Central European Journal of Sport Sciences and Medicine | Vol. 44, No. 4/2023: 63–77
ISSN (print): 2300-9705 | ISSN (online): 2353-2807 | DOI: 10.18276/cej.2023.4-06

ASSESSMENT OF CHANGE OF DIRECTION AND AGILITY. RUNNING AND DRIBBLING AMONG SOCCER, BASKETBALL AND HANDBALL PLAYERS: THE CONCEPT OF "AGILITY DEFICIT"

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[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation; [E] Funds Collection

Abstract The primary objective of this study is to conduct a comparative analysis of change of direction (COD) and agility among players engaged in soccer, basketball, and handball. Additionally, the researchers introduced the novel concept of "Agility deficit", aimed at evaluating distinctions between COD and agility during running (COD-R; Agility-R) and dribbling (COD-D; Agility-D). The participant cohort comprises 38 individuals with an average age of 20.63 years, distributed across 13 handball players, 12 soccer players, and 13 basketball players. Statistical analyses, specifically ANOVA accompanied by Tukey's post hoc comparisons, have been employed to discern significant differences among subgroups. While no noteworthy disparities among groups were observed in both COD-D and Agility-D when participants manipulated the balls using their hands, a marked superiority in performance emerged for soccer players when the balls were manipulated with their legs. Soccer players exhibited expedited responses compared to their basketball and handball counterparts when confronted with a visual stimulus during the Agility-R test (reduced Agility-R deficit). Furthermore, the Agility-D deficit underscored the heightened visual challenge to react in visual stimuli during dribbling in soccer. Independent of the type of ball handling, soccer players consistently demonstrated a diminished Agility-D deficit, affirming their superior visual ability. The performance in Agility-D further revealed that visual ability plays a pivotal role in influencing dribbling ability. The study posits that, for a comprehensive assessment of a player's visual ability during running or dribbling, interpretations of both Agility-R deficit and Agility-D deficit are imperative. Consequently, the proposed indexes of Agility-R deficit and Agility-D deficit present valuable tools for evaluating players' COD and Agility abilities during running or dibbling. However, the efficacy of these assessments in real-game situations remains undetermined, requiring further investigation.

Key words: soccer, basketball, handball, COD, agility

Introduction

Success in team sports depends on various factors including players' psychological, physical, cognitive, technical, and tactical abilities. The interaction of these factors determines performance (Chamari et al., 2004; Reilly et al., 2000; Sporiš et al., 2014). Most team sports exhibit an intermittent nature where multi-directional, linear and repeated sprint abilities have garnered significant interest in the literature (Gray & Jenkins, 2010; Murr et al., 2018). Additionally, team sports such as soccer, basketball, and handball involve multiple movement patterns that necessitate sudden and rapid changes of direction by players (Özgür et al., 2016).

While past studies have primarily focused on assessing change of direction (COD) ability and its specific requirements (e.g., straight-line sprint, leg muscle qualities, running technique), it is essential to note that COD involves only pre-planned movements (Gioldasis et al., 2022; Šimonek et al., 2017; Young et al., 2015). Currently, COD tasks are also categorized into force and sprint-oriented based on the angle of direction change and the required physical mechanism (Bourgeois et al., 2017). Consequently, various testing protocols are employed to evaluate COD performance in team sports. However, many of these tests primarily measure the ability to quickly change the direction without accounting for responses to external unpredictable stimuli (Krolo et al., 2020). In contrast, most COD movements in team sports are not pre-planned but executed in response to an external stimulus, a skill defined as agility (Sheppard & Young, 2006). It is widely recognized that agility is a multi-dimensional ability dependent on the optimal combination of physical (e.g., strength, power, speed, balance, coordination, running technique) and cognitive (e.g., anticipation, reaction time, decision making, visual scanning) abilities of players (Krolo et al., 2020; Lloyd et al., 2015; Özgür et al., 2016; Sekulic et al., 2017; Young et al., 2015). Specifically, agility is defined as a rapid, whole-body change of direction or speed in response to sport-specific stimuli (Shepard & Young, 2006).

