Materials: Women's Football

Relationship Between Agility, Change of Direction Ability, and Competitive Level in Youth Female Soccer Players: A Case Study of a High School Soccer Team

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**Performance Up Team Result

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This study examined the relationship between agility, change of direction (COD) abilities, and competitive level in youth female soccer players. Additionally, it examined the relationship between agility and COD abilities and physical capacity. Twenty-eight female high school soccer players participated in this study. All participants completed the reactive shuttle test, pro-agility test, linear sprints, counter movement jump, rebound jump, and standing long jump. The first team's players demonstrated significantly better results in the reactive shuttle test (first team, 5.74 [5.56-5.89]; second team, 5.92 [5.81-5.97]) and pro-agility test (first team, 5.00 [4.91-5.03]; 5.08 [5.07-5.21]), with large effect sizes. Although the pro-agility test was significantly correlated with physical capacity and COD deficit, the reactive shuttle test showed no correlation with these metrics. The findings indicate that the reactive shuttle and pro-agility tests can effectively distinguish competitive levels among youth female soccer players. However, when the difference in competitive level is pronounced, COD abilities may further emphasize this disparity. Although physical capacity contributes to pro-agility test times, the reactive shuttle test appears to be influenced more by factors such as technical skills and cognitive decision-making rather than solely by physical capacity.

Keywords: reactive shuttle test, pro-agility test, female soccer player, agility, change-of-direction

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1. Introduction

Agility and change of direction (COD) abilities are essential for soccer performance. In soccer, players perform approximately 700 direction changes per game (Bloomfiled et al., 2007). Agility and COD tests have been reported to distinguish competitive levels in team sports (Lockie et al., 2014; Serpell et al., 2011; Veale et al., 2010; Young et al., 2011, Kaplan et al., 2009). Early agility and COD training are also crucial for developing high-level players in sports, such as soccer (Thieschäfer and Büsch, 2022, Kaneko, 2021). Although previous studies have shown that agility tests can differentiate competitive levels among male soccer players (Pojskic et al., 2018), little is known about the relationship between agility, COD ability, and competitive levels in youth female soccer players.

In soccer, players perform directional changes at various angles, and the ability to perform 180° COD has been shown to be related to the competitive level of soccer players (Bloomfileld et al., 2007; Kaplan et al., 2009). This suggests that the COD and agility tests incorporating 180° COD could effectively differentiate competitive levels in youth female players. The pro-agility test has long been used to assess 180° COD ability (Magal et al., 2009), whereas the reactive shuttle test, which incorporates external stimuli into this traditional test, has recently been used as an agility test. The reactive shuttle test requires players to respond to a visual stimulus and then change direction repetitively at 180°. This test, implemented in high-performance settings such as the National Basketball Association, has shown high intra-class correlation coefficients and reliable results in adolescent basketball players (Stojanović et al., 2019).

If agility and COD tests can be used to distinguish the performance levels of youth female soccer players, examining the relationship between these abilities and related capacities is essential for developing effective training programs to enhance these abilities. Agility and COD abilities are multifaceted and involve physical capacity (Sheppard et al., 2006, Young et al., 2015). Several previous studies have examined the relationship between COD test time and physical capacity in female soccer players (McFarland et al., 2016, Merino-Muñoz et al., 2021); however, the relationship between agility and physical capacity has not been investigated in female soccer players.

This study aimed to clarify the relationship between agility and COD abilities and competitive level in female high school soccer players. Since the reactive shuttle test includes not only changes of direction but also a response to external stimuli, we hypothesized the effect size between the first and second teams to be larger than that of the pro-agility test. The present study also examined the relationships between agility, COD, and physical capacities.

2. Methods

2.1. Experimental Design

This study used an observational cross-sectional design. Participants were recruited from a high-school soccer team. This team was at a level equivalent to qualifying for the national championship. A total of 37 players consented to participate in this study. However, due to injuries and physical conditions, 7 players did not take part in the measurements, resulting in 30 participants. Of these, the study focused on 28 field players, excluding 2 goalkeepers. The participants' heights and body weights were self-reported, and each test was conducted on artificial turf. The participants had a rest day on the day prior to the measurement. At first, it was confirmed that the participants had no injuries and were in appropriate health condition. Before conducting the measurements, an approximately 10-minute warm-up, including the movements required for the tests in this study, was performed. Participants completed the reactive shuttle test, pro-agility test, linear sprint, countermovement jump (CMJ), rebound jump (RJ), and standing long jump (SLJ). Each test was preceded by a practice trial. Participants were divided into two groups for testing, with one group starting with agility and sprint tests, and the other group starting with jump tests. Information on the first and second teams was obtained from the team staff. Players in the first team are selected based on the coach's evaluation, considering their ability to perform at high exercise intensities during matches, soccer skills, and mental attributes. For participation in this study, both the participants and their guardians were informed about the study's purpose and details, potential risks and risk management, and the handling of collected data. Written informed consent was obtained from both the players and guardians. The measurements were conducted with careful consideration of the participants' conditions and safety.

