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**Original Article**

# Does reactive shuttle test differentiate performance levels in youth soccer players?

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**Abstract:**
***Problem Statement:*** Exploring the relationship between the reactive shuttle test or pro-agility test and physical capacity, change-of-direction (COD) could offer valuable insights for improving the agility of soccer players.***Purpose:*** In this study, we aimed to determine whether the reactive shuttle test could differentiate competitive levels among high school soccer players and to explore the relationships between the reactive shuttle test and both physical capacity and change-of-direction deficit. This study employed an observational cross-sectional design. We included 82 high school soccer players in various field positions. They completed the reactive shuttle test, pro-agility test, linear sprint, and various jump assessments. Comparative analyses of each metric were performed between starters and non-starters, both across the entire cohort and within specific positions. Correlations between reactive shuttle test times and each individual metric were also determined. ***Results:*** Starters exhibited significantly shorter times in the reactive shuttle and pro-agility tests compared to non-starters, both across the entire cohort (reactive shuttle test, non-starters: 5.63±0.24, starters: 5.45±0.19; pro-agility test, non-starters: 4.85±0.19, starters: 4.76±0.12) and within the defender group (reactive shuttle test, non-starters: 5.68±0.21, starters: 5.43±0.21; pro-agility test, non-starters: 4.88±0.19, starters: 4.74±0.09). Furthermore, the reactive shuttle test exhibited a larger effect size than the pro-agility test, with the most pronounced effect size observed among defenders. Notably, a minimal correlation was found between reactive shuttle test times and physical capacity. ***Conclusions:*** The reactive shuttle test proved effective in identifying the competitive levels of high school soccer players, particularly for defenders. Additionally, the lack of a significant correlation between reactive shuttle test times and physical capacities suggests that factors, such as cognitive decision-making and technical skills, may play a more substantial role in determining reactive shuttle test performance compared to purely physical capacities.
**Key Words: agility, change of direction, reactive shuttle test, soccer**

## Introduction

Agility is the ability to rapidly change direction and speed in response to external stimuli (Sheppard & Young, 2006), making it a vital skill in soccer. Bloomfield et al. (2007) reported approximately 700 directional changes per match among soccer players. Furthermore, enhancing agility in young athletes is considered crucial for developing players with highly competitive performance in field sports, such as soccer (Thieschafer & Busch, 2022). Recently, agility has been assessed using agility tests that include change-of-direction (COD) challenges and cognitive decision-making components (Lockie et al., 2014; Serpell et al., 2011; Veale et al., 2010). Notably, several studies have shown that agility tests, such as the Y-shaped agility test, can differentiate between competitive levels (Lockie et al., 2014; Veale et al., 2010).

Recently, the reactive shuttle test has been used to evaluate agility in high-level athletes, including those in the National Basketball Association (Stojanović et al., 2019). This test involves an initial sprint in response to visual stimuli, followed by two 180° turns. A previous study demonstrated that the reactive shuttle test has high within-subject reliability, indicating sufficient consistency as an agility assessment (Stojanović et al., 2019). However, its validity, particularly for criterion-related validity, is yet to be explored in team sports like soccer.
In soccer, executing a 180° COD is as crucial as decision-making. During soccer matches, 0–180° COD is performed (Ade et al., 2016; Sheppard & Young, 2006), and studies have shown that performance on 180° COD tests is correlated with the competitive level of soccer players (Kaplan et al., 2009). Therefore, the reactive shuttle test, which includes cognitive decision-making and a 180° COD in its protocol, may be suitable for assessing agility in soccer players. The Y-shaped agility test is commonly used to evaluate agility in team sports; however, it may not adequately assess agility in soccer players (Pojskic et al., 2018), as it was originally designed to evaluate agility specific to rugby players (Serpell et al., 2011). Therefore, if the reactive shuttle test can differentiate competitive levels among young soccer players, it can be used to enhance agility and identify players with potentially high performance.