At this juncture, it is evident that both COD and agility are crucial factors for the future success of players in soccer, basketball, and handball (Little & Williams, 2003; Loturco et al., 2018; Šimonek, et al., 2017; Young & Rogers, 2014). Players need to effectively perform various complex dynamic movements with or/and without the ball in response to unpredictable environments influenced by opponents, teammates, and ball possession (Cortis et al., 2013; Esfahankalati & Venkatesh, 2013). Players with high agility levels gain a defensive or attacking tactical advantage, reducing opponents' chances of an appropriate response (Iacono et al., 2015; Nimphius et al., 2017; Sisic et al., 2016). Moreover, they perceive relevant information about opponents' activities and react with higher accuracy and velocity than players with lower agility levels (Jackson et al., 2006; Serpell et al., 2011). While COD enables players to outperform opponents with pre-planned movement patterns, they must also respond and use non-planned movements in response to unpredictable opponents' reactions (Sisic et al., 2016). Consequently, agility and COD abilities vary among sports due to different sport requirements and rules. For instance, soccer, basketball, and handball differ in playing field, goal or point-scoring methods, general rules, and participating body limbs during dribbling, all of which likely influence sport-specific requirements. Among the skills related to agility and COD abilities, running with the ball (dribbling) constitutes a significant portion of gameplay and is crucial to the outcome of a game (Scanlan et al., 2018; Trecroci et al., 2016). This skill likely advances player's agility and COD abilities, introducing the additional challenge of maintaining ball possession under unpredictable stimuli (Bekris et al., 2018a). Additionally, this skill may partially explain the significant differences in observed agility among players in various team sports (Horička et al., 2014).

Although numerous studies have identified different types of COD (e.g., zig-zag, lateral, forward-backward running), investigate different types of agility is also essential (Sekulic et al., 2013). In soccer, agility primarily involves non-stop running scenarios, while in handball and basketball, players often perform stop-and-go reactive-agility patterns (Karcher & Buchheit, 2014; Spasic et al., 2015). Players with superior agility in team sports can outperform their opponents in 1vs1 duels, blocking, defensive and offensive positioning, and quickly reacting to opponents' changes in direction (Delextrat et al., 2015; Hammami et al., 2015; Krause & Nelson, 2018; Spasic et al., 2015). In soccer, weak agility and low balance during dribbling can lead to opponents easily capturing the ball. Therefore, agility significantly influences speed and dribbling skills, and a low agility level makes it challenging to outperform opponent's defense (Abidin et al., 2020).

A relevant factor explaining agility differences among team sports is the development of different visual strategies used by high and low-skilled players (Bekris et al., 2018a; Rivilla García et al., 2013; Turner, 2011; Wu et al., 2013). The crucial role that agility plays in performance emphasizes the importance of the fundamental element of visual scanning. Consequently, sports' structure influences visual demands and improves players' visual behavior at different levels. More skilled players produce more accurate and quicker responses due to their ability to pick up anticipatory cues about the posture and kinematics of an opponent (Turner, 2011). Visual training is suggested to enhance visual processing, cognition of visual information, and attention to read environmental changes such as teammates' and opponents' activities as well as the ball's trajectory (Afshar et al., 2019; Chaalali et al., 2016; Hatzitaki et al., 2009). Despite the distinctive role of visual behavior in playing level, it is important to note that most players have never received specific visual training (Alves et al., 2015). In this study, the researchers explore the difference between COD and Agility with a ball (Agility-D deficit) and the difference between COD and Agility without a ball (Agility-R deficit) to isolate perceptual strategies (e.g., visual scanning) likely affecting these abilities. The term "deficit" from COD testing is used to isolate change of direction ability from straight-line sprint ability (Nimphius et al., 2013). The researchers decided to apply this definition to isolate the cognitive patterns of COD and Agility, abilities crucial in team-sports.

The objective of this study was to investigate: (a) the subtraction between COD and Agility abilities (i.e. Agility-R and Agility-D deficits) aiming to assess the perceptual components of Agility; (b) the perceptual challenges inherent in various sports, as indicated by differences in Agility deficits within each sport, both with and without the presence of a ball; (c) the identification of players exhibiting superior performance under distinct ball-handling rules and exploring the potential impact of technical proficiency on perceptual abilities; and (d) the identification of players demonstrating heightened Agility deficit performance. The researchers posited two main hypotheses: (a) that sports exhibit variability in agility demands due to distinctions in perceptual requirements; and (b) that soccer players encounter greater challenges during dribbling compared to running, while concurrently demonstrating heightened perceptual adaptations.

