal movements can be of great relevance and importance. The ability to make maximum moves at crucial moments can determine the outcome of the game, such as scoring or saving a goal (Freitas et al., 2022). Running, tackling, and quickly changing direction are classic examples of maximal movements that contribute significantly to total energy expenditure (Mizuguchi et al., 2014).

The specialized COD literature has shown that football players perform approximately 650 CODs during a medium intensity match, and 580 of these CODs are 0-90° turns (Praça et al., 2020). Approximately 50 of the CODs in a football match are performed at maximum intensity (Praça et al., 2020). PoVoas et al. (2012), state how handball players use a large amount of force during tasks that require a COD. Despite the fact that most actions are completed at medium-low intensity, the study states that stops, decelerations and CODs account for 60% of the physical actions executed during the game. In basketball, 20% of sprints involve rapid changes of direction (Merino-Muñoz et al., 2021), less than in sports such as football and handball, already mentioned (PoVoas et al., 2012). On the other hand, Pyne y Mansh (2006) results suggest that rugby is the sport with the fewest rapid changes of direction compared to the other studies noted above. Their study revealed that only 16% of all sprints in rugby included a quick change of direction. In track and field sports such as football, handball,

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rugby and basketball, they suggested that the ability to make quick changes of direction is a determining factor in relation to match outcomes (Freitas et al., 2022).

Among the tests for the training and improvement of DOC are pre-planned tests in which athletes perform a predetermined route without reacting to external stimuli. This contrasts with reactive (unplanned) tests, which require decision-making about the direction of the subsequent movement (Sugiyama et al., 2021) that have gained attention in the last decade because they are believed to assess cognitive function as a determinant of performance in invasive sports (Cuthbert et al., 2019; Freitas et al., 2019). During the development of training for the improvement of physical abilities and technical skills of male and female players, tests for the improvement or search for performance or failure are performed in order to determine the efficiency of movements and turns during CODs (Mizuguchi et al., 2014). Rehearsing CODs helps to perfect the technique of these movements in order to show the best technical version when it comes to the field of play, favoring sporting performance and avoiding injuries from malpractice (Barrera-Domínguez et al., 2020). The search for new ways of working on changes of direction is also a way of perfecting this field of study, as well as its performance (Nygaard Falch et al., 2019). For this type of activity, strength and power are also factors that influence the execution of changes of direction. So much so that deficits can occur in their purpose (Freitas et al., 2019).

COD through training programs such as, for example, with elastic bands over a certain period of time, greatly benefit explosive muscular performance when performing DOCs in the lower limbs (Aloui et al., 2021). Castillo-Rodríguez et al. (2012), conclude, based on jumping power, that the right leg is the one that best performs this type of movement in most athletes who participated in their study. Age also influences the development of this type of movement, so that it can affect agility and technique in the performance of COD in the case of youth football, for example (Chaouachi et al., 2014). In this context, it is observed that the implement used in each sport, for example, in rugby CODs in relation to the execution time that it takes the athlete to perform a COD with the ball in both hands is faster and more efficient than if it is not held in this way (Pyne & Mansh, 2006). COD speed is often considered a major determinant of successful performance in many team sports and is routinely measured by field tests (Padrón-Cabo et al., 2020; Salaj & Markovic, 2011). However, controversy still exists regarding training selection based on the reliability and specificity of the tests used. This implies that it is not enough to settle for tests that have already been verified as valid, but also implies that the search for new forms of training and hypothetical situations that are close to the reality and demands of the game are necessary (Stojanović et al., 2019).

By considering COD as a multifactorial skill, it is suggested that a combination of training that addresses multiple factors can lead to increased performance. The ability to perform COD effectively is a key aspect of team and invasion sports (Barrera-Domínguez et al., 2020). Therefore, it is essential to know the optimal programs and tests for this purpose. As described above, during the acceleration phase of sprints, a horizontal force is exerted on the ground, followed by a vertical adjustment of the body to generate greater velocity. Bourgeois et al. (2017), suggest that where the ability to perform DOCs is truly assessed is in sprints of less than 10m. In addition, the number of directional changes will influence the specificity of sprint training: a number of DOC maneuvers with force application to the ground in different directions differentiate the muscular work performed in a COD from that of sprinting (Hammami et al., 2017). Previous work points to the need for training actions that are similar to the movement patterns performed in competition (Martín-Moya, R. 2022). Differences in movement patterns are a challenge when performing straight-line sprint training to develop COD performance to that in a sprinting event, as the technique is different to that required in a COD, even though the acceleration phase is similar (Rouissi et al., 2017).

