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CHANGE OF DIRECTION SPEED AND AGILITY: MANIFESTATION AND RELATION IN YOUTH SOCCER PLAYERS

Change of direction speed (CODS) and agility are critical components of soccer performance because of the high number of changes of direction ocured during a match. This study investigates the relationships between various CODS tests, both with and without the ball, and a newly designed agility test in youth soccer players. A sample of 111 youth soccer players (11.15 ± 0.47 years) participated in a series of physical tests, including modified versions of the Illinois and T-tests, the 505 test, the s180 test, and a Zigzag test with the ball. The results revealed strong correlations and variances between CODS with the ball and CODS tests without the ball, ranging from ($\rho = 0.739$, $R^2 = 0.546$) to ($\rho = 0.787$, $R^2 = 0.619$). Very strong correlations were found between the CODS tests (modified Illinois and T-tests, 505, the s180) without the ball, ranging from ($\rho = 0.857$, $R^2 = 0.734$) to ($\rho = 0.923$, $R^2 = 0.852$). Additionally, very strong correlations were observed between CODS with and without the ball and agility, ranging from ($\rho = 0.805$, $R^2 = 0.648$) to ($\rho = 0.831$, $R^2 = 0.690$). These findings suggest that the tests measure similar underlying attributes of agility and CODS, both with and without the ball. The study provides valuable insights into the interrelationships between different CODS and agility, contributing to a better understanding of performance assessment in youth soccer players.

Key words: *Change of Direction speed, COD, Agility, Youth Soccer Players, Performance Analysis.*

Introduction and the current state of the research problem. Football players change their direction of movement every 2–4 seconds during the match game Davids et al. (2000), concluding that (CODS) and agility are crucial components of soccer success (Andrašić et al., 2021). Developing these skills is particularly important for youth

soccer players, as it can influence their future performance and career progression (Mirkov et al., 2010).

The definition of CODS is "skills and abilities needed to explosively change movement direction, velocity, or modes" as defined in the textbook endorsed by the National Strength and Conditioning Association (Nimphius et al., 2018), being a component of agility (Sheppard & Young, 2006; Young et al., 2022) which is by definition "a rapid whole-body movement with change of velocity or direction in response to a stimulus" (Sheppard & Young, 2006), and is known that are independent capacities and skills (Morral-Yepes et al., 2023), still large portion of the sports literature that claims to discuss agility actually refers to pre-planned movements or CODS (Young et al., 2022).

Several studies have explored the relationships among various CODS tests. Stewart et al., (2014) found strong correlations ($r = 0.84–0.89$) among five CODS tests (Illinois (IAT), L-Run, Pro-Agility, T-test, and 505) in physical education students who compete in team sports. Raya et al., (2013), observed a strong positive correlation between the IAT and T-test ($r = 0.76$, $p < 0.001$) in male soldiers, and moderate negative correlations between the Extended Shuttle Sprint Test and both the T-test ($r = -0.69$, $p < 0.001$) and IAT ($r = -0.65$, $p < 0.001$).

Hachana et al., (2013) found a significant correlation between the IAT and T-test ($r = 0.31$, $p < 0.05$). Çınarlı et al., (2018) identified a correlation between Pro-Agility and IAT ($r = 0.598$, $p < 0.05$) and Illinois and 505 ($r=.515$; $p<0.05$), in adult soccer players, but no significant correlations with other CODS tests.

Another study examined the relationships between various CODS tests, including the IAT, T-test, 505 Test , Gewandtheitslauf (GewT), Triangle Test (Tri-t), and Square Test (SQT), in youth elite soccer players (U17-U23). The study found strong significant correlations between tests with similar designs, such as the SQT-L and Tri-t-R ($r = 0.74$, $r^2 = 0.55$) and between Tri-t-L and Tri-t-R ($r = 0.63$, $r^2 = 0.40$). However, not all correlations were strong; for instance, the SQT-R and Tri-t-R showed only a weak correlation ($r = 0.33$, $r^2 = 0.11$). The explained variances ranged from 8% to 55%, indicating a spectrum from weak to strong correlation coefficients between different CODS test performances (Kadlubowski et al., 2019). If we are looking to all articles collected in this short review, its visible and heterogenous aspects between CODS testing protocols.