Methods

Participants

A total of thirty-eight male players (aged 20.63 ±1.94 years, training experience 8.9 ±2.0 years) participated in the study. Specifically, thirteen Handball Players (HP; aged 21.00 ±2.31 years, training experience 8.12 ±2.21 years), twelve Soccer Players (SP; aged 20.08 ±1.44 years, training experience 9.28 ±2.05 years), and thirteen Basketball Players (BP; aged 20.77 ±1.96 years, training experience 9.51 ±1.93 years), all members of amateur adult teams, were included. Participants engaged in three training sessions and one day game per week. None of them had received specific visual training in the past, and all were undergraduate students at the Sports Sciences University. Informed written consent, approved by the university ethics committee (National and Kapodistrian University of Athens; Department of Physical Education and Sport Science; Dafni; Wednesday 11 March 2020; Protocol Number: 1173/11-03-2020), was obtained from all participants. Additionally, participants completed a questionnaire identifying any potential lower extremity injuries, vestibular and visual problems gained in the last competitive season, and those not meeting the criteria were excluded from the study.

Procedures

The study occurred during the transition period of soccer, basketball, and handball amateur leagues. Participants underwent two familiarization trials a week before the main recorded trials. Researchers randomly assigned players to testing groups and evaluated them in all tests (four in total) on different days and times to prevent extended breaks. Two main trials were conducted per day, with the superior performance chosen for further analysis. Each day featured a different test, ensuring a 48-hour rest period between trials (Asadi et al., 2016). In dribbling tests, players executed the tasks by hands for basketball and handball measurements and by legs for soccer measurement. Participants donned athletic attire and non-spiked footwear while undergoing assessments on a wooden court surface. Before the assessments, each participant was verbally encouraged and instructed to perform a maximal effort during the tests. Furthermore, before testing participants completed a 15-minute without-ball warm-up (jogging, running, sprinting, and stretching) and a 10-minute with-ball warm-up (passing, dribbling, duels, and shoots).

Testing

Body mass and height were measured with a weight and height scale to the nearest 0.1 kg/cm (BC1000, Tanita, Japan). COD Running (COD-R) and COD Dribbling (COD-D) were assessed using an adapted format of the Dribbling Agility Test (DAT) (Bekris et al., 2018b). Specifically, researchers “constructed” a 7X7m square-shaped area, including another small square (1-m long on each side) in the centre. Four gates, 80cm wide between the cone and the light of the agility test, were positioned in the middle of each side of the large square (Figure 1). A dual infrared reflex photoelectric cell system (Polifemo, Microgate, Bolzano, Italy) was used to measure the time.

One pair of photocells was initially placed in the middle of the small square and removed by researchers after the participants' first pass. Another pair was placed at the 3rd gate. The COD-R and COD-D tasks involved running on a preplanned path (either with or without a ball) from the small central square and passing through the gates between the cones and photocells. The test began with players in the central small square, facing the researchers standing behind gate N°1. The specific route used was from the centre to gate N°1 (straight), from gate N°1 to gate N°2 (right), from gate N°2 to gate N°3 (right), from gate N°3 to gate N°1 (straight), from gate N°1 to gate N°4 (left), from gate N°4 to gate N°3 (left), from gate N°3 to gate N°2 (left), and from gate N°2 to gate N°3 (right). Participants always had to pass through the small central square before reaching the next gate.

The same square-shaped area was used to evaluate Agility Running (Agility-R) and Agility Dribbling (Agility-D) with DAT (Bekris et al., 2018b). Researchers removed photocells and utilized four lights from the FitLight trainer (Sport Corp.; Ontario, Canada), positioned in the middle of each side. At the beginning of the agility tests, participants were placed inside the central square (either with or without a ball), and all lights were turned on in different colors (red, yellow, blue, green). Following a visual signal, participants had to run and pass through the gate with the blue light. Immediately after passing the gate, the light was turned off, and the light of another gate turned blue. Agility tests included two different but equal protocols with a specific number of direction changes (three to the left and three to the right) and the same total distance. Participants were informed that the test used a random pattern, making it pointless to memorize the sequence. They were encouraged to react to the blue light as quickly as possible. Additionally, players were not allowed to observe the trials of their teammates.

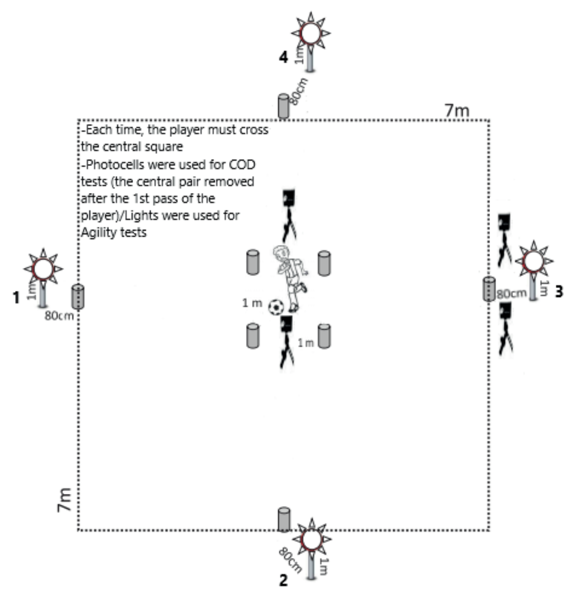

Figure 1. Adapted COD and Agility DAT tests with and/or without the ball [derived from Bekris and colleagues (2018b)]

