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Assessing the Interrelationship Between Agility and Change of Direction in Elite Senior Soccer Players

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Abstract

Introduction: Invasion team sports specifically feature a widely studied component – agility. Agility is crucial in team sports players when evading an opponent and orienting the body position. Numerous studies confirm that AG and CD are distinct qualities, yet others indicate otherwise. The qualities of AG and CD, which, though commonly considered independent, have been the subject of studies regarding their interdependence or codependence to establish criteria. **Objective:** This study aims to determine whether a difference exists between these qualities. **Statistical analysis:** A canonical correlation analysis ($p<0.05$) was employed to determine the relationship between both constructs (CD and Ag). **Results:** The results indicate a significant relationship between the constructs: R_c= 0.569, sig= 0.001, eigenvalue= 0.478, Wilks' statistic= 0.639, and R^2_c= 32.37%. **Conclusion:** a marked difference is revealed by employing the most recurrent tests in the literature to evaluate each construct.

Keywords: sports performance, relationship, soccer, physical performance, tests.

Introduction:

Team sports serve as a broad testament to human evolution, showcasing themselves as a social activity indicative of cooperation to achieve goals. Nature provides examples of groups of individuals who cooperate, reaping gains in various functional aspects when coordinating their actions through teamwork and communal living(Duarte et al., 2012).

Invasion team sports specifically feature a widely studied component – agility. This particular attribute of such sports has been defined as a "rapid change of direction of the entire body in response to a stimulus" (Sheppard & Young, 2006). From this definition, two essential components can be extracted: one is the change of direction (CD) component, defined as "the ability to execute sudden changes of direction" (Chaouachi et al., 2012), and the other is the perceptual-cognitive component, defined as "the ability to identify and acquire environmental information for integration with existing knowledge in such a way that it can select and execute appropriate responses" (Mann et al., 2007).

Agility is a crucial component in team sports players when evading an opponent and orienting the body position, all within fractions of a second, resulting in improved technical performance for the player and, subsequently, a better team outcome(Miller, 2017).

The ability to accelerate, stop quickly, change direction, and accelerate again is essential to motor skills in team sports players. However, despite these skills being included in agility definitions, they refer to the CD ability. The study by Young et al. (2015) indicates that as long as the movement occurs in a predetermined location on the field and at a specific time, with the characteristic of not requiring a response to a stimulus, it is usually classified as a pre-planned skill or a closed skill.

CD skills are usually pre-planned; materials such as cones, coordination ladders, shells, or others are tools used to facilitate executing actions, while agility actions require a stimulus. The stimuli used in agility measurement tests commonly include light stimuli, videos with sport-specific movements, or real-time executed movements by individuals. The response to the stimulus in agility actions includes a CD (Miller, 2017). One can infer that, given the use of temporal units (seconds) in the tests designed to assess both abilities, speed emerges as a third significant element in shaping both constructs. Therefore, it is proposed to consider speed as an essential factor that should be incorporated into the inherent components of both qualities (Figure 1).

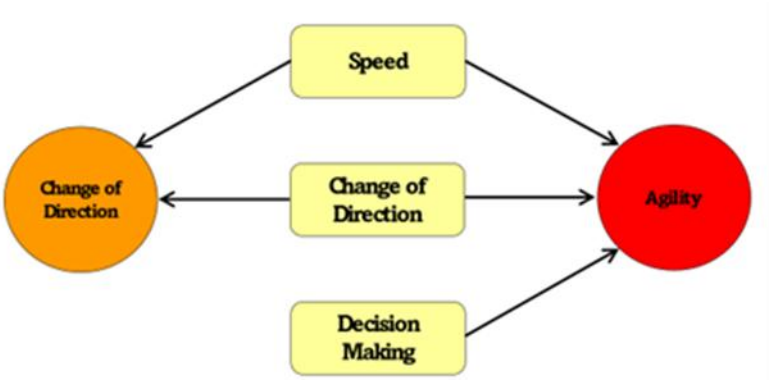


Figure 1. Components of agility (Author's own work).