Therefore, the aim of this review is twofold: (1) to investigate how different types of training: strength, plyometric, sprinting, specific COD training or a combination of these approaches can improve COD performance; and (2) to determine which protocols or considerations should be taken into account for the improvement and evaluation of CODs through the different tests that are most prominent in the scientific literature for their reliability and validity.

Method

A systematic review of the literature was carried out, in accordance with the guidelines of the currently pre-established reporting elements for systematic reviews and meta-analyses (PRISMA) (Page, McKenzie, et al., 2021). This review of the literature was conducted during October and November 2021 and January 2022 to ensure that as complete a list of relevant studies on the topic as possible was compiled. A systematic review attempts to gather all available scientific evidence according to inclusion and exclusion criteria.

Eligibility and selection criteria

Following the PRISMA guidelines, the report was developed according to the PICO framework. This framework is often used to organize the reporting of eligibility criteria for intervention reviews (Page et al., 2016). It was established as follows: Participants: individuals taking part in any sport, exercise or physical activity; Interventions: because of the novelty of the study topic, any experimental intervention dealing directly with the use and evaluation of COD tests in team sports (thus excluding any opinion studies and papers dealing with other concepts); Comparisons: articles containing definitions and information on recommendations and

guidelines to be followed, i.e. type of test, test improvement program and results obtained. Outcomes: any results derived from the implementation or proposal of a program related to improving CODs (therefore, no limitations were imposed with regard to outcomes). The systematic review was conducted in three distinct phases: identification, screening, and eligibility and inclusion (Figure 1). Each phase was carried out by the lead author.

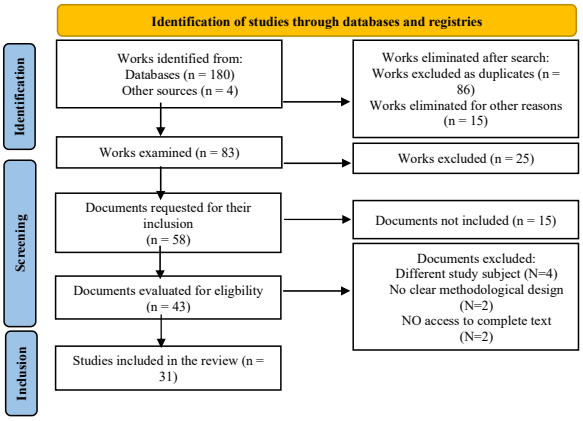

Figure 1. Flow chart of article selection, screening and inclusion process.

Sources of information

The following databases were examined: *ISI Web of Science (WOS), Scopus* and *Google Scholar.* Due to the topicality of the study subject, publication date limitations were applied the search focused on articles published between 2007 and 2022 in double-blind peer-reviewed journals in order to obtain complete and up-to-date search results from the last 15 years.

Search strategy

In general, articles were selected for inclusion following the PICO framework described above and matching the object of study. Exclusion criteria identified studies presented as reviews, reports, book chapters, topics other than the one sought, or did not definitively present any relationship to the proposed intervention. Advanced searches were conducted within the databases defined above and were based on combinations of the following English search terms related to change of direction test ("*change of direction test*" OR "*cod test*" OR "*cd test*" OR "*cod ability test*") and sport, exercise and physical activity (*exercise* OR sport OR "*physical exercise*" OR "*physical activity*")).

Results

In response to the study objective of what protocols or considerations to take into account for the improvement and evaluation of change of direction through the different tests used in team sports, the search initially yielded a total of 184 results in the different databases. Finally, this review included a total of 31 articles. The results are presented based on two predominant themes: 1) Strength, plyometric and COD-specific training programs and 2) COD tests used for performance assessment in team sports.