Analysis

All statistical analysis were performed using the SPSS statistical package (IBM corporation released 2019; IBM SPSS Statistics for Windows, Version 26.0; Armonk, NY: IBM corporation), and the level of significance was set at $p < 0.05$. G*Power 3.1 software was utilized to calculate statistical power (=0.67). Descriptive statistics are presented as means (M) and standard deviations (SD). Tests for normal distribution and homogeneity (Shapiro-Wilk and Levene's, respectively), conducted with a significance level of $p > 0.05$ before analysis, indicated a normal and homogeneous distribution of the dataset. One-way analysis of variance (ANOVA) was chosen to examine differences among sports concerning COD-R, COD-D, Agility-R, and Agility-D (Sheskin, 2000). Tukey's post hoc comparisons were conducted where significant main effects were observed. Effect sizes for main effects and interactions were determined by calculating partial eta squared (η^2) values. Effect sizes were categorized as small (0.01–0.06), moderate (0.06–0.14), and large (≥0.14). Pearson correlation analyses (*r*) were performed, and the significance level was classified as very weak (0.0 to 0.2), weak (0.2 to 0.4), moderate (0.4 to 0.7), strong (0.7 to 0.9), and very strong (0.9 to 1.0) (Rowntree, 2000; Tomczak & Tomczak, 2014).

Results

The following table presents the descriptive statistics of the sample, as well as the one-way analysis of variance (ANOVA) of the variables and the Tukey's post hoc comparisons.

Table 1. Descriptive statistics and comparisons of COD and Agility abilities among handball, basketball, and soccer players

Sport	Total	Handball HP	Soccer SP	Basketball BP	ANOVA	df	η^2	Tukey's
N	38	13	12	13				
Age	20.63 ±1.94	21.00 ±2.31	20.08 ±1.44	20.77 ±1.96				
Body height (cm)	171.70 ±7.2	165.9 ±6.30	174.5 ±6.90	174.70 ±7.80				
Body weight (kg)	69.90 ±8.90	65.10 ±9.10	73.1 ±8.20	71.50 ±10.10				
BMI (kg/m²)	23.60 ±2.40	23.60 ±2.70	23.9 ±2.10	23.20 ±2.40				
COD-R	18.61 ±0.74	18.39 ±0.74	18.94 ±0.61	18.52 ±0.78	4.379	2	0.11	
COD-D					25.573***	2	0.62	SP>HP;SP>BP
Handball Ball	20.42 ±0.99	20.58 ±0.91	20.64 ±0.90	20.04 ±1.11				
Soccer Ball	28.56 ±4.10	30.37 ±4.93	24.91 ± 1.22	30.13 ±2.55				
Basketball Ball	20.29 ±1.16	20.61 ±1.25	20.52 ±0.99	19.76 ±1.09				
Agility-R	20.13 ±0.93	19.91 ±0.94	20.03 ±0.81	20.43 ±1.00	1.713	2	–0.07	
Agility-D					26.360***	2	0.64	SP>HP;SP>BP
Handball Ball	21.87 ±1.20	22.02 ±1.03	21.91 ±1.60	21.68 ±1.00				
Soccer Ball	31.15 ±4.07	33.09 ±4.42	27.23 ±1.55	32.82 ±2.62				
Basketball Ball	21.59 ±1.12	21.92 ±0.96	21.68 ±1.45	21.17 ±0.84				
Agility-R deficit	1.52 ±0.75	1.52 ±0.62	1.09 ±0.71	1.91 ±0.75	4.379*	2	0.11	SP<BP

Sport	Total	Handball HP	Soccer SP	Basketball BP	ANOVA	df	η^2	Tukey's
Agility-D deficit								
Each Sport's Ball	1.71 ±0.98	1.45 ±0.86	2.32 ±1.18	1.41 ±0.63	3.935*	2	–0.02	SP>HP;SP>BP
Handball Ball (same ball all the players)	1.46 ±0.88	1.45 ±0.86	1.27 ±0.90	1.64 ±0.91	1.42	2	–0.07	
Soccer Ball (same ball all the players)	2.59 ± 1.36	2.72 ± 1.67	2.32 ±1.18	2.69 ± 1.21	0.323	2	–0.11	
Basketball Ball (same ball all the players)	1.30 ±0.74	1.32 ±0.82	1.16 ±0.80	1.41 ±0.63	0.757	2	–0.09	