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In the model proposed by previous litertures (Sheppard et al. 2006; Young et al. 2015), physical capacity and COD identified as critical factors influencing agility. However, few studies have investigated the relationship between agility test time and physical capacity, COD (Paprancova et al., 2024; Spiteri et al., 2014), no research has specifically examined the relationship between reactive shuttle test time and physical capacity. Therefore, exploring the relationship between the reactive shuttle test or pro-agility test and physical capacity, COD could offer valuable insights for improving the agility of soccer players.

Thus, in this study, we aimed to determine whether the reactive shuttle test can differentiate between the competitive levels of young soccer players. Additionally, we examined the relationship between the reactive shuttle tests and physical capacities, COD. We hypothesized that the reactive shuttle test time would identify the competitive level of soccer players and be more effective than the pro-agility test.

**Material & methods**

*Study design*

This study employed an observational cross-sectional design. Measurements were conducted on the participants' usual soccer field, which featured artificial turf, and the subjects wore their standard soccer cleats. Initially, height and weight were measured. Following these assessments, the participants engaged in a warm-up that included activities associated with the upcoming tests. After the warm-up, the reactive shuttle test, pro-agility test, countermovement jump (CMJ), squat jump (SJ), rebound jump (RJ), and standing long jump (SLJ) were performed. The participants were divided into two groups: one group performed the agility and sprint tests first, whereas the other group completed the jump tests first. Notably, the participants underwent a practice trial before each test. Furthermore, information regarding the players' positions and their classification as starters or non-starters was gathered through interviews with team coaches.

*Participants*

The sample size was calculated using G*Power 3.1 software (Heinrich Heine University, Düsseldorf, Germany) with an effect size (ES) of 0.72, α error of 0.05, and power of 0.80. ES was calculated based on values from previous studies comparing agility test times between non-starters and starters among youth soccer players (Krolo et al., 2020). The number of non-starters was greater than that of starters in the candidate teams; therefore, the allocation ratio (N1: starters / N2: non-starters) for sample size calculation was set to 0.3. This calculation indicated a sample size of 88 participants (non-starters: 68, starters: 20).

The participants were recruited from two high school soccer teams with similar competitive levels. The details of the study were explained to the participants and their parents, and written consent was obtained from the parents. Overall, 82 field players expressed their intention to participate, including 29 midfielders, 32 defenders, and 21 forwards. Additionally, we interviewed the coaches of each team to determine whether the participating players were non-starters or starters (63 non-starters and 19 starters). This study was approved by the Ethics Review Committee on Research with Human Subjects of Waseda University (Approval Number: 2023-365).

*Measurement items*

Reactive shuttle test

Three lines were marked at 5-yard intervals, with participants starting in a standing position straddling the middle line. Two lights for visual stimuli were positioned in front of the participants. Upon presentation of a lit light, the participant would turn toward it and sprint in that direction, step on the outer line, turn back to the opposite direction, step on the other outer line, and then quickly return to the middle line (Stojanović et al., 2019). The time was measured using a photocell timing system (Dashr, Dashr Motion Performance Systems, NE, USA).

The reaction time was recorded from the moment the visual stimulus was presented until the body left the infrared sensor. However, the total time was measured from the presentation of the visual stimulus until the participant reached the finish line. Each participant performed two trials, and the better time was selected as the representative value.

*Pro-agility test*

Except for the visual stimuli, the protocol and measurement methods for the pro-agility test were identical to those of the reactive shuttle test. Initially, the direction of movement was aligned with the direction recorded when the representative value was obtained in the reactive shuttle test, and participants were instructed on this direction beforehand. Each participant completed two trials, and the better time was selected as the representative value.

*COD deficit*

Since the time in COD tests, such as the pro-agility test, is influenced by linear sprint time (Nimphius et al., 2013), COD ability was also evaluated using COD deficit.The COD deficit was calculated by subtracting the linear sprint time from the pro-agility test time following the concept proposed by Nimphius et al.(2013):

$$\text{Pro-agility test time} - \text{5-yard time} \times 2 - \text{10-yard time}$$

Equation 1. The formula for calculating the COD deficit.

