ORIGINAL ARTICLE

Reliability and contributing factors to a newly developed reactive agility test performance

Henrieta Horníková ✉ . *Department of Track and Field and Sport Conditioning. Faculty of Physical Education and Sport. Comenius University in Bratislava. Bratislava, Slovakia.*
Filip Skala. *Department of Biological and Medical Sciences. Faculty of Physical Education and Sport. Comenius University in Bratislava. Bratislava, Slovakia.*

ABSTRACT

This study assessed the intra-session reliability and the impact of cognitive and physical factors on the performance of a newly developed Triple Y reactive agility test (3YRAT). Twenty-eight male soccer players (12.74 ± 0.93 years, 161.14 ± 13.46 cm, 49.81 ± 9.73 kg) completed the 3YRAT, visual inhibition task (Go/No-go), choice reaction test, and 10 m sprint test. The 3YRAT demonstrated good reliability (ICC = 0.85 with 95 % CI = 0.71-0.93; CV = 2.3 %; SEM = 0.31s; MDC = 0.85s). The time in 3YRAT was significantly correlated with 10 m sprint time (r = 0.74, $p < .001$), and the response times in cognitive tests (Go/No-go: r = 0.48, $p = .01$; choice reaction: r = 0.41, $p = .03$). Regression analysis found that acceleration sprint speed decision-making, and visual inhibition were the significant predictors of 3YRAT performance, explaining 70 % of the variance ($R^2 = .70$). Overall, both motor (38 %) and cognitive components (32 %) significantly contributed to the 3YRAT performance. This study introduced a new and reliable procedure for assessing reactive agility in youth soccer players, which could be applicable to other athletes of "*agility-saturated*" sports. This test represents a compromise between force- and velocity-oriented changes of direction, balancing the demands on perceptual-cognitive skills and motor abilities in reactive agility tasks.
Keywords: Performance analysis, Sports performance, Open-skill agility, Cognitive component, Motor component, Team sports.

Cite this article as:
Horníková, H., & Skala, F. (2025). Reliability and contributing factors to a newly developed reactive agility test performance. *Journal of Human Sport and Exercise, 20*(4), 1212-1224. https://doi.org/10.55860/5e02qa30

✉ **Corresponding author.** *Department of Track and Field and Sport Conditioning. Faculty of Physical Education and Sport. Comenius University in Bratislava. Bratislava, Slovakia.*
E-mail: henrieta.hornikova@uniba.sk
Submitted for publication May 01, 2025.
Accepted for publication August 02, 2025.
Published August 23, 2025.
Journal of Human Sport and Exercise. ISSN 1988-5202.

doi: https://doi.org/10.55860/5e02qa30

INTRODUCTION

Recent research has shown that one of the most crucial factors influencing athletes' performance in invasive sports is their change of direction speed in response to a visual stimulus, commonly referred to as reactive agility (Frederick et al., 2020; Hassan et al., 2022; Munivrana et al., 2022; Pojskic et al., 2018; Trajković et al., 2020). Reactive agility encompasses both motor components (such as linear sprint speed and leg muscle qualities) and cognitive elements of performance (Young et al., 2015). In many studies, only the cognitive aspect of reactive agility has been effective in distinguishing higher-level athletes from their lower-level counterparts (Farrow et al., 2005; Gabbett et al., 2008; Serpell et al., 2010; Sheppard et al., 2006). Several authors have aimed to design a reactive agility test tailored to the specific demands of various sports (Frederick et al., 2020; Krolo et al., 2020; Munivrana et al., 2022; Sekulić et al., 2017; Sinkovic et al., 2023). Despite advancements in diagnostic methods and devices, creating practical tests that reflect real-game situations including time restricted problem solving and the pressure from opponents remains challenging. To improve the ecological validity of reactive agility testing, some researchers recommend using a "*human stimulus*" instead of a reaction to lights (Gabbett et al., 2008; Chaalali et al., 2016; Spiteri et al., 2012; Trajković et al., 2020). Although tests that involve live testers demonstrate good reliability, the variability in their movements can affect the overall agility score (Young and Willey, 2010). Video-based specific stimuli have been shown to be a suitable alternative (Farrow et al., 2005; Serpell et al., 2010; Young et al., 2011). Notably, a study by Young et al. (2011) revealed that using sport-specific video-based stimuli in reactive agility tests can more effectively differentiate higher-skilled athletes from lower-skilled ones compared to light-based stimuli. However, reactive agility tests utilizing light stimuli have also successfully categorized two performance-level groups (Lockie et al., 2014; Pojskić et al., 2018).