Among the most employed assessments for measuring CD are the Illinois Agility Test, T-test, and L-test, among others. These tests, as previously mentioned, aim to measure CD. Consequently, since the definition of agility has encompassed perceptual components such as decision-making, novel methods of agility measurement have been devised. Among the widely utilized tests are the Y-test, the reactive T-test, and the "Stop and Go", all incorporating perceptual factors into their content. Morral et al. (2020) systematic review indicated that, while agility lacks a "gold standard", 75% of the studies included in this review employed the Y-test for evaluating agility (AG). Furthermore, to instill confidence that the test measures what it intends to measure, construct validity has been established by distinguishing between players of higher and lower sporting levels, yielding significant differences (Gabbett & Benton, 2009; Green et al., 2011; Lockie et al., 2014; Pojskic et al., 2018).

As the baseball player Yogi Berra once asserted, *"In theory, there is no difference between theory and practice. In practice, there is"*. This quote can be illustratively applied to the qualities of AG and CD, which, though commonly considered independent, have been the subject of studies regarding their interdependence or codependence to establish criteria. However, despite the clear theoretical distinction between these qualities, practical application presents certain complexities.

Numerous studies confirm that AG and CD are distinct qualities, yet studies also indicate otherwise (Mackala et al., 2020; Oliver & Meyers, 2009; Sattler et al., 2015; Sekulic et al., 2019; Young et al., 2015). All preceding studies conduct analyses based on two tests, while this study utilizes eight tests for analysis. This study aims to determine whether a difference exists between these qualities. This issue will be examined from a correlational perspective by analyzing various tests evaluating performance in the respective qualities of CD or agility. Therefore, this study aims to establish the relationship between the CD construct and the

agility construct, with each construct being estimated by four tests that provide a performance score for each.

Methodology:

Subjects:

Four high-performance football teams from Costa Rica participated, representing 66 players. At the time of the study, the subjects were active players from the high-performance football teams of the Costa Rican Soccer Federation. Additionally, subjects were required to be free from any active injuries or to have suffered any injuries in the last three months. Subjects could only engage in regular team training sessions. The research received approval from an ethical scientific committee of the University of Costa Rica. It adhered to the Declaration of Helsinki policy. All participants provided informed consent, including participation's risks and benefits. After explaining these points to the participants, they were invited to join the study by signing the informed consent form.

Body Composition:

The player's body composition was assessed using the InBody 120 impedance instrument (BridgePower Inc, CA 90703, USA). This instrument conducts ten Impedance Measurements using two Different Frequencies (20kHz, 100kHz) in each of the five segments (Right arm, left arm, torso, right leg, and left leg). It provides the best measurement precision among portable instruments. The collected data included weight, height, body fat, and muscle percentage.

Measurement of Execution Time:

The execution time of the tests was measured using SmartSpeed photocells from the FUSION-SPORT brand (AUS) (Figure 2a). In addition, the reactive light training system FITLIGHT was employed. The system comprises wireless LED lights, marketed as a patented and fully programmable sensor with tactile impact and kinetic impact (during movements) (Figure 2b).

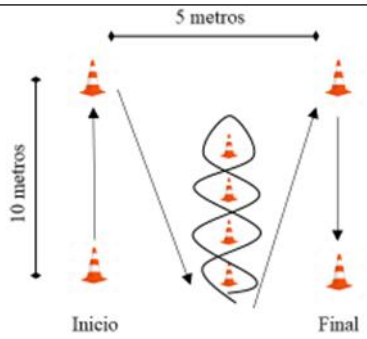
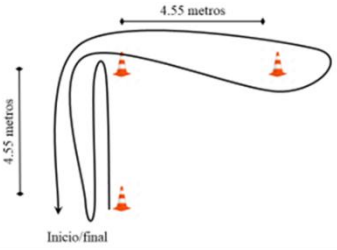
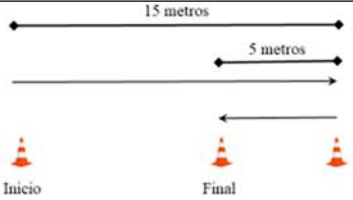
(a) (b)