2.2. Measurements

2.2.1. Reactive Shuttle Test

The test protocol of the reactive shuttle test is illustrated in **Figure 1**. Three lines were set five yards apart, with the participant positioned straddling the center line. Two signal lights were placed in front of the participants to present the visual stimuli. The participants ran toward the illuminated signal, stepped on the line, and then reversed their direction to step on the opposite line, continuing until they crossed the center line. During the test, participants were instructed to move without changing their body orientation and to change direction once with each foot, left and right. Time was recorded using a photoelectric timing system (Dashr, Dashr Motion Performance Systems, NE, USA). The time from the appearance of the light stimulus to the moment the participant crossed the finish line was recorded as the reactive shuttle test time. Additionally, the reaction time was measured as the interval from the visual stimulus to the moment the participant left the infrared sensor. Each participant completed one trial. This test was performed based on a previous study (Stojanović et al., 2019).

2.2.2. Pro-Agility Test

The test protocol of pro-agility test is illustrated in **Figure 2**. The pro-agility test followed the same protocol as the reactive shuttle test, except for the visual stimuli. The starting direction was the same as that in the reactive shuttle test and the participants were informed of the direction in advance. Test times

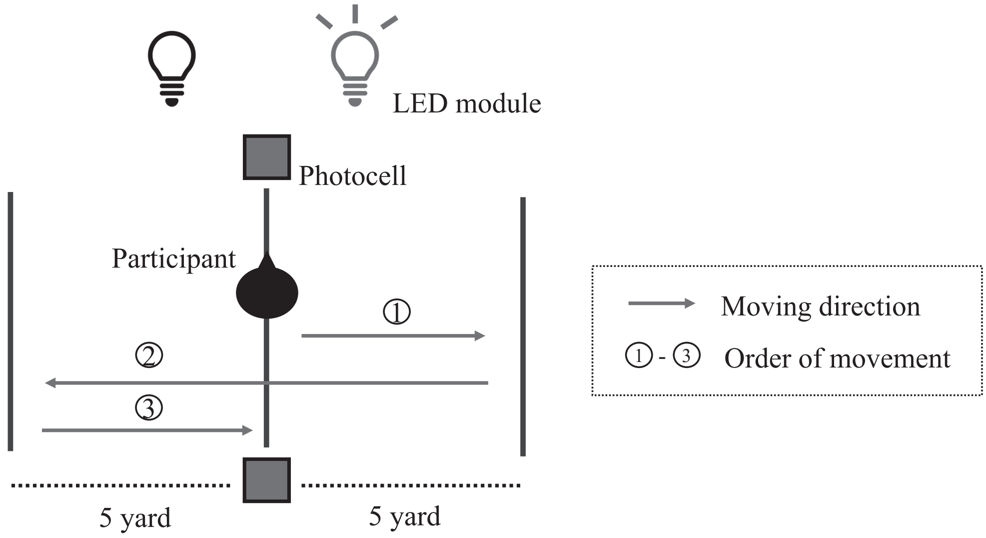

Figure 1 Test protocol of reactive shuttle test

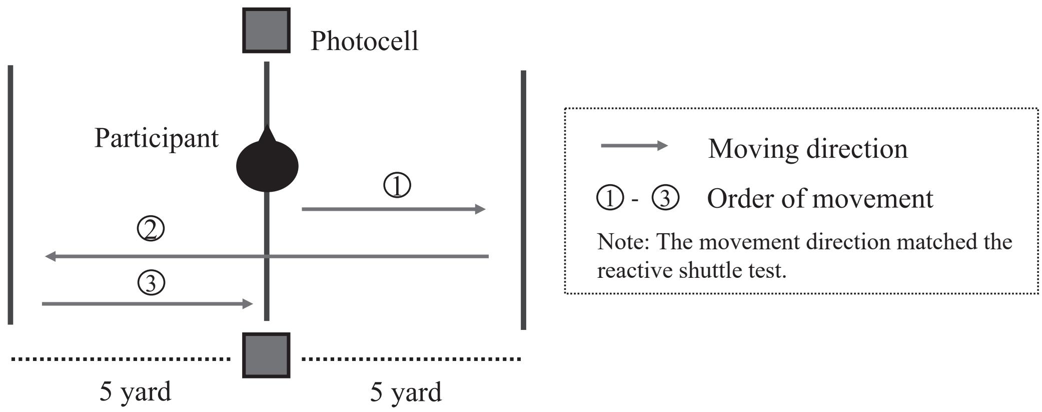

Figure 2 Test protocol of pro-agility test

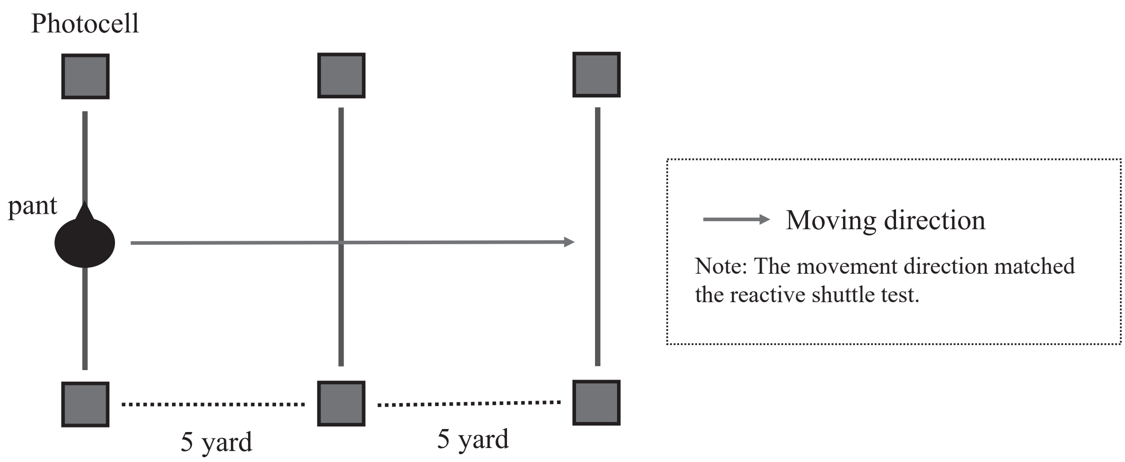

Figure 3 Test protocol of linear sprint

were recorded using a photoelectric timing system (as described above). Each participant completed one trial.

2.2.3. Linear Sprint

The test protocol of linear sprint is illustrated in **Figure 3**. The starting position for the linear sprint was set with the participants straddling the starting line to match the direction and distance of the reactive shuttle and pro-agility tests. Infrared sensors were placed at the start, 5-yard, and 10-yard points to measure the split times at these distances. Time was recorded using a photoelectric timing system (as described above). Each participant completed one trial.