Notes: sig. p < 0.05 *, p < 0.01 **, p < 0.001 ***
Effect size (η^2): <0.06 = small effect, 0.06–0.14 = moderate effect, ≥0.14 = large effect.
Abbreviations: Handball Players (HP, Soccer Players (SP), Basketball Players (BP), COD-Running (COD-R), COD-Dribbling (COD-D), Agility-Running (Agility-R), Agility-Dribbling (Agility-D).

ANOVA tests were conducted to examine differences in COD-R, COD-D, Agility-R, and Agility-D among different sports (Table 1). Specifically, the ANOVA analysis revealed non-significant differences among handball, soccer, and basketball players in COD-R. However, a significant difference was found among handball, soccer and basketball players in COD-D. Tukeys' comparisons indicated that SP (24.91 ±1.22) significantly differed from HP (20.58 ± .91) and BP (19.76 ±1.09). Furthermore, the ANOVA analysis revealed non-significant differences among handball, soccer, and basketball players in Agility-R. Conversely, a significant difference was found among handball, soccer, and basketball players in Agility-D. Tukeys' comparisons showed that SP (27.23 ±1.55) significantly differed from HP (22.02 ±1.03) and BP (21.17 ±0.84). Concerning Agility-R deficit, the ANOVA analysis revealed a significant difference among handball, soccer, and basketball players, with Tukeys' comparisons indicating that SP (1.09 ±0.71) significantly differed only from BP (1.91 ±0.75). Additionally, the ANOVA analysis revealed a significant difference among handball, soccer, and basketball players in Agility-D deficit when specific sport players used the ball of their sport. Tukeys' comparisons showed that SP (2.32 ±1.18) significantly differed from HP (1.45 ±0.86) and BP (1.41 ±0.63). On the contrary, the ANOVA analysis revealed a non-significant difference among handball, soccer, and basketball players in Agility-D deficit when assessed with the handball ball, soccer ball, and basketball ball.

The following table reports the correlations between the measured abilities for the entire sample, as well as each sport separately.

Table 2. Correlations of COD and Agility abilities, with and/or without the ball, among handball, basketball, and soccer players

	COD-R	COD-D	Agility-R	Agility-D
Total sample				
COD-R	1			
COD-D	0.492**	1		
Agility-R	0.610***	–	1	
Agility-D	–	0.946***	0.097	1
Soccer				
COD-R	1			
COD-D	0.327	1		
Agility-R	0.535	–	1	
Agility-D	–	0.653*	0.664*	1

	COD-R	COD-D	Agility-R	Agility-D
Basketball				
COD-R	1			
COD-D	0.802***	1		
Agility-R	0.670**	–	1	
Agility-D	–	0.819***	0.829***	1
Handball				
COD-R	1			
COD-D	0.522	1		
Agility-R	0.756**	–	1	
Agility-D	–	0.616*	0.112	1

Notes: sig. p < 0.05 *, p < 0.01 **, p < 0.001 ***
COD-R and Agility-D as well as COD-D and Agility-R were not interpreted.
Magnitude (r): <0.20 = very weak correlation, 0.20–0.40 = weak correlation, 0.40–0.70 = moderate correlation, 0.70–0.90 = strong correlation, 0.90–1.00 = very strong correlation.

Table 2 illustrated the correlations among abilities within each examined sport. Specifically, COD-D and COD-R abilities in team sports were moderately positively correlated. More specifically, in soccer and handball, these abilities were not correlated, while in basketball, they were strongly positively correlated. Agility-R and COD-R abilities in team sports were moderately positively correlated overall. Specifically, in soccer, they were not correlated, while in basketball and handball, they were moderately positively and strongly positively correlated, respectively. Agility-D and COD-R abilities in team sports were moderately positively correlated overall. However, in subgroup correlations, no significant relationship was found. Agility-R and COD-D abilities in team sports were not correlated overall. In particular, in soccer and handball, no correlation was found, while in basketball, they were strongly positively correlated. Agility-D and COD-D abilities in team sports were very strongly positively correlated overall. Although in soccer and handball, they were moderately positively correlated, in basketball, they were strongly positively correlated. Finally, Agility-D and Agility-R abilities in team sports were not correlated overall. However, in soccer, they were moderately positively correlated, in basketball, they were strongly positively correlated, and in handball, they were not correlated.