*Linear sprint*

Furthermore, to standardize the starting posture and running distance for the reactive shuttle and pro-agility tests, the participants started in a standing position while straddling the start line. Initially, the direction of movement was aligned with the direction in which a representative value was obtained during the reactive shuttle test. The photocells (mentioned above) were placed at the start, 5-yard, and 10-yard lines, and the time from the start to each line was measured. The participants completed two trials, and the better times for the 5-yard and 10-yard runs were selected.

*Vertical jump tests*

CMJ, SJ, and RJ were performed to assess physical capacity. Jump height was measured using a velocity-monitoring device (Enodepro, BM Sports Technology GmbH, Magdeburg, Germany), as used in a previous study (Jimenez-Olmedo et al., 2023). The device was attached to the right side of the waist using a belt, and the participants were instructed to place their hands on their waists to avoid contact with the device.

In the CMJ test, participants were instructed to descend quickly from a standing position and immediately perform a maximal effort jump. The depth of the countermovement was determined by each participant based on their perception of the optimal depth to achieve maximum jump height.

However, in the SJ test, the starting position was the squat position, with the knees bent at approximately 90°. Participants were instructed to set their hands on their waist and jump without countermovement. A skilled tester visually monitored the presence of countermovement during the trial, and the trial was repeated if countermovement was detected. Each participant performed three trials, with the highest jump height recorded as the representative value for the CMJ and SJ tests.

Furthermore, in the RJ test, the participants performed six consecutive jumps, aiming to minimize ground contact time while maximizing jump height. The reactive strength index (RSI) was calculated by dividing the jump height (m) by the ground contact time (s), and the highest RSI from the six jumps was selected as the representative value for the RJ test.

*SLJ*

Participants stood at the starting line and were instructed to jump as far as possible. The distance was measured from the starting line to the closest heel to the starting point using a measuring tape. Each participant performed two trials, with the longest jump distance recorded as the representative value.

*Statistical analysis*

Before conducting between-group comparisons and correlation analyses, the normality of the data was assessed using the Kolmogorov–Smirnov test, and appropriate statistical tests were selected accordingly. Participants were categorized into non-starters and starters, with measured values compared using Welch's t-test and ES calculated using Cohen's d. Positional comparisons between starters and non-starters were conducted as a secondary analysis, focusing only on forwards and defenders, where the sample size for statistical testing was sufficient. For each comparison, normal distribution was confirmed within each group. ES were interpreted as small for $d \leq 0.50$, moderate for $0.51 \geq d \leq 0.80$, and large for $d \geq 0.81$ (Cohen, 1988). Due to the lack of normality in the measured values across all participants, reactive shuttle and pro-agility test correlation analyses were performed using Spearman's rank correlation coefficient. Correlation coefficients were interpreted as follows: $rs \leq 0.30$ as small, $0.31 \geq rs \leq 0.49$ as moderate, $0.50 \geq rs \leq 0.69$ as large, $0.70 \geq rs \leq 0.89$ as very large, and $rs \geq 0.90$ as nearly perfect for predicting relationships (Hopkins, 2016). Statistical significance was set at $p < 0.05$, and all statistical analyses were performed using the R Studio (ver.4.4.1; R Software for Statistical Computing, Vienna, Austria).

**Results**

*Comparison between non-starters and starters*

When comparing non-starters and starters across all measures, starters had significantly shorter times in the reactive shuttle and pro-agility tests compared with non-starters (Table 1). The ES for the reactive shuttle and pro-agility test time were moderate, with the reactive shuttle test time ($d = 0.77$) showing a slightly higher ES than the pro-agility test time ($d = 0.52$).

*Correlation between pro-agility test, reactive shuttle test, and other evaluation metrics*

The results of these correlations are presented in Table 2. The pro-agility test showed a moderately significant correlation with the 5-yard sprint time, 10-yard sprint time, and COD deficit. It also demonstrated small albeit significant correlations with the SJ and CMJ heights, the RSI of the rebound jump, and the jump distance in the SLJ. The reactive shuttle test showed a moderate correlation with the COD deficit and a weak correlation with the SJ height and the jump distance in the SLJ.