A review by Morral-Yepes et al. (2022) on reactive agility testing in team sport players found that 75 % of studies utilized tasks such as Y-shaped or T-shaped movements. Light and human stimuli were the most common in them while video stimuli were used less frequently. Most studies required athletes to execute a single change of direction at angles of either 45 or 90 degrees over distances ranging from 7 to 12 meters. These types of reactive agility tests have been employed in various sports, including basketball (Horníková and Zemková, 2022; Jeffriess et al., 2015; Lockie et al., 2014; Scanlan et al., 2014), rugby (Green et al., 2011; Serpel et al., 2010), netball (Cochrane, 2013), soccer (Chaalali et al., 2016; Fiorilli et al., 2017), handball (Spasić et al., 2015), and Australian football (Henry et al., 2011; Young et al., 2011). However, this reactive agility testing insufficiently evaluates the cognitive aspects of performance, since the decision-making processes generally occur in a simplified context where participants make a single response with only two available options (Horníková and Zemková, 2022). Moreover, it seems that low correlation appears between total agility time and choice reaction time when the general cognitive functions measured by the laboratory-based tests are used (Matlák et al., 2024). Sekulić et al. (2014) introduced reactive agility test named "*Stop´n´go*" (SNG-RAT) requiring multiple changes of direction to visual stimuli including moments of zero velocity. For instance, the reactive agility test with stop-and-go movement patterns (SNG-RAT) has been widely used in soccer (Pojskic et al., 2018) and other "*agility-saturated sports*" (Sattler et al., 2015; Sekulić et al., 2014). The SNG-RAT involves repetitive responses to four possible answers. In the study by Born et al. (2016), players performed 9 sprints with varying cutting angles (10° - 180°) and distances in response to visual stimuli. The increased number of options increases the demands on decision-making ability, which, along with physical and technical factors, influences reactive agility performance (Young et al., 2015).

The contribution of the cognitive component is typically calculated as the difference between the reactive and preplanned versions of the same test (Fiorilli et al., 2017; Popowczak et al., 2021). Alternatively, it can be assessed using psychological tests (Pavlinović et al., 2024) or reaction time tests (Horníková and Zemková, 2022). The contribution of the motor component to performance in reactive agility tests can be analysed by examining its relationship with linear speed and change of direction speed (Horníková and Zemková, 2022; Horníková et al., 2021; Chow et al., 2022; Krolo et al., 2020; Pojskic et al., 2018; Popowczak et al., 2021). While a significant influence of motor factors has been frequently identified (Krolo et al., 2020; Pojskic et al., 2018; Popowczak et al., 2021), there remains a lack of tests that adequately reflect cognitive factors.

The number of sport-specific reactive agility tests is steadily increasing; however, there remains a relatively small number of general tests suitable for a broader range of athletes across different team sports. The aim of this study was to develop a reliable test that would be useful in practice when comparing the reactive agility performance of players of different sports. The aim of this study was to adapt the test to the requirements of team sports in terms of distance covered as well as the type of performing changes of direction (under different angles) and a more pronounced contribution of the cognitive component compared to the most commonly used Y-shaped type of test. The reactive agility test employed in this research utilized light-based visual stimuli, requiring participants to perform correct movement responses while combining non-stop running with stop-and-go actions during the change of direction. This newly developed test, named the Triple Y reactive agility test, has not been used in any prior studies. Thus, the objectives were twofold: 1) to investigate the intra-session reliability and construct validity of the Triple Y reactive agility test among soccer players, and 2) to identify the factors that contribute to its performance. Although reliability was assessed in young soccer players, this test has the potential to be suitable for athletes in various other invasive sports. Improving the evaluation of reactive agility performance may help practitioners to identify crucial aspects of sport performance and facilitate talent identification in invasive sports.

MATERIAL AND METHODS

Participants

A total of twenty-eight male youth soccer players participated in this study (12.74 ± 0.93 years, 161.14 ± 13.46 cm, 49.81 ± 9.73 kg). They had an average of 4.93 years (±1.84) of soccer-specific organised training experience. Using G*Power software (Version 3.1.9.7, Institut für Experimentelle Psychologie, Düsseldorf, Germany), we calculated the necessary sample size for linear multiple regression, which determined that an optimal sample size of 25 participants was required (effect size = 0.50, power (1-β) = 0.90, significance level α = .05). Our sample size increased the power to 0.96. The inclusion criteria for this study were as follows: participants had to be active soccer players who regularly attended training sessions and matches, with a minimum of one year of experience. Additionally, they must not have suffered any injuries in the last three months. Goalkeepers and players who do not train consistently were excluded from the study. All soccer players participating in the study had a similar training volume, attending three training sessions per week. All of them were informed of the risks and benefits of participation, and written informed consent was obtained from them and their legal guardians prior to the testing. The study was conducted in accordance with the ethical regulations for research, approved by the Ethics Committee of Comenius University in Bratislava, Faculty of Physical Education and Sport (No. 2/2023) in accordance with the latest version of the Helsinki Declaration.

Procedures

This study conducted a cross-sectional analysis involving youth soccer players. After familiarization and personal data collection, the participants completed two cognitive tests indoors: the visual inhibition task (Go/No-Go test) and the choice reaction test. Afterwards, they moved outside to an artificial grass soccer field and performed a 15-minute warm-up that included light jogging, dynamic stretching, running-specific drills, and short sprints. Then they performed the reactive agility test (3YRAT) and a 10-meter sprint test. All tests were carried out using the Sportreact system, which was connected to a mobile application (Sportreact, Zagreb, Croatia). This system includes six photoelectric sensors and LED screens that display different signs and colours, allowing the sensors to function as either single-beam timing gates or proximity sensors. Tests including reactions to the visual stimuli (cognitive tests and 3YRAT) were performed in three trials. Since we expected a learning effect after the first trial, we did not record its value, and it was intended only as a practice trial. According to Zemková and Hamar (2001), this effect should disappear after the third trial. Therefore, we considered three trials sufficient.