2.2.4. Vertical Jump Tests

The CMJ and RJ were performed to assess physical capacity in this study. CMJ was performed using a velocity-monitoring device (Enodepro, BM Sports Technology GmbH, Magdeburg, Germany) as previously described (Jimenez-Olmedo et al., 2013). The participants placed their hands on their hips to avoid contact with the device and performed three jumps from a standing position with countermovements. They were instructed to perform countermovements as quickly as possible and jump with maximum effort. The highest jump height among the three attempts was recorded as the representative value.

The RJ was conducted using the same device as that used for CMJ (described above). The participants placed their hands on their hips to avoid contact with the device and performed six consecutive jumps to minimize the ground contact time and maximize jump height. Reactive strength index (RSI) was calculated by dividing jump height by ground contact time. The highest RSI of the six jumps was recorded as the representative value.

2.2.5. Standing Long Jump

The participants were instructed to jump as far as possible from a standing position just behind the takeoff line, with the jump distance measured from the heel closest to the line. A measuring tape was used to measure the distance. Each participant performed two jumps, and the best distance was recorded as the representative value.

2.3. Statistical Analysis

The Shapiro-Wilk test confirmed that the data were non-normally distributed; therefore, non-parametric tests were applied. The Brunner-Munzel test was used for between-group comparisons (first team vs. second team), and the effect sizes were assessed using Cliff's delta. Significance was set at 0.05 ($p < 0.05$), with delta values categorized as follows: negligible, < 0.147; small, 0.147-0.329; medium, 0.330-0.474; large, > 0.474 (Wan et al., 2021). The correlation between reactive shuttle test time, pro-agility test, and other metrics was evaluated using Spearman's rank correlation coefficient combined with the bootstrap method, with coefficients (rs) interpreted per Hopkins (2002): small, ≤ 0.30; moderate, 0.31-0.49; large, 0.50-0.69; very large, 0.70-0.89; nearly perfect, ≥ 0.90. The significance of the correlations was determined based on the 95% confidence intervals obtained using the bootstrap method.