Two article study the relation between CODS and agility, Bayraktar, (2017), reported a significant correlation between the agility test using right foot and CODS ($r = 0.63$, $p < 0.05$) in professional female handball players, but no significant correlation with agility test using left foot and, Sattler et al., (2015) reported moderate correlations between CODS and agility ($r = 0.51–0.65$, $p < 0.05$) in college athletes.

The aim of the study. Due to the heterogeneity of CODS test relationships and the limited research on these relationships in youth soccer players, as well as the lack of studies examining CODS and agility in this group, this study aims to fill the gap. It focuses on the relationships between CODS tests with and without the ball and the relationship between CODS and agility in youth soccer players.

Methods.

Design and settings. This study followed a cross-sectional design. All participants were tested on synthetic turf while wearing soccer boots. Testing occurred between 4:00 PM and 6:00 PM under stable weather conditions, with no rain and relatively consistent humidity. Each team was tested on separate days over a three-week period from October 23, 2023, to November 10, 2023, during competitonal season, after minimum 48h before and after the official game.

The order of test execution was carefully chosen to minimize fatigue (Agility, 505, T-test, s180, Iillinois and Zigzag test). Agility was tested first due to its reliance on perceptual factors. This was followed by tests of increasing length and complexity, with the COD test with the ball conducted last.

Participants were allowed two attempts per test, with each attempt separated by a 3-minute break. The mean time of these two attempts was used for statistical analysis. If a participant did not follow the correct test itinerary, the attempt was canceled, and they were allowed to repeat it after all participants had completed the test. Additionally, a 5-minute break was provided between different tests.

The warm-up began with 5 minutes of nonspecific running at low-to-medium intensity. This was followed by 5 minutes of special running exercises, including running with knees lifted, heeling, and side steps. Next, athletes completed 5 minutes of dynamic full-body mobility exercises. Finally, two acceleration runs over approximately 25 meters were performed, with short walking breaks as active pauses in between.

Participants. The study sample consisted of 111 youth soccer players randomly recruited, both male and female, with an average age of 11.15 ± 0.47 years. These participants were actively involved in a regional under-12 championship, representing seven clubs from Alba and Hunedoara counties in Romania. Eligibility criteria for the study required participants to be in good health, with no existing health issues that could impede their performance or participation in the physical tests. The recruitment process ensured a diverse representation of players across different skill levels and playing positions, providing a comprehensive overview of COD speed and agility within this age group. All participants and their guardians provided informed consent prior to participation, adhering to ethical guidelines for research involving minors.

Physical tests. A battery of seven tests was used to assess the participants' performance, consisting of five tests for COS, one for CODS with the ball, and one for agility. The CODS tests included the 505 (Jones & Nimphius, 2018, p. 143), Illinois modified (Hachana et al. 2014), T-test modified (Dawes, 2019, p.92), s180° (Sporis et al., 2010), and Zigzag with the ball (D. Mirkov et al., 2008), all well-documented in existing literature. The agility test with double COD, designed by the research team, was similar to the Y-shape test (Lockie et al., 2014)

but included an additional change of direction and a linear segment. The human tester shows a visual signal to the right or left with their hand when the participant crosses the trigger signal gate. The participant must then change direction to touch the indicated cone and run through the finish line (see Figure 1).

We used modified versions of the Illinois and T-test due to the shorter distances, ensuring that the test duration was not too long. This modification aimed to minimize the influence of metabolic conditioning and sprint ability on test performance, allowing for a more accurate assessment of pure COD speed and agility of youth soccer players (Jones & Nimphius, 2018). Table 1 show the main characteristics of the tests used in measurements.

Data Collection. Photocells (Witty System, Microgate, Bolzano, Italy) were used to measure the performance of each test. The photocells were placed 2 meters apart and 75 cm above the ground at the start and finish line. Each participant was required to start from a point 30 centimeters before the start line to eliminate the risk of triggering the timing system prematurely.