Go/No-go test (visual inhibition task)
The Go/No-Go test, which assesses response inhibition, is one of the predefined tests in the Sportreact application. We designed a modified version using four light photocells arranged in a line, spaced 10 cm apart, and set at approximately chest height for the participant. The test begins with a countdown from the main photocell (5-4-3-2-1), after which the first stimulus appears. The stimulus is either a green light ("*go*" signal), indicating that the participant must respond using their dominant hand, or a red light ("*no-go*" signal), indicating that the participant should not respond. If the participant does not respond within two seconds, the signal disappears. When he responded to the signal "*no-go*," the photocells did not react. The test consists of 20 stimuli presented in random order, with a random generation time between 500 and 1000 ms between the signals. The ratio of "*go*" to "*no-go*" signals is consistent for each participant, set at 11 "*go*" signals to 9 "*no-go*" signals. One visual demonstration and practice trial were carried out. After that, participants undergo two trials with 2 min recovery between them. The result is the shorter total duration of the test taken for the two trials. The intra-session reliability showed to be moderate (ICC = 0.623).

Choice reaction test (decision-making)
The photocells were set up in the same manner as in the previous Go/No-Go test. This was the predefined neurocognitive test within the Sportreact mobile application, which was modified for our study. After a countdown, all four photocells lit up. One of the signals was always either a red "*X*" (indicating that the participant should respond with their right hand) or a blue "*O*" (indicating that the participant should respond with their left hand), presented in equal ratios. A total of 32 stimuli appeared in random order, with a random generation time between 500 and 1000 ms. The examiner monitored the participants to ensure that each response was made with the correct hand. Participants were instructed to respond carefully to minimize incorrect responses. When the incorrect response was observed, the new trial must be performed. One visual demonstration and practice trial were carried out. After that, two trials with 2 min recovery time between them were conducted. The result of the test is the shorter total duration of the test taken for the two trials. The intra-session reliability showed to be moderate (ICC = 0.715).

Triple Y reactive agility test (3YRAT)
The structure of the Triple Y reactive agility test (running distance, angles of changes in direction) was adapted to mimic the demands of several team sports. It consists of 5+10+10+5-meter sprints that incorporate changes of direction at the angles of 30° (three times) and 180° (three times). It is a combination of a velocity- and force-oriented reactive agility test, given that both stop-and-go and non-stop running scenarios are included.

The sensors were arranged as illustrated in Figure 1. Participants began the test 50 cm behind the starting line, positioned in the centre of a timing gate formed by two sensors (labelled No. 0 and 1) facing each other. This timing gate served as a trigger point for the additional light signals generated by sensors No. 2 to 5. As soon as a participant crossed the middle gate, the sensors would light up green. Participants had to cross the middle gate three times, following these steps: 1) accelerate, change direction toward the green lit sensor that is lit green, and deactivate it by bringing their hand within 20 cm distance; 2) run back through the middle gate and change direction according to the lit sensor on the opposite side; 3) run back again, deactivate the last sensor, and return to the middle gate. The test finishes after the final crossing of the middle gate. Two trials were conducted with predefined sequences (2-4-3, 3-5-3) after one practice trial (3-5-2). The outcome of the test was the shorter total time recorded from the two trials.

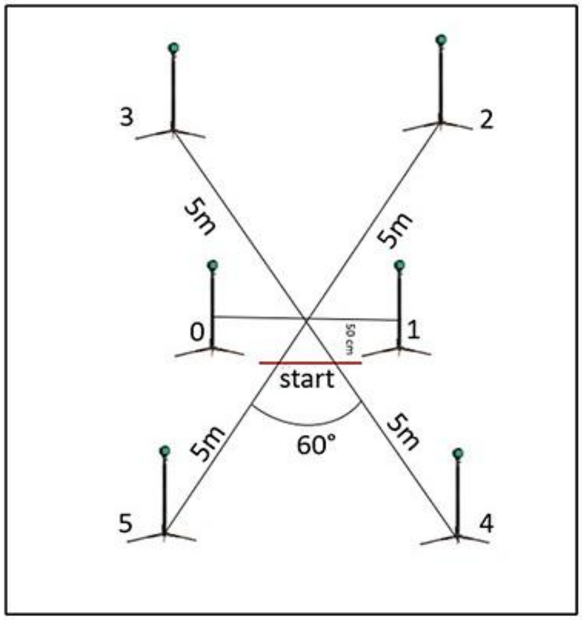

Figure 1. Triple Y reactive agility test.

10m sprint test
The 10-meter sprint test evaluates linear acceleration speed. In this test, participants were required to cover a distance of 10 meters between two pairs of photocells as quickly as possible. Each participant started from a line positioned 0.5 meters behind the starting photocells. Participants completed two trials with a one-minute rest interval between them. The test was measured using Sportreact (Zagreb, Croatia), which has an accuracy of 0.001 seconds. The final result was recorded as the fastest time from the two trials, measured in seconds.

Statistical analysis
Data analysis was conducted using SPSS version 23.0 for Windows. The Shapiro-Wilk test confirmed the normal distribution of data. Intra-session reliability (trial-to-trial) of the Triple Y reactive agility test was assessed by calculating Intraclass Correlation Coefficient (ICC) using the ICC (3,1) model, applying a two-way mixed effects approach, absolute agreement, and single measures (Koo and Li, 2016). Reliability was classified as follows: fair (0.25–0.50), moderate (0.50–0.75), good (>0.75), and excellent (>0.90; Portney, 2020). The absolute reliability of the Triple Y test was expressed as the within-subject coefficient of variation (CV), which was also used to determine the magnitude of measurement error. A CV of ≤ 10 % was deemed acceptable (Uthoff et al., 2018). The paired t-test was used to find the differences between the first and second trials. To visually analyse the differences between Trial 1 and Trial 2, a Bland-Altman plot with a 95 % confidence interval (95 % CI) was generated. Additionally, the minimal detectable change (MDC) was calculated using the standard error of measurement (SEM) to emphasize its practical application using the following formulae:

$$SEM = SD \times \sqrt{(1 - ICC)}$$

$$MDC = 1.96 \times \sqrt{(2)} \times SEM$$

A paired sample t-test was conducted to determine whether significant differences existed in the mean times between test trials. Pearson's correlation analysis was employed to examine the relationships between reactive agility time (the dependent variable) and independent variables (times from the Go/No-Go test, choice reaction task, and 10 m sprint time). The magnitude of the correlation was interpreted according to the following scale: 0.1 or less = trivial, greater than 0.1 to 0.3 = small, greater than 0.3 to 0.5 = moderate, greater than 0.5 to 0.7 = large, greater than 0.7 to 0.9 = very large, and greater than 0.9 to 1.0 = almost perfect (Hopkins, 2009). Multiple regression analysis (using the enter method) was performed to identify the predictor variables for Triple Y reactive agility performance. Variance inflation factor was used to detect multicollinearity in multiple regression model. The significance level was set at $\alpha = .05$.

RESULTS

The mean score (±SD), and coefficient of variation (CV) for all tests are presented in Table 1.

Table 1. Test results of cognitive, reactive agility, and speed tests.

Test	Time [s]	CV
Go no-go test	29.76 ± 0.63	2.0 %
Choice reaction test	51.00 ± 3.67	7.2 %
3YRAT	10.46 ± 0.77	7.4 %
10 m sprint test	2.10 ± 0.18	8.4 %

Intra-session reliability of the Triple Y reactive agility test

The paired samples t-test did not show a significant difference between the two trials ($t = 0.92$, $p = .37$). The mean score for the 3YRAT obtained from both trials conducted on the same day, along with the ICC 95 % confidence intervals, percentual values of CV, SEM, and MDC are summarized in Table 2. The intra-session reliability of the 3YRAT was assessed using the ICC. The analysis revealed an ICC value of 0.85 (0.71 - 0.93 95% CI), indicating good reliability. The SEM was 0.31 s, corresponding to 2.87 % of the mean test result. The MDC was calculated as 0.85 s, equivalent to 7.96 %, suggesting that any change greater than 0.85 s can be considered a real change beyond measurement error. The CV was 7.43 %, which is generally considered acceptable for performance tests. Thus, the agility test demonstrates satisfactory reliability for intra-session performance assessment.

Table 2. Intra-session reliability statistics of the Triple Y reactive agility test.

Test	Trial 1 [s]	Trial 2 [s]	ICC (95% CI)	CV	SEM	MDC
3YRAT	10.67 ± 0.83	10.59 ± 0.76	0.85 (0.71-0.93)	7.43 %	2.87 %	7.96 %

Note: ICC – Intraclass correlation coefficient; CV – Coefficient of variation; SEM – Standard error measurement; MDC – Minimal detectable change).

The Bland-Altman plot in Figure 2 illustrates the agreement between Trial 1 and Trial 2. The chart indicates that most of the differences fall within the 95 % agreement limits, which range from -0.78 s to 0.93 s, with only 1 out of 30 data points (3.3 %) lying beyond these limits.

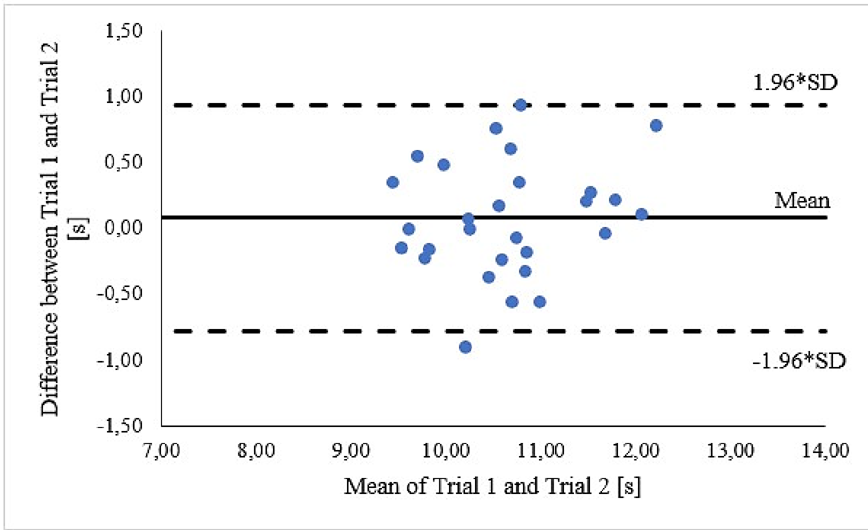

Figure 2. Bland-Altman plot with 95 % CI.

Contributing factors to Triple Y reactive agility performance

Significant moderate to large relationships were found between the Triple Y reactive agility time and times in the 10 m sprint (r = 0.77, p < .001), Go no-go test (r = 0.45, p = .02), and choice reaction test (r = 0.41, p = .03). Initially, all independent variables, including age, body height, body mass, and years of experience, were included in the multiple linear regression model to control for potential confounding effects. However, after assessing significance and multicollinearity, non-significant predictors were removed to achieve a parsimonious model. The final model included performances in choice reaction test, go-no/go test, and 10m sprint test as predictors. The model explained 70 % of the variance in the dependent variable ($F_{(3,24)}$ = 18.70, R^2 = .70, Adjusted R^2 = .66, p < .001). The choice reaction (p = .02) and 10 m sprint (p < .001) were statistically significant predictors, while time in go-no/go test approached significance (p = .07) (Table 3). These findings suggest that performance in the choice reaction and 10 m sprint tests is strongly associated with the outcome variable, even after controlling for other potentially confounding variables.

