Baltic Journal of Sport and Health Sciences *No. 2*(139); 2026; 20–31; eISSN 2538-8347;
DOI: https://doi.org/10.33607/bjshs.v2i139.2135

LITHUANIAN SPORTS UNIVERSITY

Baltic Journal of Sport and Health Sciences

Journal homepage: https://journals.lsu.lt/baltic-journal-of-sport-health

Reliability and Performance Correlates of Life-Size Reactive Agility Test in Netball Players

Fitry Azrul bin Nor Saafri[1, 2]*, Halijah binti Ibrahim[1]
[1] *Faculty of Educational Sciences and Technology, University of Technology Malaysia, Skudai, Malaysia*
[2] *Jabatan Belia dan Sukan Wilayah Persekutuan Kuala Lumpur, Kuala Lumpur, Malaysia*
* *Correspondence: fitryazrul89@gmail.com; +60 13-711 5523*

ABSTRACT

Reactive agility is an important component in many team sports, with human stimulus considered more realistic for performance assessment than video- or light-based stimulus testing. This study aimed to evaluate the reliability of a newly adopted netball specific Life-Size Reactive Agility Test (LSRAT), and to determine the correlation between action accuracy and total time. Twenty young female netball players, mean age = 15.1 ± 1.7 years, completed two test conditions using a live tester with netball-specific movements: (a) the tester acted as an opponent by delivering an offensive stimulus for the subject to react to; and (b) the tester acted as a teammate by delivering a ball pass as a stimulus to which the subject had to react by receiving the pass. Results showed very high reliability for total time in both test conditions, with Pearson's correlation coefficient (Pearson's r) values of 0.90–0.94, and intraclass correlation coefficient (ICC) values of 0.91–0.93. However, action accuracy for both subjects and testers yielded moderate to low Pearson's r and ICC values across both test conditions. The usefulness of the test in detecting moderate performance changes was evaluated as 'good' for the total time in both test conditions. In contrast, subject action accuracy was rated from 'good' to 'marginal', while tester action accuracy was rated as 'marginal' in both test conditions. In conclusion, the LSRAT is a reliable tool for measuring reactive agility in netball players while action accuracy measures may require further refinement for optimal utility in coaching and research.

Keywords: Netball, reactive agility, decision making, reactive agility testing, speed

1. INTRODUCTION

Netball is primarily played on indoor courts with seven players in each team, and each player performs at a certain position (Sweeting et al., 2017). Matches are usually played for 60 minutes, and divided into four 15-minute quarters, with each position restricted to specific court areas (World Netball, n.d.). According to Brooks et al. (2020), netball players must perform high-intensity multidirectional efforts such as changes of direction, running, and jumping within a restricted court area. Furthermore, these movements, which require perceptual–cognitive abilities, including anticipation and decision-making, are typically not pre-planned but rather performed in response to a stimulus (Paul et al., 2016).

Netball-specific stimuli may include netball-specific actions like jumping, ball passing, and dodging, as well as physical movements like body swerves performed by both teammates and opponents. Pre-planned changes of direction are considered closed skills, which can be characterised by a change in the direction of movement that is already known in advance, and players do not need to react to any specific stimulus. Contrastively, open skills require players to change direction in response to a stimulus by integrating cognitive components such as observation and decision-making (Gabbett & Benton, 2009; Perić et al., 2021; Zeljko et al., 2020). This type of skill has recently been termed reactive agility, which is defined as the capacity to read the game and to quickly initiate an adequate motor response (Altmann et al., 2020). Furthermore, it is regarded as a necessary factor to succeed in team sports such as netball (Paul et al., 2016).

On the other hand, in an actual game situation, an opponent's movement initiates the vast majority of footwork patterns that players perform, especially when playing a defensive role. It is therefore maintained that, in order to properly assess a player's reactive agility, tests need to include a visual–perceptual component to accurately capture this reactive aspect of performance. The use of life-size stimuli (human stimuli) in combination with sport specific response patterns in a Y-shaped design has become a popular methodology over the past ten years to increase environment's validity in reactive agility testing in team sports like soccer (Chaalali et al., 2016; Trajković et al., 2020; Trecroci et al., 2016, 2018), basketball (Scanlan et al., 2014, 2015), and rugby (Meir et al., 2014). In these Y-shaped tests, athletes are required to perform change of direction at a 45° angle in reaction to the tester's movement.