Statistical Analysis. For statistical analyses, JASP software (version 0.18.3, University of Amsterdam) was used. The variables are presented through descriptive analysis using key metrics, which include the mean, standard deviation, 95% confidence intervals (CI) for the mean, and 95% CI for the variance. The Shapiro-Wilk test statistic was also reported. The average between two trials was used in this section. A bivariate Spearman's correlation coefficient (ρ) analysis was used to assess the relationship between test result pairs that were not normally distributed, and Pearson's correlation coefficient (r) was used for test result pairs that were normally distributed. The determination coefficient (R^2) was calculated by

Table 1

Requirements for CODS and agility tests

Test	Total Test Distance	Number of CODS	Degree of COD	Approximate Range Time of CODS Test (s)	References
Agility test	15	2	45º, 90º	3.9 – 5.5	-
505 Test	20	1	180º	2.5 – 3.3	(Jones & Nimphius, 2018)
T-test modified	20	4	90º, 180º	6.4 – 9	(Dawes, 2019)
s180 test	30	5	180º	9.1 – 12.5	(Sporis et al., 2010)
Illinois Test modified	30	7	25º, 45º, 120º	10.6 – 15.3	(Hachana et al. 2014),
Zigzag with ball	20	3	100º	7.2 – 13.8	(Mirkov et al., 2008)

Note. Adapted from Kadlubowski et al., (2019), in "The relationship between change of direction tests in elite youth soccer players", https://www.mdpi.com/2075-4663/7/5/111

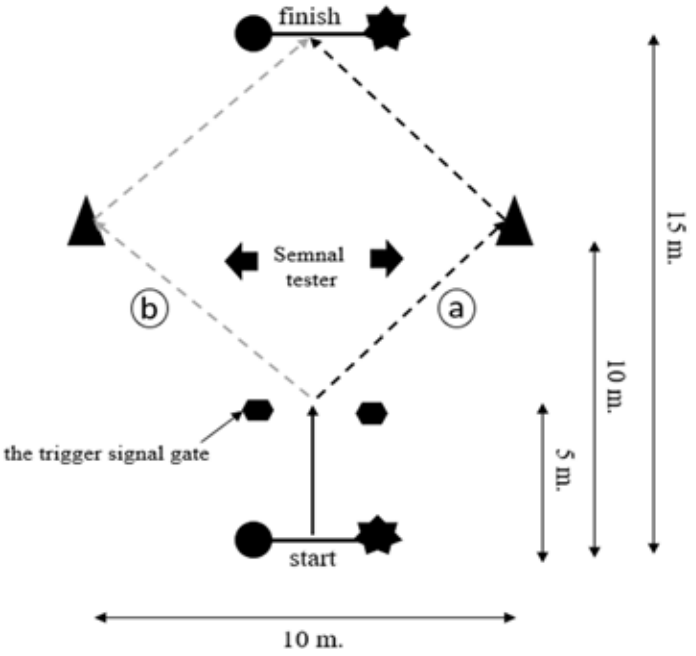

Fig. 1. Agility test with double COD

squaring the Spearman's and Pearson's correlation coefficients. A p-value less than 0.05 was considered statistically significant for all statistical analyses. The average time of trials was used for the statistical analysis. According to the qualitative correlation assessment, correlations were interpreted as follows: 0 – 0.10 negligible correlation; 0.10 – 0.39 = weak correlation, 0.40 – 0.69 = moderate correlation; 0.70 – 0.89 = strong correlation, 0.90 – 1.0 = very strong correlation (Schober et al., 2018).

Results. The agility and CODS performances, both without and with the ball, for all the different tests are displayed in Table 2.

The Shapiro-Wilk test statistics and their p-values suggest that the data for all tests were not normally distributed. Specifically, the p-values for the Shapiro-Wilk test were less than 0.05 for the 505 Test (p = 0.014), T-test (p = 0.020), s180 Test (p = 0.012), and Zigzag Test (p = 0.006), indicating significant deviations from normality. The Agility Test and Illinois Test showed p-values of 0.103 and 0.087, respectively, suggesting they did not significantly deviate from normality.

Table 3 displays the Spearman's (ρ) and Pearson (r) correlation coefficients, corresponding p-values, and determination coefficients (R^2) for the agility and CODS tests. The results indicate that all correlations are statistically significant ($p < 0.001$).

The correlations range from strong to very strong, with the strongest correlation observed between the s180 Test and Illinois Test (ρ = 0.923, R^2=0.852), indicating that 85.2% of the variance in the Illinois Test is explained by the s180 Test. Conversely, the weakest correlation is observed between the s180 Test and Zigzag Test (ρ = 0.739, R^2=0.546), with 54.6% of the variance explained.