After adjusting for the explained variance (R^2 = .700), the 10 m sprint test accounted for 37.78 % of the explained variability in 3YRAT performance, followed by choice reaction (17.84 %) and go-no/go test (14.38 %). This indicates that 10 m sprint speed had the strongest influence on the reactive agility test outcome.

Table 3. Multiple regression analysis and predictive model for Triple Y reactive agility test.

Model	**Dependent variable - Triple Y reactive agility test (R = 0.84, R^2 = .70)**					
Predictors	B	β	95 % CI		t	*p*-value
10 m sprint	2.71	0.62	1.59	3.83	4.98	<.001
Go/no-go test	0.06	0.29	0.01	0.11	2.53	.02
Choice reaction test	0.29	0.24	-0.02	0.59	1.94	.07

DISCUSSION

The Triple Y reactive agility test demonstrated good relative reliability (ICC = 0.85). These results are comparable to the intra-session reliability of the Stop-and-Go Reactive Agility Test (SNG-RAT) in college-aged athletes, which ranges from ICC 0.81 to 0.86 (Sekulić et al., 2014). Additionally, a sport-specific reactive agility test for basketball players, which used a non-stop movement template, reported reliability values of ICC 0.85 to 0.86 (Sekulić et al., 2017). Pojskić et al. (2018) noted that the intra-session reliability of the SNG-RAT varied across different testing protocols in U17 and U19 soccer players. The second and third protocols showed higher reliability, with ICC values of 0.88 and 0.87, respectively, compared to the first protocol, which had an ICC of 0.70. Their testing sequence included four directional options, similar to the reactive agility test utilized in Sekulić et al. (2014). In contrast, a somewhat lower reliability was found in a football-specific reactive agility test, which involved one directional change followed by a response to one of two options, yielding ICC values of 0.79 in U13 players and 0.82 in U15 players (Krolo et al., 2020). Zeljko et al. (2020) applied the same reactive agility test in futsal players with a mean age of 23 years, reporting ICC values of 0.72 to 0.74. Their testing protocol also incorporated soccer-specific skills, such as kicking the ball. This likely contributed to the slightly lower reliability compared to tests that did not include sport-specific skills. The reliability of the YRAT was also found to be higher than that of the Stop-and-Go Reactive Agility Test involving lateral movements for tennis players, which reported ICC values of 0.72 to 0.74 (Sinković et al., 2022). Overall, the 3YRAT can be considered as reliable as most other validated tests.

The absolute reliability parameters showed acceptable values (SEM % = 2.87, MDC % = 7.96, CV % = 7.43). The value of MDC suggests that any change greater than 0.85 s can be considered a real change beyond measurement error. The SEM is lower than MDC (SEM = 0.31 s) which is desirable. The value of CV is slightly higher than the mean CV for the Y-shaped agility test (approximately 3 %) (Oliver and Meyers, 2009), the reactive agility test for rugby players (2.8 %; Gabbett et al., 2008), and the sport-specific reactive agility test for basketball players (2.9 % to 5 %; Scanlan et al., 2014).

A non-significant difference between the first and second trials indicates that there was no intra-session learning effect. Büchel et al. (2022) demonstrated that a strong learning effect occurs in the reactive agility task from one session to the next. Therefore, inter-session learning should not be entirely disregarded. However, Zemková and Hamar (2001) have found that the learning effect occurred only until the third trial when the protocol with random generating stimuli was used. In 3YRAT, altogether three trials were performed (one practice and two recorded trials). Based on previous observations, including a practice trial is beneficial for minimizing the learning effect in subsequent counting trials, familiarizing participants with the types of stimuli and helping them understand how to coordinate their upper extremity movements to deactivate the sensors. Therefore, two trials after one practice trial may be considered sufficient for evaluating performance in the 3YRAT.

The aim of the study was also to quantify the relationship between measured cognitive and physical variables and the score from a developed reactive agility test (3YRAT), which served as the dependent variable. The time recorded in the 3YRAT significantly correlated with all three variables - 10-meter sprint time (r = 0.77, $p < .001$), time in the Go/No-Go test (r = 0.45, $p = .02$), and choice reaction time (r = 0.41, $p = .03$). This suggests that both motor (38 %) and cognitive components (32 %) significantly contribute to the performance in the 3YRAT. Other studies have also shown a significant correlation between reactive agility performance and sprint speed. This is noted in scenarios involving non-stop running (Horníková and Zemková, 2022; Horníková et al., 2021) as well as the stop-and-go model of the reactive agility test (Chow et al., 2022). However, it is more closely related to the change of direction speed (Krolo et al., 2020; Pojskic et al., 2018; Popowczak et al., 2021). The index of reactivity, which represents the cognitive component, showed a small but significant correlation with stop-and-go reactive agility test performance in professional female basketball and handball players (r = 0.48, $p = .007$; Popowczak et al., 2021). In contrast, the correlation was nonsignificant when the reactive Y-shaped agility test was used with soccer players in different playing positions (Fiorilli et al., 2017). This lack of correlation may be due to the simplified context of the Y-shaped agility test, where a single change of direction followed by a single reaction to a stimulus may not adequately capture the cognitive aspects of reactive agility. The total time in the Y-shaped agility test did not show significant relationships with computer-based simple and choice reaction times (Horníková and Zemková, 2022; Horníková et al., 2021; Matlák et al., 2024). From this viewpoint, using a human stimulus in the Y-shaped agility test was more appropriate when decision time and response movement time were also measured (Henry et al., 2011; Matlák et al., 2024; Young and Willey, 2010). In this study, new setup of cognitive tests assessing visual inhibition and choice reaction were introduced. Although these tests are considered "*laboratory-based*" with general visual stimuli, the results suggest that these tests can sufficiently reflect the cognitive component of the reactive agility performance. The increased demands on perceptual and decision-making compared to previously used reaction time tests, may capture the cognitive aspect of reactive agility more sensitively.