The results of the tests show high validity and reliability, with several investigations of the parameters such as the total time to complete the test, response time, and the decision-making time representing perceptual–cognitive components as well as the movement time representing physical ability (Scanlan et al., 2014; Young & Willey, 2010). Therefore, these parameters focus on the importance of both the physical factors and the perceptual–cognitive components in relation to reactive agility performance (Paul et al., 2016).

However, according to Paul et al. (2016), no reactive agility test to date has used netball-specific stimuli, which limits the test's ecological validity in netball contexts. As a result, this study developed a test specifically designed for netball necessities. Trecroci et al. (2016, 2018) adopted this test as their reactive agility test. However, netball-specific movements and ball passing take the place of the assistant tester's generic movement patterns. The primary purpose of this study was to examine the reliability of the Life-Size Reactive Agility Test (LSRAT) for netball players. The secondary aim was to determine the correlation between action accuracy and total time. The LSRAT is hypothesised to demonstrate high reliability based on the results from related studies in other team sports described above.

2. MATERIALS AND METHODS

All participants attended a briefing session where they received a clear explanation of the study, observed test performances, and completed two trials under each of the two test conditions, with four protocols per test condition. During the session, participants were also informed about the potential risks and benefits of their participation in the study. Upon agreeing to participate, each participant was given an assent form and asked to complete and sign the form. For guardian consent, an informed consent form was given to the parent or guardian of the participant who were asked to complete and sign the form. The researcher obtained data on participants' age, height, body weight, years of netball experience, and the highest level of competition they had participated in.

Additionally, participants completed a health screening questionnaire which asked a range of questions related to their personal health, wellbeing, exercise habits, and history of past injuries. All tests were performed in the evening on indoor netball hard courts. Participants wore appropriate netball attire and shoes. The research methodology was approved (approval number UTMREC-2024-88) by the University of Technology Malaysia Research Ethics Committee (UTM REC).

Twenty young female netball players from a sports school in Kuala Lumpur, Malaysia, participated in this study. All participants had at least three years of experience competing at the state level netball competition at the time of testing. As a result, they were familiar with fundamental netball skills such as ball passing (shoulder pass) and one-on-one offensive and defensive aspects of play that are common in netball. The physical characteristics of the participants who completed all tests were as follows (mean ± standard deviation (SD)): age = 15.1 ± 1.7 years; height = 172.4 ± 3.7 cm; body mass = 64.4 ± 9.6 kg; body mass index = 21.6 ± 2.7; netball experience = 5.5 ± 2.0 years.

2.1. PROCEDURES

All participants performed a standardised 15-minute warm-up, including jogging, short accelerations, and a one-on-one ball passing drill. After the warm-up activity was completed, participants were divided into two groups equally, namely the tester group and the subject group. In each of the testing sessions across both testing conditions, the tester group provided stimuli to the subject group to react to. After completion, the tester group switched roles to become the subject group and the subject group to become the tester group. Each tester completed all possible protocols twice in a balanced randomised order, resulting in eight trials (four trials per session), with a passive rest of three minutes between the trials of each test, while a 10-minute passive rest was provided between the sessions to ensure full recovery (Altmann et al., 2019). For all tests, a wireless single-beam timing gate system (*Brower TCi-System*) was used. The 'start' and 'stop' commands were triggered when a foot or a hand was detected by the photogate and a beep sound was heard. Timing gates were positioned from the starting line to the finish line at a height of 1.00 m, approximately at hip level. The starting distance from the initial timing gate was set at 0.30 m (Altmann et al., 2017).