Discussion

The primary objective of this investigation is to discern variances in both physical and technical capabilities among the examined soccer, basketball, and handball players, measured with COD-R, Agility-R, COD-D, and Agility-D tests. Furthermore, the study seeks to elucidate the factors that impact the relationships among these abilities. In an innovative approach, the researchers introduce the concept of “agility deficit”, a metric contingent upon the temporal disparity between change of direction (COD) and agility, with and/or without the presence of a ball.

The significance of this study is underscored by the dynamic nature inherent in these sports, wherein players are compelled to execute complex movement patterns in response to external stimuli. These stimuli encompass diverse factors such as ball movement, interactions with teammates and opponents, and evolving game scenarios (Sheppard & Young, 2006). Significant emphasis lies in the prompt identification of visual stimuli by participants, exerting influence on perceptual and cognitive parameters, notably decision-making abilities. This, consequently, assumes a pivotal role in shaping the overarching performance of the individuals.

The principal findings of this study reveal that both COD-R and Agility-R did not exhibit significant differences among various sports. These outcomes align with earlier research, indicating either no differences or slight variations in COD-R and Agility-R among players engaged in diverse team sports (Horička et al., 2014; Šimonek et al., 2017). Literature review suggests the independence of COD and Agility as physical abilities. It underscores the significance of incorporating perceptual components in defining agility, thereby contributing to the differentiation between these two abilities (Sheppard & Young, 2006; Young et al., 2002). This finding allows researchers to compare and interpret differences in dribbling based on the observation that participants did not significantly differ in physical parameters encompassed by COD and Agility running. Consequently, any distinctions observed are attributed to the required technique and associated perceptual cues. Specifically, the examined soccer, basketball, and handball players significantly differed in both COD-D and Agility-D abilities. Soccer players exhibited longer COD-D and Agility-D durations compared to their basketball and handball counterparts. This suggests that, with the introduction of a dribbling task, soccer places higher demands on players, requiring complex movement patterns involving ball manipulation with the legs, thereby accentuating the sport's unique demands. In contrast, basketball and handball players, manipulating the ball with their hands, potentially find it easier to perceive environmental changes.

The inquiry pertains to the impact of augmented visual stimuli on the preplanned movement patterns of players during agility assessments. In this context, it was imperative to calculate the disparity between Agility-R and COD-R (Agility-R deficit), as well as Agility-D and COD-D (Agility-D deficit) in each sport. While a significant difference among sports was identified, only soccer players exhibited a significantly smaller deficit compared to basketball players, and a smaller, albeit non-significant, disparity compared to handball players. The interpretation of these outcomes suggests that soccer players demonstrated superior responsiveness to a visual stimulus during the Agility-R test in comparison to basketball and handball players. This finding likely indicates that the examined soccer players had already developed heightened visual abilities, including peripheral vision and visual recognition, along with an enhanced adaptability to unpredictable visual stimuli (Chaalali et al., 2016). Consequently, soccer players' performance on Agility-R deficit was not reduced as pronounced as observed in basketball and handball players. In summary, within the specific population under investigation in this study, these differences can be attributed to the inherently more demanding and dynamic nature of soccer. Soccer necessitates more frequent and rapid motor reactions to visual stimuli, particularly under conditions of high intensity speeds, within the confines of smaller court dimensions with a greater number of competing players. Collectively, a soccer player must not only possess the requisite physical capabilities to effectively navigate the sport's demands but also the cognitive abilities to perceive and react within a constrained timeframe (Sariati et al., 2020).

Similarly, when assessing Agility-D deficit in each sport, considerable differences were found, particularly for the examined soccer players compared to basketball and handball players. These differences underscore the increased visual difficulty when reacting to visual cues during dribbling in soccer. Despite testing of all players with balls from other sports, no significant differences were noted, except from the examined soccer players who exhibited shorter Agility-D deficit, independent of the ball. While the performance of the examined soccer players exhibited similar outcomes in terms of COD-D when utilizing with basketball and handball ball, their performance manifested a lesser degree of negative impact than that observed in other players with respect to Agility-D. This observation substantiates the superior visual ability that the examined soccer players have developed in the context of dribbling ability, irrespective of their primary sport. Presumably, this proficiency can be attributed to an augmented perceptual acumen and an elevated level of adaptation of soccer players who have previously undergone training under analogous visually demanding conditions. The extant literature aligns with these findings by positing the heightened relevance of agility to soccer, given that COD movements seldom occur in isolation from external stimuli, as noted by Chaalali et al. (2016). Consequently, it is inferred that the proficiency in dribbling does not wield a commensurate influence on Agility-D, thereby recommending training interventions that incorporate perceptual and visual components, as advocated by Young et al. (2015).