The Y-shaped template is a widely used reactive agility test in team sports. However, stop-and-go tests that require multiple movement responses are gaining popularity (Chow et al., 2022; Pojskić et al., 2018; Popowczak et al., 2021; Sekulić et al., 2014; Krolo et al., 2020). This study may be among the first few to evaluate the reliability of a reactive agility test that combines two scenarios: change of direction with non-stop running (featuring 30° changes of direction before the turns) and a stop-and-go model (including a 180° turn). This design results in a more complex test, because it may be considered both force- and velocity-oriented. Additionally, athletes must respond to three visual stimuli, which is more than what is typically required in the commonly used Y-shaped agility test with non-stop running. Athletes need to cover a longer distance between consecutive movement responses compared to a stop-and-go scenario used by Sekulić et al. (2014), which is closer to the demands of several team sports. As a result, the 3YRAT can be viewed as a compromise between these two approaches, balancing the demands on perceptual-cognitive skills and motor abilities in reactive agility tasks. Although Born et al. (2016) used the reactive agility test which included changes of direction with both scenarios, their test seems to be time-consuming and leads to significant involvement of the glycolytic system compared to our 3YRAT.

It is important to acknowledge certain limitations of this study. Firstly, we are aware of the shortcomings associated with the nature of cross-sectional design and that the experimental study could bring the stronger evidence of practical applicability of 3YRAT. Secondly, the research focuses on only two cognitive tests - neural inhibition and decision-making - which may not fully capture all cognitive abilities related to reactive agility such as pattern recognition, attention, and working memory. Moreover, it is also worth considering shortening the total duration of cognitive tests either by shortening the stimulus generation time or by limiting the maximum response waiting time and adding one or more additional trials. This will avoid the possible occurrence of learning effect, which is a relatively common phenomenon in cognitive tasks. Afterwards, we can avoid the potential occurrence of mental fatigue even in such young athletes. Future research should investigate whether the YRAT can effectively differentiate among athletes from various sports, genders, and performance levels, thereby providing even greater practical and scientific contributions.

CONCLUSIONS

This study proposed a new reliable procedure for assessing reactive agility in youth soccer players and potentially in other athletes involved in "*agility-saturated sports*." This approach provides a more comprehensive diagnostic tool for evaluating agility, because both change of direction scenarios (non-stop running & stop-and-go) are performed. It provides an assessment of the athlete's ability to quickly change running direction at an already acquired speed, as well as decelerate to zero speed and then maximally accelerate again. The Triple Y agility test has been found to be reliable and incorporates essential components of agility - cognitive and motor skills. Moreover, cognitive tests used in this study seems to be suitable for detecting the cognitive aspects of reactive agility.

AUTHOR CONTRIBUTIONS

All authors have contributed to all phases of the project. Henrieta Horníková: design of the study, development of the theoretical bases, analysis and interpretation of the data and writing of the article. Filip Skala: study design, data collection, writing the article. The final version of the manuscript was reviewed, edited, and approved by all authors.

SUPPORTING AGENCIES

This work was supported by the Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences under Grant [No. 1/0725/23].

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

ACKNOWLEDGEMENTS

We would like to thank Mr. David Nemec and the players from his club for participating in the data collection.

REFERENCES

Born, D. P., Zinner, C., Düking, P., & Sperlich, B. (2016). Multi-directional sprint training improves change-of-direction speed and reactive agility in young highly trained soccer players. Journal of Sport Science and Medicine, 15(2), 314-319.

Büchel, D., Gokeler, A., Heuvelmans, P., & Baumeister J. (2022). Increased Cognitive Demands Affect Agility Performance in Female Athletes - Implications for Testing and Training of Agility in Team Ball Sports. Perceptual and Motor Skills, 129(4), 1074-1088. https://doi.org/10.1177/00315125221108698

Chaalali, A., Rouissi, M., Chtara, M., Owen, A., Bragazzi, N. L., Moalla, W., Chaouachi ,A., Amri, M., & Chamari, K. (2016). Agility training in young elite soccer players: promising results compared to change of direction drills. Biology of Sport, 33(4), 345-351. https://doi.org/10.5604/20831862.1217924

Coh, M., Vodicar, J., Zvan, M., Simenko, J., Stodolka, J., Rauter, S., & Mackala, K. (2018). Are change-of-direction speed and reactive agility independent skills even when using the same movement pattern? Journal of Strength and Conditioning Research, 32(7), 1929-1936. https://doi.org/10.1519/JSC.0000000000002553

Cochrane, D. J. (2013). The effect of acute vibration exercise on short-distance sprinting and reactive agility. Journal of Sport Science and Medicine, 12(3), 497-501.