2.1.1. LIFE-SIZE REACTIVE AGILITY TEST (LSRAT)

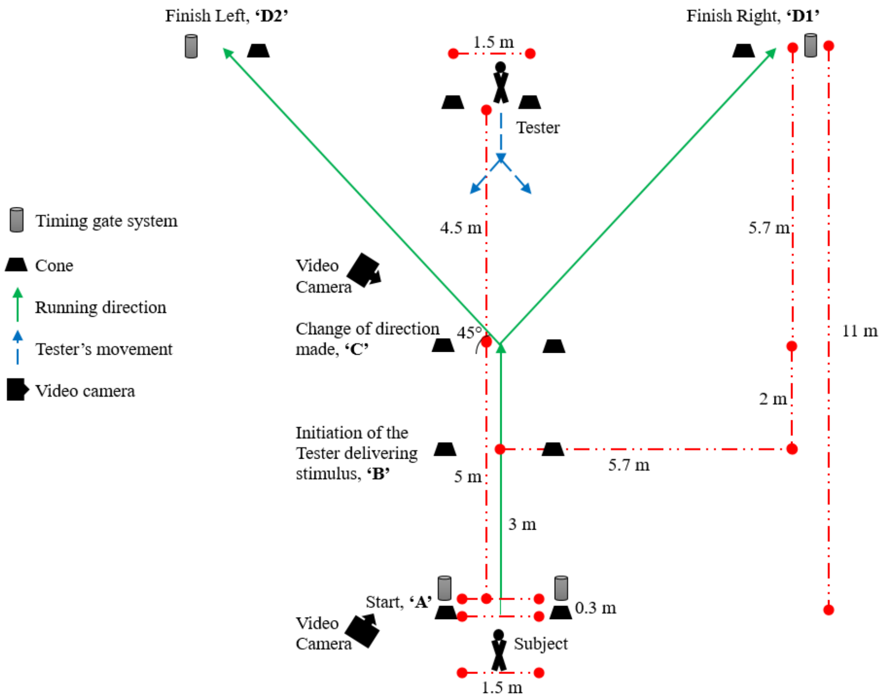
The LSRAT used in this study was based on the Y-shaped agility test previously adopted from Trecroci et al. (2016), with two modifications in order to increase ecological validity. First, the generic movement patterns of the tester were substituted with netball-specific movements, as recommended in a recent review by Paul et al. (2016). Second, based on the mean height of the participants in this study (both subject and tester), additional directional changes were added, thereby increasing the total distance. In short, the subjects stood at the starting line, facing the live tester at a distance of approximately 11 m. The tester was introduced as either a teammate or opponent in a standardised briefing prior to the test condition. Timing began when the subject initiated a sprint from point 'A'. When the subject reached point 'B', the tester displayed one of four possible protocols based on the test conditions described below:

a. Test Condition 1 – Tester acts as an opponent
    i. Step forwards with right foot, change direction to the left, and sprint at 45°
    ii. Step forwards with left foot, change direction to the right, and sprint at 45°
    iii. Jump forwards and land with right foot, change direction to the left, and sprint at 45°
    iv. Jump forwards and land with the left foot, change direction to the right, and sprint at 45°
b. Test Condition 2 – Tester acts as a teammate
    i. Step forwards with right foot, change direction to the left, make a left-hand ball pass, and receive the return pass from the subject
    ii. Step forwards with left foot, change direction to the right, make a right-hand ball pass, and receive the return pass from the subject
    iii. Jump forwards and land with right foot, change direction to the right, make a right-hand ball pass, and receive the return pass from the subject
    iv. Jump forwards and land with left foot, change direction to the left, make a left-hand ball pass, and receive the return pass from the subject

The subjects responded to the tester's movement or ball pass by changing direction either to the left or the right, attempting to fulfil the instruction to recognise and anticipate the movement or ball passing as swiftly as possible, while emphasising both action accuracy and movement speed. After changing direction in response to the tester's movement or ball passing at a 45° angle, which is approximately 5 m from the start line, the subjects sprinted through the finishing timing gates (Figure 1).

Each of the four movements and ball passing placed unique physical and cognitive demands on the subject and were repeated once per participant in a separate testing session. Therefore, the mean score from all four trials per testing session was recorded for analysis. To ensure consistent test conditions, both subjects and testers were not allowed to discuss possible scenarios or running strategies during the testing sessions.

Figure 1. **Schematic illustration of the Life-Size Reactive Agility Test (LSRAT) for netball players**



2.1.2. ACTION CHECKLIST

The action checklist for the LSRAT was used to measure the correctness of the tester's ability to conduct the tasks required by the testing protocols for both test conditions and the subject's ability to respond appropriately to the stimulus given by the tester. In Test Condition 1, which focused on basic movement skills, the checklist included actions to be performed by the tester and the subject, such as stepping forwards, changing body position, and sprinting at a 45° angle. In Test Condition 2, which incorporated ball-passing tasks, the checklist included skills such as shoulder passing, receiving the ball while running, and maintaining proper footwork. Each protocol listed specific actions with checkboxes to indicate 'Yes' or 'No' for completion.