Strength, plyometric and COD-specific training programs

If we analyse the publications included in this review, we find the study Falch et al. (2021), which proposes the evaluation of lower body strength through the performance of squats on the Smith Machine. In this line, Aloui et al. (2019), present an eight-week strength training program with elastic bands to assess the ability to produce force when performing the COD by means of the one repetition maximum (1RM) test in half squats. On the other hand, Barrera-Domínguez et al. (2020) and Beato et al. (2018), evaluate unilateral strength through the horizontal triple jump test as a tool to find muscular asymmetries when performing the CODs with one leg or the other. Finally, Spiteri et al. (2014), evaluate through 1RM in a back squat and a workout of isometric work of the lower body, the benefits that a combined strength and entertainment training program produces on the performance of the COD.

With regard to the influence of plyometric training on improvement and performance in the performance of the COD, more than half (18) of the publications include plyometric evaluation with the jump with drop (DJ), ether a jump with countermovement (CMJ) or squat with jump tests (SJ).

With regard to the evaluation of the DOC through the tests related to running, we found greater prevalence in the use of the 10m linear sprint test (Beato et al., 2018; Castillo-Rodríguez et al., 2012; Pereira et al., 2018; Rouissi et al., 2018), 20m sprint (Cuthbert et al., 2019; Freitas et al., 2019, 2022; Pereira et al., 2018) and 30m sprint (Aloui et al., 2021; Barrera-Domínguez et al., 2020; Beato et al., 2018; Chaouachi et al., 2014; Falch et al., 2021; Salaj & Markovic, 2011).

Other tests were found to assess running speed with different distances, although used to a lesser extent were 5m sprint (Aloui et al., 2019) 15m sprint (Chaouachi et al., 2014) and 40m sprint (Beato et al., 2018; Hammami et al., 2017).

COD tests used for the assessment of performance in team sports

The assessment of the performance of the DOC can be performed by means of pre-planned tasks or by performing the unplanned DOC based on the reaction to an external stimulus. Following a review of the literature, a multitude of tests appear to be used to assess the ability to perform the DOC. The most commonly established assessments in the various publications are the 505 test and its modified version (a 180° change of direction, Beato et al., 2018; Stojanović et al., 2019), Y-agility test, in its pre-planned and reactive version (Fiorilli et al., 2017), COD with different angulations (45º, 90º, 135º y 180º, Rouissi et al., 2018), T Test (90° y 180°, Spiteri et al., 2015), zig-zag COD (Loturco et al., 2018) and Illinois test as one of the most commonly used tests (Fiorilli et al., 2017; Negra et al., 2017; Rouissi et al., 2016). Other assessments that have been developed for sport-specific assessment are also described and appear to a lesser extent.

In relation to the types of tests used, it is important to highlight the number of times each test is used in order to increase the reliability and validity of data collection. The number of attempts needed to obtain the most accurate and precise data can be obtained by examining session reliability (i.e., within-session) and individual reliability (i.e., within-individual) for a duration equal to the duration of the intervention (Hopkins, 2000). However, the publications in the present review describe an average of three attempts per task with a minimum of 2 prior familiarisation attempts. Therefore, it would be within an average of 2-5 attempts with maximum effort after 2 trials of familiarization with the test (Stojanović et al., 2019). This provides a more accurate and precise approach to monitoring athlete and team performance.

Discussion

The aim of this review was to investigate how different types of training: strength, plyometric, sprint, specific DOC training or a combination of these approaches can improve DOC performance. It also intends to determine what protocols or considerations should be taken into account for the improvement and evaluation of change of direction through the different, most prominent tests in the scientific literature for their reliability and validity. Previous research on the frequency of plyometric training indicates that a moderate frequency (around two sessions per week) is optimal compared to a higher training frequency. These data are in agreement with those found by Paes et al., (2022) who show how a medium frequency of plyometric training induces a greater capacity to produce maximal force in 20m sprints, which are physical determinants of COD performance (Freitas et al., 2022). A relevant finding with useful importance for strength coaches and physical trainers is that younger participants did not reveal a greater effect on these variables than older participants (Aloui et al., 2021; Beato et al., 2018).