*Comparison between non-starters and starters based on position*

Forwards did not show significant differences between starters and non-starters across any evaluation metrics (Table 3). However, among defenders, starters presented shorter times in the reactive shuttle test, pro-agility test, and COD deficit compared with non-starters (Table 4). The ES for reactive shuttle test time, pro-agility test time, and COD deficit was large, with the reactive shuttle test time ($d = 1.16$) showing a higher ES than the pro-agility test time ($d = 0.82$).

Table 1. Differences between non-starters and starters for the observed agility, change-of-direction, and physical capacities in all participants

| | | Non-starter (n = 63) | | | Starter (n = 19) | | | p.value | ES |
|---|---|---|---|---|---|---|---|---|---|
| All subjects | Height (cm) | 168.4 | ± | 5.2 | 170.5 | ± | 7.4 | 0.252 | 0.37 |
| | Body weight (kg) | 59.1 | ± | 6.3 | 60.5 | ± | 5.1 | 0.324 | 0.23 |
| | Reactive shuttle test time (s) | 5.63 | ± | 0.24 | 5.45 | ± | 0.19 | 0.002* | 0.77 |
| | Reaction time (s) | 0.64 | ± | 0.07 | 0.63 | ± | 0.05 | 0.338 | 0.20 |
| | Pro-agility time (s) | 4.85 | ± | 0.19 | 4.76 | ± | 0.12 | 0.014* | 0.52 |
| | 5-yard time (s) | 0.99 | ± | 0.05 | 0.97 | ± | 0.05 | 0.154 | 0.26 |
| | 10-yard time (s) | 1.73 | ± | 0.07 | 1.72 | ± | 0.06 | 0.306 | 0.37 |
| | COD deficit (s) | 1.14 | ± | 0.20 | 1.10 | ± | 0.13 | 0.375 | 0.18 |
| | SJ height (cm) | 39.3 | ± | 4.8 | 41.8 | ± | 5.2 | 0.064 | 0.53 |
| | CMJ height (cm) | 42.4 | ± | 5.4 | 44.4 | ± | 5.0 | 0.144 | 0.38 |
| | RJ-RSI (m/s) | 2.21 | ± | 0.42 | 2.29 | ± | 0.43 | 0.469 | 0.19 |
| | SLJ (cm) | 221 | ± | 15 | 223 | ± | 14 | 0.448 | 0.19 |

CMJ height, countermovement jump height; COD deficit, change-of-direction deficit; ES, effect size; RJ-RSI, rebound jump-reactive strength index; SJ height, squat jump height; SLJ, standing long jump.
* indicates statistical significance at $p < 0.05$. Data are presented as means ± standard deviations (SD).

Table 2. Correlation between pro-agility test time, reactive shuttle test time, and physical capacities

| | | Reaction time (s) | Pro-agility time (s) | 5-yard time (s) | 10-yard time (s) | COD deficit (s) | SJ height (cm) | CMJ height (cm) | RJ-RSI (m/s) | SLJ (cm) |
|---|---|---|---|---|---|---|---|---|---|---|
| Reactive shuttle test time (s) | p | 0.081 | 0.000* | 0.065 | 0.15 | 0.001* | 0.009* | 0.054 | 0.514 | 0.028* |
| | rs | 0.194 | 0.572 | 0.205 | 0.16 | 0.368 | −0.288 | −0.214 | −0.073 | −0.243 |
| Pro-agility test time (s) | p | 0.459 | | 0.001* | 0.002* | 0.000* | 0.015* | 0.077 | 0.028* | 0.040* |
| | rs | 0.083 | | 0.365 | 0.342 | 0.465 | −0.267 | −0.196 | −0.242 | −0.227 |

CMJ height, countermovement jump height; COD deficit, change-of-direction deficit; ES, effect size; RJ-RSI, rebound jump-reactive strength index; SJ height, squat jump height; SLJ, standing long jump.
* indicates statistical significance at $p < 0.05$; rs indicates correlation coefficient in Spearman's rank correlation coefficient.