Discussion. The aim of this cross sectional study was to focus on the relationships between CODS with and without the ball and the relationship between CODS and agility in youth soccer players. The explained variances range from 54.6% to 85.2%, indicating a spectrum from strong to very strong correlation coefficients between different CODS test and agility performances. Strong significant correlations are evident between the Zigzag test and all CODS tests, varying from (ρ = 0.739, R^2 = 0.546 to ρ = 0.787, R^2 = 0. 619), while very strong correlations occur between all other tests, starting at (ρ = 0.805, R^2 = 0.648) for the Zigzag with the ball and Agility tests, and finishing with (ρ = 0.923, R^2 = 0.852) for the Illinois and s180 tests (see Table 4). This suggests that these tests

Table 2

Summary of Descriptive Statistics for Various CODS and Agility Tests

	Agility	505	T-test	s180	Illinois	Zigzag
Valid	111	111	111	111	111	111
Mean	4.549	2.837	7.663	10.346	12.390	9.400
Std. Deviation	0.323	0.190	0.573	0.696	0.821	1.239
95% CI Variance Upper	0.132	0.046	0.400	0.624	0.878	1.947
95% CI Variance Lower	0.078	0.028	0.257	0.355	0.500	1.147
Shapiro-Wilk	0.980	0.970	0.972	0.969	0.980	0.965
P-value of Shapiro-Wilk	0.103	0.014	0.020	0.012	0.087	0.006

Table 3

Spearman's and Pearson's Correlation Coefficients Among Agility and VDSD Tests

Variable		Agility	Illinois	505	T-test	s180	Zigzag
1. Agility Test		–	–				
2. Illinois Test	r	0.797	–				
	p-value	< .001	–				
	R^2	0.635					
3. 505 Test	ρ	0.831	0.864	–			
	p-value	< .001	< .001	–			
	R^2	0.690	0.746				
4. T-test	ρ	0.818	0.860	0.857	–		
	p-value	< .001	< .001	< .001	–		
	R^2	0.668	0.739	0.734			
5. s180 Test	ρ	0.827	0.923	0.877	0.863	–	
	p-value	< .001	< .001	< .001	< .001	–	
	R^2	0.684	0.851	0.769	0.744		
6. Zigzag Test	ρ	0.805	0.759	0.787	0.780	0.739	–
	p-value	< .001	< .001	< .001	< .001	< .001	–
	R^2	0.648	0.575	0.619	0.608	0.545	

Note. ρ, Spearman's rho correlation coefficinet; r, Pearson's correlation coefficient, R^2, coefficient of determination.

are capturing similar underlying attributes of agility and CODS with an without the ball, in youth soccer players.

This study aligns with findings from previous research, such as**:** Stewart et al., (2014), Raya et al., (2013), Hachana et al., (2013), Çınarlı et al., (2018), Kadlubowski et al., (2019), which also reported moderate to strong correlations between similar CODS tests. However, it contrasts with other studies by Çınarlı et al., (2018) and Kadlubowski et al., (2019), which found no significant correlations.

As in the case of the correlations between the CODS tests themselves, this study found very strong correlations between CODS and agility. This is not perfectly in line with other studies, such as those by Bayraktar, (2017), and Sattler et al., (2015), which reported only moderate to significant correlations between CODS and agility.

The strong correlation of the Zigzag with the ball test indicates that it might be capturing some unique aspects of CODS or movement patterns not fully assessed by other CODS tests. Nonetheless, the Zigzag with the ball test shows a very strog correlation with agility, indicating that it effectively measures key components of agility, possibly because both tests involve more complex tasks (e.g. adaptation of locomotor profil about external stimul) than simply preplanned CODS. To the best of our knowledge, no other studies have specifically examined the relationship between CODS with and without the ball, or the relationship between CODS with the ball and agility.

Generally, these heterogeneous correlation results of literature can be attributed to differences in study designs, tests used, the types of subjects involved (e.g., athletes from different sports), and varying training levels Kadlubowski et al., (2019). It is important to mention that none of the aforementioned authors used the Illinois and T-test in their shorter modified versions. The strong and very strong correlations between all tests in this study may be attributed to the distances of the tests, which do not have significant differences (ranging between 15 and 30 meters) in the agility and CODS tests used.