3. Results

3.1. Difference in Agility, COD, and Physical Capacity between the First and Second Teams

The results are presented in **Table 1**. The first team showed significantly better times on the reactive shuttle and pro-agility tests than the second team, with a large effect size (reactive shuttle test time, delta = 0.497; pro-agility test time, delta = 0.667). The first team showed a significantly higher rebound jump-reactive strength index than the second team, with a large effect size (delta = 0.497).

3.2. Correlations between Agility and COD and Physical Capacity

The results are presented in **Table 2**. The reactive shuttle and pro-agility tests showed a significant correlation, with a large correlation coefficient (rs = 0.581). The pro-agility test time showed significant correlations with the 5-yard time, and 10-yard time, with correlation coefficients ranging from moderate to large (rs = 0.394-0.584). Additionally, this test showed a significant negative correlation with the SLJ, with a large correlation coefficient (rs = 0.617). The reactive shuttle test time showed no significant correlation with the linear sprint, or any of the jump tests.

4. Discussion

This study examined whether the pro-agility and reactive shuttle tests could distinguish competitive levels among female high school soccer players. The results showed that the first team players performed

Table 1 Difference in agility, change-of-direction ability, and physical capacity between the first and second teams

	First team (n = 13)	Second team (n = 15)	p value	δ
Height cm	158 (155.0-161.5)	159.0 (156.0-162.0)	0.670	−0.105
Body weight kg	46.0 (45.0-53.5)	50.0 (46.0-55.0)	0.649	−0.117
Reaction time s	0.69 (0.65-0.73)	0.78 (0.66-0.81)	0.505	−0.181
Reative shuttle test time s	5.74 (5.56-5.89)	5.92 (5.81-5.97)	0.027	−0.497
Pro-agility test time s	5.00 (4.91-5.03)	5.08 (5.07-5.21)	0.006	−0.667
5-yard time s	1.11 (1.07-1.15)	1.12 (1.11-1.14)	0.234	−0.257
10-yard time s	1.92 (1.87-1.97)	1.96 (1.93-1.99)	0.145	−0.316
CMJ height cm	34.5 (32.9-36.7)	32.1 (29.9-35.9)	0.286	0.292
RJ-RSI m/s	1.99 (1.81-2.23)	1.75 (1.60-1.96)	0.019	0.497
SLJ cm	193 (189-206)	190 (176-197)	0.118	0.374

CMJ, counter movement jump; RJ-RSI, rebound jump-reactive strength index; SLJ, standing long jump; * indicates significant correlation.

significantly better on these tests than the second team players, with a large effect size (reactive shuttle test, delta = 0.497; pro-agility test, delta = 0.667). Thus, it is possible that these tests are effective for identifying the competitive level of youth female soccer players. Previous studies have highlighted that COD tests involving a 180° change direction are valid for distinguishing competitive levels among male soccer players (Kaplan et al., 2009), and the same may apply to youth female players. While the reactive shuttle test protocol was like that of the pro-agility test, the correlation coefficient between the two was 0.581, suggesting that although related, they measure distinct abilities. The reactive shuttle test assesses the ability to quickly establish an optimal movement posture in response to visual stimuli. This test includes visual stimuli at the start, which influences posture during directional changes (Mornieux et al., 2014; Kameda et al., 2019). In this study, there was no significant difference in the reaction time at the start of the reactive shuttle test between the first and second team players. Additionally, although the pro-agility test showed a from medium to large correlation with sprint times (rs = 0.39-0.58), the reactive shuttle test did not demonstrate a significant correlation. These findings suggest that not only the reaction speed or straight-line running speed but also the ability to quickly start running after visual cues is important.