Farrow, D., Young, W., & Bruce, L. (2005). The development of a test of reactive agility for netball: A new methodology. Journal of Science & Medicine in Sport 8, 52-60. https://doi.org/10.1016/S1440-2440(05)80024-6

Fiorilli, G., Iuliano, E., Mitrotasios, M., Pistone, E. M., Aquino, G., Calcagno, G., & di Cagno, A. (2017). Are Change of Direction Speed and Reactive Agility Useful for Determining the Optimal Field Position for Young Soccer Players? Journal of Sports Science and Medicine, 16(2), 247-253.

Frederick, M. F. A., Zulkapri, I., Soeed, K., Tariq, I., Hamid, T. A. H., Omar, A. H., Hasan, K., & Nadzalan, A. M. (2020). Changes of direction speed and reactive agility performance using badminton reactive agility tests system (BRATS) among state, district and school badminton players. European Journal of Molecular & Clinical Medicine, 7(2), 4040-4047.

Gabbett, T., Kelly, J. N., & Sheppard, J. M. (2008). Speed, change of direction speed, and reactive agility of rugby league players. Journal of Strength and Conditioning Research, 22(1), 174-181. https://doi.org/10.1519/JSC.0b013e31815ef700

Green, B. S., Blake, C., & Caulfield, B. M. (2011). A valid field test protocol of linear speed and agility in rugby union. Journal of Strength and Conditioning Research, 25(5), 1256-1262. https://doi.org/10.1519/JSC.0b013e3181d8598b

Hassan, A. K., Alhumaid, M. M., & Hamad, B. E. (2022). The Effect of Using Reactive Agility Exercises with the FITLIGHT Training System on the Speed of Visual Reaction Time and Dribbling Skill of Basketball Players. Sports (Basel, Switzerland), 10(11), 176. https://doi.org/10.3390/sports10110176

Henry, G., Dawson, B., Lay, B., & Young, W. (2011). Validity of a reactive agility test for Australian football. International Journal of Sports Physiology and Performance, 6(4), 534-545. https://doi.org/10.1123/ijspp.6.4.534

Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. Medicine and Science in Sports and Exercise, 41(1), 3-12. https://doi.org/10.1249/MSS.0b013e31818cb278

Horníková, H., Jeleň, M., & Zemková, E. (2021). Determinants of Reactive Agility in Tests with Different Demands on Sensory and Motor Components in Handball Players. Applied Sciences, 11(14), 6531. https://doi.org/10.3390/app11146531

Horníková, H., & Zemková, E. (2022). Determinants of Y-shaped agility test in basketball players. Applied Sciences, 12(4), 1865. https://doi.org/10.3390/app12041865

Chow, C. G., Kong, Y. H., & Wong, C. L. (2022). Reactive-Agility in Touch Plays an Important Role in Elite Playing Level: Reliability and Validity of a Newly Developed Repeated Up-and-Down Agility Test. Journal of Sports Science and Medicine, 21(3), 413-418. https://doi.org/10.52082/jssm.2022.413

Jeffriess, M. D., Schultz, A. B., McGann, T. S., Callaghan, S. J., & Lockie, R. G. (2015). Effects of Preventative Ankle Taping on Planned Change-of-Direction and Reactive Agility Performance and Ankle Muscle Activity in Basketballers. Journal of Sports Science and Medicine, 14(4), 864-876.

Koo, T. K., & Li, M. Y. (2016). A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. Journal of Chiropractic Medicine, 15(2), 155-163. https://doi.org/10.1016/j.jcm.2016.02.012

Krolo, A., Gilic, B., Foretic, N., Pojskic, H., Hammami, R., Spasic, M., Uljevic, O., Versic, S., & Sekulic, D. (2020). Agility Testing in Youth Football (Soccer)Players; Evaluating Reliability, Validity, and Correlates of Newly Developed Testing Protocols. International Journal of Environmental Research and Public Health, 17(1), 294. https://doi.org/10.3390/ijerph17010294

Lockie, R. G., Jeffriess, M. D., McGann, T. S., Callaghan, S. J., & Schultz, A. B. (2014). Planned and reactive agility performance in semiprofessional and amateur basketball players. International journal of Sports Physiology and Performance, 9(5), 766-771. https://doi.org/10.1123/ijspp.2013-0324

Matlák, J., Fridvalszki, M., Káródi, V., Szamosszegi, G., Pólyán, E., Kovács, B., Kolozs, B., Langmár, G., & Rácz, L. (2024). Relationship Between Cognitive Functions and Agility Performance in Elite Young Male Soccer Players. Journal of Strength and Conditioning Research, 38(1), 116-122. https://doi.org/10.1519/JSC.0000000000004644

Morral-Yepes, M., Moras, G., Bishop, C., & Gonzalo-Skok, O. (2022). Assessing the Reliability and Validity of Agility Testing in Team Sports: A Systematic Review. Journal of Strength and Conditioning Research, 36(7), 2035-2049. https://doi.org/10.1519/JSC.0000000000003753

Munivrana, G., Jelaska, I., & Tomljanović, M. (2022). Design and Validation of a New Tennis-Specific Reactive Agility Test-A Pilot Study. International Journal of Environmental Research and Public Health, 19(16), 10039. https://doi.org/10.3390/ijerph191610039