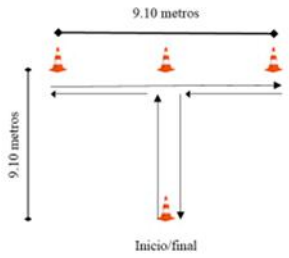
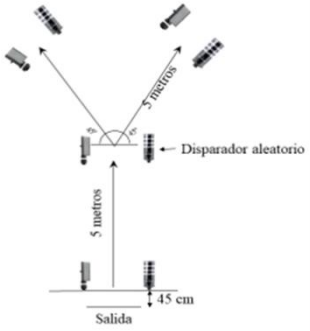
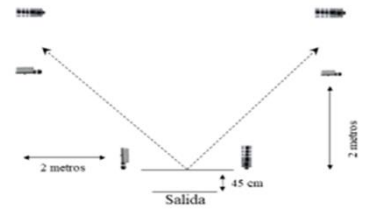
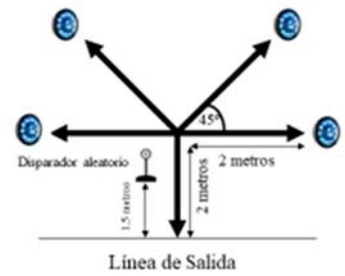
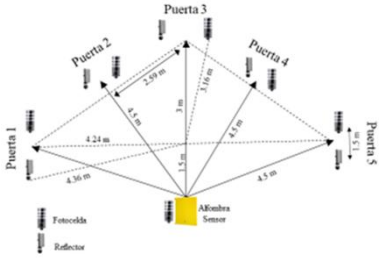
Figure 2. SmartSpeed photocells (a) FITLIGHT (b)

Tests to Evaluate COD and AG:

All tests are presented in Table 1, where their reliability and the graphical design of each test are displayed.

Table 1. Tests were used for change of direction and agility in this study.

Variable	Test	Reliability	Diagram
Change of Direction	**Illinois**	r= 0.89 (Stewart et al., 2014)	
	L-run	r= 0.94 (Stewart et al., 2014)	
	5-0-5	r= 0.86 (Dugdale et al., 2020)	

	T-test	r= 0.95 (Stewart et al., 2014)	
Agility	**Y shaped**	ICC= 0.86 (Dugdale et al., 2020)	
	Reactive Agility	ICC= 0.88 (J. M. Sheppard et al., 2006)	
	Stop & Go	ICC= 0.81 (Sekulic et al., 2014)	
	5 Shuttle run	ICC= 0.83 Morral, et al. (2020)	

- r=Pearson's correlation coefficient. ICC= Intraclass Correlation Coefficient.

Change of Direction:

Illinois Test:

Description:

Players had to complete the designated course in the shortest time possible. Starting from the bottom-left corner of a rectangle, participants moved toward the upper-left corner. They turned towards the center of the rectangle, where a row of four cones was positioned. They navigated through the cones in a zigzag direction and then back. From there, they moved to the upper-right corner, turned around the cone, and finally finished by heading towards the cone in the bottom-right corner. Photocells were placed at the start and end of the test. Approximate duration: 15 seconds.

L-run Test:

Description:

Players executed the course as indicated in the diagram. They had to move from the first cone to the second, return to the first, and then circle the third cone before returning to the first. Approximate duration: 10 seconds.

505 Test:

Description:

Players ran for 15 meters, performed a 180º change of direction, and finished with a 5-meter sprint. Approximate duration: 6 seconds.

T Test:

Description:

Each participant began by running straight towards the bifurcation point. Then, with lateral movements, they headed to the right and subsequently to the left. Afterward, they returned to the bifurcation point and ran backward to the starting point. Approximate time: 10 seconds.