In contrast, the examined basketball and handball players subjected to assessment while manipulating the ball with their legs demonstrated a comparatively lesser degree of adaptability. This suggests that the proposed parameters of Agility-R deficit and Agility-D deficit may serve as valuable metrics for evaluating players' COD and Agility abilities, both with and without ball. However, the translational efficacy of these assessments to real-game scenarios remains uncertain and warrants further investigation. It is imperative to underscore that these differences necessitates a comprehensive analysis by practitioners, considering not only the outcome in Agility-R and Agility-D but also in COD-R and COD-D, to derive a holistic perspective and optimize players' performance. Notably, when all players employed a soccer ball, the examined soccer players exhibited a substantial Agility-D deficit. Nevertheless, their overall time in Agility-D was considerably shorter than that of their basketball and handball counterparts. This discrepancy is explicable by the soccer players' superior initiation time in COD-D, resulting in accelerated movement, rendering it impractical to diminish difference in Agility-D.

The data analysis also disclosed a non-significant correlation between Agility-R and Agility-D in the total sample. This finding suggests that the introduction of a ball during the dribbling test induces alterations in visual behavior and elevates the level of test complexity relative to running tests. However, upon disaggregating this relationship within each sport, notable disparities emerged, revealing a high correlation in basketball and a moderate correlation in soccer. Presumably, these distinctions are elucidated by the divergent technical requisites inherent to each sport and the techniques employed by individual players. It is conceivable that the examined basketball players remained unaffected by ball handling during the dribbling test, suggesting that this particular task did not introduce additional difficulty. This outcome underscores the imperative to devise a different evaluation protocol for assessing Agility-D in basketball. Conversely, in the context of handball, no discernible relationship was observed between Agility-R and Agility-D abilities.

Evidently, for the examined handball players, the aptitude to interact and respond with a ball amidst visual stimuli represents a skill distinctly disparate from executing dribbling maneuvers along a pre-planned trajectory. This finding is likely attributed to the sport's technical demands and the smaller size of the ball. Moreover, the examined handball players are presumably unaccustomed to protracted periods of dribbling without ball catching to explore the court. Consequently, the formulation of distinct assessment protocols tailored to the unique requirements of handball may be imperative for appraising Agility-R and Agility-D abilities.

In the domain of soccer, the manipulation of the ball exerted a moderate influence on the examined players' performance in the Agility-D test. This observation implies that the Agility-D test can serve as a viable metric for evaluating the agility ability of soccer players, including the differentiation between Agility-D and Agility-R, a pivotal performance indicator necessitating improvement during training. Furthermore, a moderate relationship between COD-R and COD-D was observed for the whole sample. Nevertheless, upon closer scrutiny within each sport, a high positive relationship was only discernible for the examined basketball players. This alignment with prior research (Scanlan et al., 2018) underscores the notion that incorporating a dribbling task during COD imposes comparable additional time demands, highlighting the significance of dribbling ability in COD movements within basketball. This finding underscores the significance of dribbling within COD movements, particularly within the context of basketball, which encompasses extensive multidirectional actions necessitating the execution of dribbling maneuvers while altering directions in various in-game scenarios, such as crossover maneuvers and evading opponents (Abdelkrim et al., 2007; Torres-Unda et al., 2013). While limited studies specifically investigate the relationship between COD-R and COD-D, extant evidence indicates low or non-significant associations in soccer and handball (Islam & Kundu, 2020; Zapartidis et al., 2018). Notably, it has been posited that among various motor abilities potentially influencing dribbling skill in handball, running does not contribute significantly to this relationship, likely attributable to the different sport requirements (Kelmendi et al., 2016).

It is imperative to note that the current test needs validation in subsequent studies, particularly in the context of basketball, where a player's quickness appears to correlate with performance during the dribbling test, irrespective of technical proficiency. It was further shown that the better the COD-R is the moderately more the Agility-R improves when the whole sample was examined. Additionally, the findings affirm that while a swift player is more likely to excel in Agility-R, these variables remain relatively independent, sharing minimal common variance (Coh et al., 2018; Dugdale et al., 2020; Nimphius et al., 2017; Sheppard et al., 2006). The strength of the correlation varies within each sport, with soccer exhibiting marginal non-significance and basketball and handball showing moderate significance. The degree of these correlations indicates that Agility-R exhibits a relatively independent relationship with the COD-R, a finding substantiated by prior research in the domains of basketball and handball (Hallberg Lyggemark, 2018; Spiteri et al., 2014). These outcomes lend support to the proposition that COD and agility should not be construed as the same ability (Sattler et al., 2015; Spasic et al., 2015) supporting the notion that physical and physiological factors, such as linear speed and lower-body muscular activity, play a more pronounced role in COD as a component of agility (Hojka et al., 2016). The suggestion is further posited that improvements in agility hinge predominantly on enhanced perceptual abilities to respond to external stimuli, rather than on actual movement speed, which exhibits a stronger correlation with COD (Young & Rogers, 2014).