Oliver, J. L., & Meyers, R. W. (2009) Reliability and generality of measures of acceleration, planned agility, and reactive agility. International Journal of Sports Physiology and Performance, 4(3), 345-354. https://doi.org/10.1123/ijspp.4.3.345

Pavlinović, V., Foretić, N., Kovačević, N., Galić, T., Lušić Kalcina, L., Mihanović, F., & Modric, T. (2024). Cognitive and Motor Capacities Are Poorly Correlated with Agility in Early Pubertal Children: Gender-Stratified Analysis. Applied Sciences, 14(8), 3148. https://doi.org/10.3390/app14083148

Pojskić, H., Åslin, E., Krolo, A., Jukić, I., Uljević, O., Spasić, M., & Sekulić, D. (2018). Importance of Reactive Agility and Change of Direction Speed in Differentiating Performance Levels in Junior Soccer Players: Reliability and Validity of Newly Developed Soccer-Specific Tests. Frontiers in Physiology, 9, 506. https://doi.org/10.3389/fphys.2018.00506

Popowczak, M., Cichy, I., Rokita, A., & Domaradzki, J. (2021). The Relationship Between Reactive Agility and Change of Direction Speed in Professional Female Basketball and Handball Players. Frontiers in Psychology, 12, 708771. https://doi.org/10.3389/fpsyg.2021.708771

Portney, L. G. (2020). Foundations of clinical research: applications to evidence-based practice (4th ed.). F.A. Davis Company.

Sattler, T., & Šajber, D. (2015). Change of Direction Speed and Reactive Agility Performance - the Reliability of a Newly Constructed Measuring Protocols: A Brief Report. Kinesiologia Slovenica, 21(2), 31-38.

Scanlan, A. T., Tucker, P. S., & Dalbo, V. J. (2014). A comparison of linear speed, closed-skill agility, and open-skill agility qualities between backcourt and frontcourt adult semiprofessional male basketball players. Journal of Strength and Conditioning Research, 28(5), 1319-1327. https://doi.org/10.1519/JSC.0000000000000276

Sekulić, D., Krolo, A., Spasić, M., Uljević, O., & Perić, M. (2014). The development of a new stop'n'go reactive-agility test. Journal of Strength and Conditioning Research, 28(11), 3306-3312. https://doi.org/10.1519/JSC.0000000000000515

Sekulić, D., Pehar, M., Krolo, A., Spasić, M., Uljević, O., Calleja-González, J., & Sattler, T. (2017). Evaluation of Basketball-Specific Agility: Applicability of Preplanned and Nonplanned Agility Performances for Differentiating Playing Positions and Playing Levels. Journal of Strength and Conditioning Research, 31(8), 2278-2288. https://doi.org/10.1519/JSC.0000000000001646

Serpell, B. G., Ford, M., & Young, W. B. (2010). The development of a new test of agility for rugby league. Journal of Strength and Conditioning Research, 24(12), 3270-3277. https://doi.org/10.1519/JSC.0b013e3181b60430

Sinković, F., Foretić, N., & Novak, D. (2022). Reliability, Validity and Sensitivity of Newly Developed Tennis-Specific Reactive Agility Tests. Sustainability, 14(20), 13321. https://doi.org/10.3390/su142013321

Spasić, M., Krolo, A., Zenić, N., Delextrat, A., & Sekulić, D. (2015). Reactive agility performance in handball; development and evaluation of a sport-specific measurement protocol. Journal of Sports Science & Medicine, 14(3), 501-506.

Spiteri, T., Cochrane, J., & Nimphius, S. (2012). Human stimulus reliability during an offensive and defensive agility protocol. Journal of Australian Strength and Conditioning, 20(4), 14 - 21.

Trajković, N., Sporiš, G., Krističević, T., Madić, D. M., & Bogataj, Š. (2020). The Importance of Reactive Agility Tests in Differentiating Adolescent Soccer Players. International Journal of Environmental Research and Public Health, 17(11), 3839. https://doi.org/10.3390/ijerph17113839

Uthoff, A., Oliver, J., Cronin, J., Winwood, P., & Harrison, C. (2018). Prescribing target running intensities for high-school athletes: Can forward and backward running performance be autoregulated? Sports, 6(3), 77. https://doi.org/10.3390/sports6030077

Young, W. B., & Willey, B. (2010). Analysis of a reactive agility field test. Journal of Science & Medicine in Sport 13, 376-378. https://doi.org/10.1016/j.jsams.2009.05.006
Young, W. B., Dawson, B., & Henry, G. J. (2015). Agility and Change-of-Direction Speed are Independent Skills: Implications for Training for Agility in Invasion Sports. International Journal of Sports Science & Coaching, 10(1), 159-169. https://doi.org/10.1260/1747-9541.10.1.159
Young, W. B., Farrow, D., Pyne, D., McGregor, W., & Handke, T. (2011). Validity and Reliability of Agility Tests in Junior Australian Football Players. Journal of Strength and Conditioning Research, 25(12), 3399-3403. https://doi.org/10.1519/JSC.0b013e318215fa1c
Zeljko, I., Gilić, B., & Sekulić, D. (2020). Validity, reliability and correlates of futsal- specific pre-planned and non-planned agility testing protocols. Kinesiologia Slovenica, 26, 25-34. https://doi.org/10.52165/kinsi.26.2.25-34
Zemková, E., & Hamar, D. (2001). Posudzovanie disjunktívnych reakčno-rýchlostných schopností [The assessment of disjunctive reaction-speed abilities]. Bratislava: Fakulta telesnej výchovy a športu UK.