Agility:

Y Test:

Description:

Players started with a 5-meter sprint, executed a double stop (stopping with both feet simultaneously) at the end of the 5 meters, and then ran to the door on the right or left as indicated by the random illumination of one of the doors. Approximate duration: less than 3 seconds.

Reactive Agility Test:

Description:

The participants positioned themselves at the starting point. They had to run to one of the two doors (left or right) as indicated by a randomly lit signal. Approximate duration: less than 2 seconds.

Stop and Go Test:

Description:

Participants started from the starting line. Upon exiting and passing through the exit door, one of the 4 lights (A-B-C-D) was illuminated, and they had to run towards the lit light and return to the starting line. This cycle was repeated three times continuously, and the order of light activation was random. The test concluded after the third occurrence. Approximate duration: 6 seconds.

5 Shuttle Run Test:

Description:

Participants began the test at the starting point. Upon starting, a light from the doors illuminated, and they had to run towards it, crossing the door line with both feet and then returning to the starting point on the mat. They repeated this cycle five times, with the door light randomly illuminating each time. Approximate duration: 20 seconds.

Measurement Procedure:

Players were assigned a random order for test execution based on the day (CD tests, AG tests). The fatigue was prevented by conducting the test three days, eight days between sessions. The electrical impedance was measured on the first day. CD tests were conducted after eight days, and AG tests were performed after an additional eight days. All tests were conducted at the beginning of each team's training session. A standardized 15-minute warm-up was applied to all players, including various activities to increase heart rate, such as linear and multidirectional movements and joint mobility exercises.

Upon arriving at each assigned test, participants were informed about the test requirements and demonstrated how to perform it. Subsequently, they were given the option to practice it twice. After the practice, their performance was measured in two attempts, with the better time recorded (they had a three-minute break between attempts). Once a test was completed, they moved on to the next one based on their assigned randomized order. Each test followed

the same protocol: explanation, practice, and performance recording. Participants were instructed not to engage in any vigorous activity before the tests. They were asked to wear the shoes and sportswear they used during competitions. The measurements occurred on the team's regular training field during their usual training time.

Each subject was assigned a different and randomly determined order for the order of the test application. In other words, each subject had a unique execution order. Each participant was given a printed adhesive with the test execution order. Each test was identified with a letter (A, B, C, and D), and the adhesives were placed on each participant's shirt with their respective order and number. This facilitated a better record of test scores, ensuring participants followed the order without forgetting.

Statistical Analysis:

A canonical correlation analysis determined the relationship between both constructs (CD and Ag) (Figure 3).

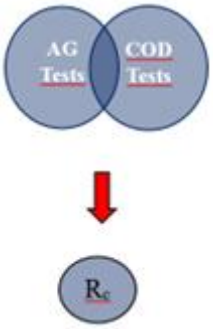


Figure 3. Study Desing.

Results:

For this section, a sample of 66 participants was obtained. There was a decrease in the sample size from 92 to 66 subjects due to some participants being absent on the second measurement day, leaving the team between measurement dates, or sustaining an injury between measurements 1 and 2. The averages of the applied tests are presented in Table 2.

Table 2. Results of change of direction, agility, and speed tests (mean ± Standard Deviation, n = 66)."

Test	Media (s)	SD
Test 505	4,213	0,251
T-test	8,939	0,797

Illinois Test	14,901	0,674
L Run Test	8,560	0,526
Y test	2,802	0,236
Reactive Agility	1,551	1,131
Stop and Go	17,254	2,885
5 Shuttle run	19,562	1,959

Canonical Correlation:

The proposed analysis, canonical correlation, was executed after conducting all the tests on the participant population. For this statistical analysis, the results of tests from two theoretical constructs were considered: change of direction (505 test, T-test, Illinois, and L run test) and agility (Y test, Reactive Agility, Stop and Go, and 5 shuttle run). The results indicate a significant relationship between the constructs: R_c= 0.569, sig= 0.001, eigenvalue= 0.478, Wilks' statistic= 0.639, and R^2_c= 32.37%. Concerning the change of direction construct, 8% of its variance is explained by the agility construct. In comparison, the agility construct's variance is explained by the change of direction construct at 13.4% (Table). This initial analysis suggests that both constructs share a small percentage of variance, indicating they have similar characteristics but also possess a percentage of unshared variance. In other words, the shared variance is attributed to the Change of Direction component present in both constructs (Figure 4).