The result of this study and very strong correlations between all CODS tests and between CODS tests and agility suggest that these tests are highly consistent in measuring the same or very similar components of agility and CODS. Based on these strong correlations, we can conclude that at this level, performance in agility is highly influenced by physical factors, a conclusion also supported by Thieschäfer & Büsch, (2022). This high level of consistency indicates that these tests can be used interchangeably to some extent for assessing these abilities in youth soccer players.

The sample size and demographic scope of this study, while sufficient for initial insights, are relatively limited. Larger and more diverse samples, including various age groups and competitive levels, could yield more generalizable results. Additionally, the modifications version of the Illinois and T-tests, although necessary to accommodate the age and skill level of the participants, may have impacted the comparability of our findings with other studies utilizing standard versions of these tests.

Furthermore, all tests were administered within a single session, which could have introduced variability due to fatigue, motivation, and other transient factors affecting the participants' performance. Conducting repeated testing sessions over time would help to better assess the consistency and reliability of the results, providing a more robust understanding of agility and CODS in youth soccer players.

Conclusions. The investigation into the relationships between various CODS tests, both with and without the ball, and a newly designed agility test, revealed significant insights. The results demonstrated strong correlations and variances between CODS tests with the ball and those without, as well as very strong correlations between CODS tests with and without the ball and agility tests, showing importance of phisical aspect in agility performance at this level. These findings suggest that the tests used in this study measure similar underlying attributes of agility and CODS, both with and without the ball. The consistency of these results with previous research underscores the reliability of the modified CODS performance tests and their applicability in assessing youth soccer players.

However, the study also acknowledges several limitations, including the relatively small and demographically limited sample size, the use of modified versions of the Illinois and T-tests and their comparability with standard versions, and the potential variability introduced by conducting all tests within a single session. Future research should consider larger and more diverse samples, repeated testing sessions, and comparisons with standard test versions to further validate and expand upon these findings.

In conclusion, the very strong correlations between all CODS tests and between CODS and agility tests suggest that these assessments are highly consistent in measuring similar components of agility and CODS. This high level of consistency supports the interchangeable use of these tests for evaluating these abilities in youth soccer players at the U12 level. The study provides valuable insights into the performance assessment of young athletes and emphasizes the need for continued research to refine these evaluation methods.

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ШВИДКІСТЬ ЗМІНИ НАПРЯМКУ ТА СПРИТНІСТЬ: ПРОЯВ ТА ЗВ'ЯЗОК У ФУТБОЛІСТІВ-ЮНАКІВ

Швидкість зміни напрямку (ШЗН) і спритність є критичними компонентами футбольної продуктивності через велику кількість змін напрямку, які відбуваються під час матчу. Це дослідження вивчає взаємозв'язки між різними тестами швидкості зміни напрямку, як з м'ячем, так і без нього, та новим тестом на спритність у молодих футболістів. Вибірка з 111 молодих футболістів (11,15 ± 0,47 років) брала участь у серії фізичних тестів, включаючи модифіковані версії тестів Іллінойсу та Т-тесту, тест 505, тест s180 та тест «Зигзаг» з м'ячем. Результати показали сильні кореляції та варіації між швидкістю зміни напрямку з м'ячем і тестами швидкості зміни напрямку без м'яча, що коливаються від ($\rho = 0,739$, $R^2 = 0,546$) до ($\rho = 0,787$, $R^2 = 0,619$). Були виявлені дуже сильні кореляції між тестами швидкості зміни напрямку (модифіковані Іллінойс та Т-тести, 505, s180) без м'яча, що коливаються від ($\rho = 0,857$, $R^2 = 0,734$) до ($\rho = 0,923$, $R^2 = 0,852$). Крім того, були помічені дуже сильні кореляції між швидкістю зміни напрямку з і без м'яча та спритністю, що коливаються у діапазоні від ($\rho = 0,805$, $R^2 = 0,648$) до ($\rho = 0,831$, $R^2 = 0,690$). Ці результати свідчать про те, що тести вимірюють схожі основні атрибути спритності та швидкості зміни напрямку, як з м'ячем, так і без нього. Дослідження надає цінні висновки про взаємозв'язки між різними тестами швидкості зміни напрямку і спритністю, що сприяє кращому розумінню оцінки продуктивності у молодих футболістів.

Ключові слова: *швидкість зміни напрямку, спритність, юні футболісти, аналіз продуктивності.*

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