Table 3. Differences between non-starters and starters for the observed agility, change-of-direction, and physical capacities in forwards

| | | Non-starter (n = 15) | | | Starter (n = 6) | | | p.value | ES |
|---|---|---|---|---|---|---|---|---|---|
| Forwards | Height (cm) | 168.0 | ± | 5.6 | 168.1 | ± | 4.6 | 0.974 | 0.01 |
| | Body weight (kg) | 61.7 | ± | 6.3 | 60.3 | ± | 4.4 | 0.571 | 0.24 |
| | Reactive shuttle test time (s) | 5.57 | ± | 0.24 | 5.51 | ± | 0.22 | 0.614 | 0.24 |
| | Reaction time (s) | 0.64 | ± | 0.06 | 0.64 | ± | 0.05 | 0.879 | 0.07 |
| | Pro-agility time (s) | 4.80 | ± | 0.15 | 4.79 | ± | 0.18 | 0.888 | 0.08 |
| | 5-yard time (s) | 0.99 | ± | 0.04 | 0.98 | ± | 0.07 | 0.717 | 0.11 |
| | 10-yard time (s) | 1.72 | ± | 0.06 | 1.72 | ± | 0.09 | 0.853 | 0.22 |
| | COD deficit (s) | 1.09 | ± | 0.18 | 1.11 | ± | 0.14 | 0.814 | 0.10 |
| | SJ height (cm) | 40.6 | ± | 5.8 | 41.4 | ± | 4.2 | 0.741 | 0.14 |
| | CMJ height (cm) | 44.0 | ± | 7.2 | 43.8 | ± | 2.7 | 0.912 | 0.04 |
| | RJ-RSI (m/s) | 2.15 | ± | 0.51 | 2.44 | ± | 0.57 | 0.312 | 0.55 |
| | SLJ (cm) | 224 | ± | 16 | 221 | ± | 13 | 0.673 | 0.19 |

CMJ height, countermovement jump height; COD deficit, change-of-direction deficit; ES, effect size; RJ-RSI, rebound jump-reactive strength index; SJ height, squat jump height; SLJ, standing long jump.
Data are presented as means ± SDs.

Table 4. Differences between non-starters and starters for the observed agility, change-of-direction, and physical capacities in defenders

| | | Non-starter (n = 23) | | | Starter (n = 9) | | | p.value | ES |
|---|---|---|---|---|---|---|---|---|---|
| Defender | Height (cm) | 170.0 | ± | 5.2 | 175.1 | ± | 6.8 | 0.067 | 0.89 |
| | Body weight (kg) | 61.1 | ± | 6.2 | 62.6 | ± | 5.0 | 0.498 | 0.25 |
| | Reactive shuttle test time (s) | 5.68 | ± | 0.21 | 5.43 | ± | 0.21 | 0.009* | 1.16 |
| | Reaction time (s) | 0.65 | ± | 0.09 | 0.64 | ± | 0.05 | 0.686 | 0.13 |
| | Pro-agility time (s) | 4.88 | ± | 0.19 | 4.74 | ± | 0.09 | 0.010* | 0.82 |
| | 5-yard time (s) | 0.97 | ± | 0.04 | 0.97 | ± | 0.04 | 0.778 | 0.23 |
| | 10-yard time (s) | 1.71 | ± | 0.05 | 1.72 | ± | 0.06 | 0.573 | 0.11 |
| | COD deficit (s) | 1.23 | ± | 0.18 | 1.08 | ± | 0.14 | 0.025* | 0.84 |
| | SJ height (cm) | 39.6 | ± | 4.9 | 41.4 | ± | 6.3 | 0.453 | 0.34 |
| | CMJ height (cm) | 43.2 | ± | 5.5 | 43.5 | ± | 6.0 | 0.926 | 0.04 |
| | RJ-RSI (m/s) | 2.30 | ± | 0.46 | 2.21 | ± | 0.27 | 0.544 | 0.20 |
| | SLJ (cm) | 222 | ± | 15 | 228 | ± | 11 | 0.234 | 0.42 |

CMJ height, countermovement jump height; COD deficit, change-of-direction deficit; ES, effect size; RJ-RSI, rebound jump-reactive strength index; SJ height, squat jump height; SLJ, standing long jump.
* indicates statistical significance at $p < 0.05$. Data are presented as means ± SDs.