Although the reactive shuttle test and pro-agility test demonstrated high effect sizes, the pro-agility test showed a slightly higher effect size. The reason for this result remains unclear but may be due to the large gap in competitive levels between the first and second teams in this study. Yoshida et al. (2017) indicated that when the difference in competitive levels is substantial, it is more likely to result in differences in the COD test, whereas when the competitive level gap is smaller, differences may more readily emerge in the agility test. In this study, the difference in competitive levels between the first and second teams was significant, which may have led to a more pronounced difference in COD ability. Although this is subjective and qualitative information, the coaches of the collaborating team commented that, based

Table 2 Correlations between agility and change-of-direction ability and physical capacity

		rs	CI lower	CI upper	
Reactive shuttle test time s	Pro-agility test time s	0.581	0.31	0.80	*
	Reaction time s	0.602	0.21	0.85	*
	5-yard time s	0.167	−0.25	0.58	
	10-yard time s	0.298	−0.14	0.64	
	CMJ height cm	−0.190	−0.56	0.21	
	RJ-RSI m/s	−0.398	−0.75	0.01	
	SLJ cm	−0.471	−0.74	−0.10	*
Pro-agility test time s	Reaction time s	0.170	−0.22	0.54	
	5-yard time s	0.394	0.03	0.68	*
	10-yard time s	0.584	0.29	0.79	*
	CMJ height cm	−0.178	−0.57	0.23	
	RJ-RSI m/s	−0.304	−0.61	0.04	
	SLJ cm	−0.617	−0.79	−0.39	*

CMJ, counter movement jump; RJ-RSI, rebound jump-reactive strength index; SLJ, standing long jump; * indicates significant correlation.

on their evaluation, there is a considerable gap in competitive level between the first and second teams.

This study also examined the relationship between the reactive shuttle and pro-agility tests and physical capacity. The findings showed that the pro-agility test was significantly correlated with the linear sprint, SLJ, and COD deficits, whereas the reactive shuttle test did not correlate with these measures or showed a smaller correlation. Therefore, in youth female soccer players, physical capacity appears to contribute to improved performance in the pro-agility test, whereas performance in the reactive shuttle test may depend on other abilities such as cognitive decision-making and technical factors. The lower correlation between physical capacity and the reactive shuttle test may be due to the visual stimuli in the reactive shuttle test, which could prevent players from starting in an optimal posture (Mornieux et al., 2014; Kameda et al., 2019). Testing physical capacity typically allows for maximal force application in an optimal posture because no external stimulus is involved. However, in the reactive shuttle test, the need to respond to visual stimuli may prevent athletes from performing optimally, resulting in a weaker correlation with physical capacity. These results are like previous studies reporting that, although in a different sport, the relationship between agility and physical capacities was weak among female basketball players (Spiteri et al., 2014).

This study had several limitations. This case study was conducted on a single high school soccer team. Since this study focuses on only one team, it cannot be defined that coach's policy and team style may have some influence on the results. Further research involving more teams is necessary to determine whether these findings apply to a broader population of youth female soccer players. Additionally, this study considers the notable difference in competitive level between the first and second teams as a possible reason for the larger effect size observed in the pro-agility test compared to the reactive shuttle test. However, it is important to note that this difference is based on the subjective and qualitative evaluation of the coaches. In future research, it will be necessary to compare agility and change of direction abilities among athletes with objectively evident differences in competitive level, such as those based on competition results. From the perspective of measurement, due to the team's scheduling constraints, the reactive shuttle test was conducted only once in this study. In the present study, the mean and standard deviation (mean ± SD) of the reactive shuttle test were 5.81 ± 0.33 s. Compared to a previous study involving male high school soccer players (mean ± SD = 5.45 ± 0.19 to 5.63 ± 0.24 s) (Ito et al., 2025), the variability observed in the current results was slightly greater. This may be attributed to the possibility that participants' anticipatory or strategic responses to external stimuli during the test were not fully eliminated, potentially contributing to increased variability in the measurements. In the future, conducting multiple agility test trials will be necessary to further ensure the validity of the measurements. Finally, although this study discussed the relationship between the reactive shuttle test and the straight sprint and jump tests in terms of posture control, these factors were not directly measured. Future research should aim to clarify why the reactive shuttle test can distinguish between competitive levels and investigate the relationship between agility, COD, and physical capacity in greater detail by assessing posture control during agility and COD tests.

5. Conclusion

The results of this study demonstrate that both the reactive shuttle and pro-agility tests effectively distinguish competitive levels among players. While physical capacity contributes to pro-agility test times, the reactive shuttle test appears to be influenced more by other factors, such as technical skills and cognitive decision-making, than solely by physical capacity.

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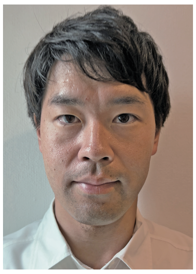

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