Finally, the interpretation of results underscores that superior COD-D corresponds to a more pronounced enhancement in Agility-D when considering the entire sample. This observation unequivocally implies that, irrespective of the presence of a visual stimulus, technique development remains a pivotal factor in augmenting Agility-D proficiency. Nonetheless, when scrutinizing this relationship within each sport, the strength of the association was notably robust for the examined basketball players but markedly weaker for the examined soccer and handball players. This finding, as previously mentioned, is likely attributable to disparities in ball manipulation, player skill level, and the inherent challenges posed by the test within each group of players.

Conclusions

Agility and COD abilities constitute integral determinants of performance in team-sports, serving as discriminators between players of varying skill levels. It is imperative to scrutinize these abilities distinctly, encompassing evaluations both with and without the incorporation of dribbling. Consequently, the examination of these abilities necessitates discrete testing, coupled with a meticulous interpretation of the outcomes. Notably, the principal findings of the study unveiled that the examined soccer players demonstrated a diminished Agility-R deficit, indicative of a heightened capacity for adapting to unpredictable visual stimuli during running.

The assessment in soccer conditions is notably demanding in relation to COD-D and Agility-D, as evidenced by the extended duration required by the examined soccer players to complete these evaluating measures. Additionally, their protracted Agility-D deficit underscored the difficulty of soccer players executing dribbling maneuvers while concurrently responding to visual stimuli. Nevertheless, they demonstrated the shortest Agility-D deficit when employing consistent ball dribbling rules across all participants, regardless of their respective sport domains. This observation suggests that soccer players, irrespective of their individual technical proficiency-a factor deemed inconsequential in determining Agility-D-manifested superior visual abilities compared to their counterparts.

This study introduces the potential performance indexes of Agility-R deficit and Agility-D deficit, which necessitate interpretation alongside performance in Agility-R, COD-R, Agility-D, and COD-D tests. The study acknowledges certain limitations, including the application of the DAT test in basketball and handball players for a first time. While the researchers maintained consistency in test structure with the soccer DAT test, validation of the test across diverse team sports is recommended for future investigations. Additionally, the study's limitation in terms of a relatively small sample of adult males underscores the necessity for future research to encompass larger, more diverse, and younger populations, including both genders. Furthermore, future research endeavors are encouraged to extend beyond controlled settings, exploring variables such as Agility-D within more realistic game scenarios, such as 1vs1 sport conditions. In essence, the presented data offers valuable insights for coaches and practitioners, aiding in the evaluation of players' abilities and informing the design of training sessions geared towards holistic development. A concluding recommendation for soccer practitioners is to intensify the complexity and visual stimuli within training exercises to foster enhanced motor and perceptual competencies among players.

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Appendix

DAT protocols

The protocols' sequence of gates for DAT testing was as follows: The first path was running or dribbling from the centre to the light N°1 (straight), from the light N°1 to the light N°2 (right), from the light N°2 to the light N°3 (right), from the light N°3 to the light N°1 (straight), from the light N°1 to the light N°4 (left), from the light N°4 to the light N°3 (left), from the light N°3 to the light N°2 (left), and from the light N°2 to the light N°3 (right). The second path was running or dribbling from the centre to the light N°4 (straight), from the light N°4 to the light N°1 (right), from the light N°1 to the light N°2 (right), from the light N°2 to the light N°4 (straight), from the light N°4 to the light N°3 (left), from the light N°3 to the light N°2 (left), from the light N°2 to the light N°1 (left), and from the light N°1 to the light N°2 (right).

Cite this article as: Bekris, E., Gioldasis, A., Zacharakis, E. , Noutsos, K., Meletakos, P. , & Smirniotou, A. (2023). Assessment of Change of Direction and Agility. Running and Dribbling among Soccer, Basketball and Handball Players: The Concept of "Agility deficit". *Central European Journal of Sport Sciences and Medicine*, *4*(44), 63–77, https://doi.org/10.18276/cej.2023.4-06