**Discussion**

Significant differences were observed between non-starters and starters in the times for the pro-agility and reactive shuttle tests across all participants. This suggests that these tests can effectively distinguish between competitive levels. The ES for the pro-agility and reactive shuttle tests was moderate; the ES for the reactive shuttle test time (d = 0.77) was higher than that for the pro-agility test time (d = 0.52). This result indicates that the reactive shuttle test may be more effective in differentiating competitive levels. The reason for the higher ES in the reactive shuttle test is not entirely clear; however, this test may evaluate the ability to quickly establish an optimal movement posture in response to visual stimuli. In this study, no significant differences were observed in reaction times between the non-starter and starter groups during the reactive shuttle test. Furthermore, the pro-agility test demonstrated a significant moderate correlation with linear sprint times (5-yard time, rs = 0.365; 10-yard time, rs = 0.342); however, no significant correlation was observed with reactive shuttle test time. These results indicate that a quick reaction and the ability to run fast after responding to visual stimuli are essential. Previous studies have shown that visual stimuli can influence posture during directional changes (Kameda et al., 2019; Mornieux et al., 2014). In the pro-agility test, there was no visual stimulus at the start, allowing participants to initiate movement from an optimal starting posture, similar to a linear sprint test. However, the reactive shuttle test requires the ability to quickly adopt an optimal movement posture in response to visual stimulus.

In this study, we also examined the relationships between reactive shuttle test time, physical capacities, and COD deficit to gain insights into improving agility in youth soccer players. The reactive shuttle test time was moderately correlated with COD deficit; however, it showed low or no significant correlations with physical capacities. Notably, to our knowledge, no previous studies have specifically examined the relationship between reactive shuttle test time and physical capacities. However, a previous research suggested a low correlation between performance in agility tests and physical capacities (Spiteri et al., 2014). This may be attributed to the suboptimal posture influenced by visual stimuli during testing, as observed earlier (Kameda et al., 2019; Mornieux et al., 2014), resulting in a relatively low correlation with tests measuring the ability to exert force from an optimal posture. Therefore, to improve agility in youth soccer players, training should focus on techniques for directional change and establishing optimal movement postures in response to visual stimuli rather than solely on enhancing physical capacities.

Additionally, we performed a secondary analysis comparing non-starters and starters based on position to investigate the relationship between performance on the reactive shuttle test and playing position. The results revealed no difference in reactive shuttle test times between non-starters and starters for forwards. However, a significant difference with high ES was found among defenders (d = 1.16). These findings suggest that the reactive shuttle test may be more effective for identifying competitive levels, particularly for defenders. In defense, it is vital to respond quickly to attacking players and minimize the time difference in initiating actions to effectively block their attacks (Fujii et al., 2014; Stølen et al., 2005). The reactive shuttle test protocol includes elements that assess these abilities, which may have contributed to the high ES observed compared with that between defenders. Conversely, forwards must generate speed and time advantages over defenders by outmaneuvering them rather than merely reacting to their movements (Young et al., 2022). Thus, the agility assessed by the reactive shuttle test may not fully reflect the specific agility demands required by forwards.

This study had some limitations. Notably, 82 players were included; however, the number of starters was limited, preventing a focused analysis of midfielders, which should be addressed in future research. The discussion of the reactive shuttle test results addresses movement posture in response to visual stimuli; however, this study did not assess the participants' movement speed or motion. Future research should gather and analyze these data.

**Conclusions**

The findings of this study indicate that the reactive shuttle test can effectively distinguish competitive levels among high school soccer players and is particularly useful for identifying players with exceptional defensive abilities. The minimal correlation between reactive shuttle test times and physical capacities suggests that technical elements, such as posture control and directional change techniques following external stimuli, may be more closely associated with performance.

**Conflicts of interest** The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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