Along these lines, it is likely that a certain level of motor control is required for plyometric training to have a noticeable transfer to DOC performance as plyometric training can be technically challenging for younger athletes (Beato et al., 2018). More physically developed athletes possess a higher level of strength (Schoenfeld et al., 2021). It should also be borne in mind that younger athletes develop more strength after puberty due to greater muscle mass (Skaal et al., 2015), higher testosterone levels (de Almeida-Neto et al., 2020) and greater motor control (Janosky, 2019). Previous research shows that physically stronger athletes will benefit more from plyometric training compared to weaker athletes (Bourgeois et al., 2017). Thus, although age-related, it will depend primarily on the maturational development of the individual athlete.

All the interventions reviewed that include plyometric training assess performance through countermovement jumps (CMJ) or drop jumps (DJ). The benefit of DJs compared to CMJs is that the eccentric phase requires a greater amount of force to be produced in the lower extremities. In addtion, the eccentric strength of the hamstrings, among other elements, has been shown to play an important role during the braking phase in the COD (Salaj & Markovic, 2011). The results found in this review show that DJs together with CMJs seem to be an optimal approach compared to those who have developed training programs with only one of the variables. Drouzas et al. (2020), show that unilateral plyometric training is more effective in increasing muscular strength and power in young football players compared to bilateral training or football training alone. These findings show that both methods are valid for developing DOC capacity, with unilateral plyometric training being more effective for the development of COD (Ramirez-Campillo et al., 2018) while bilateral training appears to be a more effective method for improving linear speed over short distances (Wallin M, 2014).

If we consider strength training through basic exercises such as the squat, it is possible that the expected benefits for COD are not obtained because propulsive strength is not developed (Ferley et al., 2020). When performing a squat, force is produced vertically, but the braking and acceleration phase during a COD requires combined vertical and horizontal force propulsion (Rouissi et al., 2017). These findings indicate that the inclusion of a strength training program can be an effective way to improve the DOCs, but it must be combined with movements that generate horizontal momentum to provide a direct transfer to the sporting action and so improve DC performance (Freitas et al., 2022; Loturco et al., 2018). Another training method used by the research reviewed here is the specific training of the DOC itself (Cuthbert et al., 2019; Freitas et al., 2022). With this in mind, the specificity of the training, in addition to age and gender, could explain the occurrence of large post-intervention improvements (Matlák et al., 2016; Rouissi et al., 2017; Spiteri et al., 2015). Younger athletes have less experience with COD training, and the inclusion of a specific training program for the COD test that measures improvement may be advantageous compared to that of groups that do not train specifically enough.

This is exemplified in the study by Chaalali et al. (2016), who implemented specific COD training with the ball among youth football players and measured improvement with a 505 COD test. Along with the amount and angle of the CODs, the use of a ball increases the complexity of the task, where the focus on proper ball control may prevent athletes from completing the COD task with speed. COD training is effective for youngsters if the task takes into account that there are no external factors that create complications in the execution (Chaalali et al., 2016). When including COD as part of improving the performance of the action and short maneuvers, it is important to ensure that the same energy systems are demanded as are used in competition. It is important to engender in athletes the ability to reproduce high-intensity CODs during training to ensure transfer to the actual game (Matlák et al., 2016; Padrón-Cabo et al., 2020).

Conclussions

The current review shows multiple training approaches, which included variations related to the number of training sessions, the age and sex of the athletes and the use of different COD tests to measure performance. This makes it complex to reveal clear guidelines and conclusions. When combining training methods, it is impossible to distinguish between the isolated effects of each individual training test on COD performance. In addition to the studies that used plyometric training, several studies revealed relevant results when including strength and speed training. The benefits of performing combined training are related to the improvement of multiple determinants on which the performance of the COD depends.

Physical coaches should exercise some caution when employing multiple CODs over longer distances. While anaerobic energy systems play a central role in COD performance, the practice of multiple maneuvers over longer distances will focus more on the aerobic energy system, neglecting the fundamental role they play in explosive anaerobic performance. The most important finding of this review is that plyometric training, strength training, speed training, specific training of the COD and a combination of these forms of training can all be used to develop the performance of the COD.

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