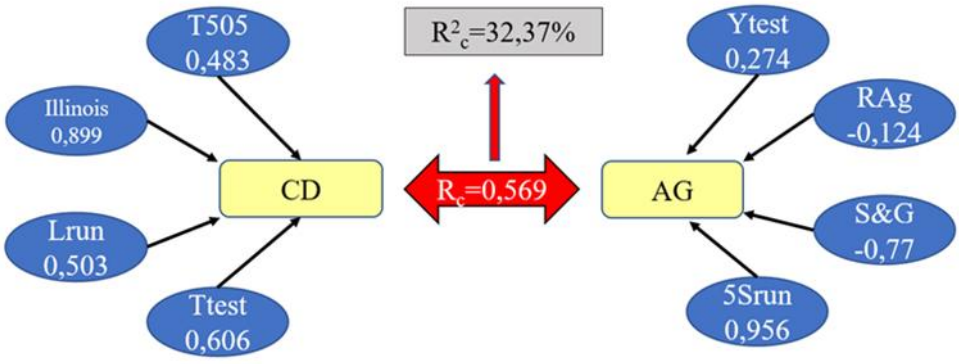


Figure 4. Canonical correlation between the constructs of Change of Direction (CD) and Agility (AG)

Discussion:

This article explores the relationship between two fundamental constructs in team sports: change of direction and agility. A canonical correlation analysis examined the interdependence between these variables in individuals undergoing various tests for both constructs. Several studies have raised this question, seeking to clarify whether both abilities are the same or can be considered as two different constructs(Altmann et al., 2021; Čoh et al., 2018; Popowczak et al., 2021; Sekulic et al., 2016, 2019). Previous studies correlated one CD test with one Agility test, proposing a correlation index. In contrast, this study used the same methodological intention to search for this correlation using four tests measuring CD and four tests measuring agility and analyzed them jointly. The result has been similar to those found previously, indicating a significant correlation between the two constructs. This conclusion is theorized in the study of Young et al. (2015) by reviewing previous correlational studies (CD and AG). Their conclusion asserts that both abilities are independent due to the low correlation (r^2= 29%) from the five reviewed studies.

This study found a similar relationship to that of Young (2015), whose shared variance percentage is r^2= 39%, not surpassing the 50% shared variance percentage that would have indicated that the constructs measure the same (Baker et al., 1994). With this result being very similar to the canonical correlation applied in this study, it must be concluded that, theoretically, the constructs share certain characteristics (speed and CD). In other words, the constructs are not entirely independent as they share a minority percentage of variance; therefore, from this theoretical perspective, they are not the same but have common elements in their composition. These results might suggest that the unshared variance may be due to the decision-making factor.

It Is concluded that a marked difference is revealed by employing the most recurrent tests in the literature to evaluate each construct. At the same time, a portion of shared variability is observed. This result indicates the need to consider the diversity of methodological approaches when addressing the constructs in question, acknowledging that conventional measures may capture different aspects of their complexity. The divergence in the tests highlights the importance of a careful selection of assessment tools. This finding also stimulates future research to discern the specific dimensions these tests measure, thereby contributing to a more precise understanding of the scrutinized constructs.

Future research:

This correlation between change of direction and agility emphasizes the importance of considering these two constructs together in the research and practice of human movement sciences. However, it is crucial to recognize the study's limitations, such as the correlational nature and the need for experimental research to establish causal relationships. Another limitation is establishing validity criteria for each test used in this study. Future research could explore underlying mechanisms, such as neuromuscular and biomechanical variables, to provide a more comprehensive understanding of the relationship between change of direction and agility in specific contexts.

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