Scoring was determined using separate rubrics for each test condition and the rubrics were validated by three experts, a national netball coach, a sport scientist, and a former national netball player. The tester in Test Conditions 1 and 2, and the subject in Test Condition 2 earned up to a maximum of three marks per protocol, each of which had three criteria. The total scores were categorised as 'Complete' (9–12), 'Needs Improvement' (5–8), or 'Incomplete' (0–4). Meanwhile, the subject in Test Condition 1 earned up to a maximum of two marks per protocol, each of which had two criteria only, and the total score was categorised as 'Complete' (7–8), 'Needs Improvement' (4–6), or 'Incomplete' (0–3). These scores were given by the researcher during the testing and collected from the checklist, and later used to validate the integrity of the testing protocols and to confirm the accuracy of the alignment between the tester's stimulus and the subject's response. Furthermore, to ensure that each score is given correctly, the researcher conducted a cross-check with video recording after the testing was completed.

For a testing procedure to be considered valid, both the tester and the subject needed to achieve a 'Complete' rating for the respective test condition. This ensured that the participants demonstrated sufficient proficiency in movement accuracy (Test Condition 1) and ball-handling coordination (Test Condition 2). The structured checklist and scoring system provided a clear, standardised method for assessing performance accuracy and determining correct execution of the testing protocols.

2.2. DATA SCREENING AND ANALYSIS PARAMETERS

The time required to complete LSRAT was automatically determined using the timing gate system and verified through video camera recording. The following parameters were recorded:

i. Total time – Duration from the moment the subject started sprinting and triggering the first timing gate to the moment the subject passed the finishing timing gate (measured in milliseconds).

ii. Subject action accuracy – Total action checklist score for the subject based on the accuracy of the movements or passes performed.
iii. Tester action accuracy – Total action checklist score for the tester based on the accuracy of the stimuli performed.

2.3. STATISTICAL ANALYSIS

All test results were analysed using IBM SPSS Statistics software version 29.0 (*SPSS Inc., Chicago, IL*). For each subject, the mean of eight trials of each test condition was included in the analysis to increase consistency of all trials and represent reactive agility performance. The data are presented as mean values, SD, and 95% confidence interval (CI) for the whole sample. Finally, in order to determine relationships between action accuracy for the subject and the tester with the total time, Pearson's correlation coefficient (Pearson's r) values were calculated. For the applied statistical procedures, the Shapiro–Wilk test was conducted and supported the use of parametric analyses. The significance level for all statistical tests was set at $\alpha = 0.05$.

2.4. RELIABILITY ANALYSIS

The test–retest reliability of the LSRAT was examined using intraclass correlation coefficient (ICC), Pearson's r, and coefficient of variation (CV) (Atkinson & Nevill, 1998). According to Hopkins (2002), the magnitude of r was interpreted as follows: small ($0.1 \leq r < 0.3$), moderate ($0.3 \leq r < 0.5$), large ($0.5 \leq r < 0.7$), very large ($0.7 \leq r < 0.9$), and nearly perfect ($r \geq 0.9$). All statistical analyses were conducted with a significance level $\alpha = 0.05$. ICC values were interpreted using the same scale. CV values below 10% were considered acceptable (Atkinson & Nevill, 1998).

Hopkins's (2004) guidelines were followed in calculating the action correctness and the usefulness of the total time as an additional measure of reliability. The measurement system, which is based on the ratio of the CV (reported in seconds) to the smallest worthwhile change (SWC), shows how sensitive a test is to detect significant changes in performance. In this context, the SWC was determined by multiplying the pooled between-subject SD of the mean over the eight trials from both test conditions by 0.2 ($SWC_{0.2}$ = small effect) and 0.5 ($SWC_{0.5}$ = moderate effect), based on Cohen's effect size principle. Consequently, usefulness ratings were established by comparing the CV with the respective SWC: good (CV < SWC), OK (CV = SWC), and marginal (CV > SWC) (Hopkins, 2004).

Finally, in order to determine correlation performance between action accuracy for subject and tester with the total time, Pearson's r was used, with interpretations consistent with the magnitudes of the correlation coefficients described above.

3. RESULTS

Descriptive statistics (mean ± SD) for all parameters under both test conditions are presented in Table 1.

Table 1. **Descriptive results for total time and action accuracy. Results are presented as mean ± SD of eight trials in Test Condition 1 and Test Condition 2**

	Test Condition 1		Test Condition 2	
	Session 1	Session 2	Session 1	Session 2
Total time (s)	1.91 ± 0.47	1.91 ± 0.47	2.52 ± 0.53	2.44 ± 0.57
Subject action accuracy (score)	7.25 ± 0.44	7.25 ± 0.44	10.20 ± 1.01	10.65 ± 0.93
Tester action accuracy (score)	9.95 ± 1.00	10.30 ± 0.73	9.80 ± 0.83	9.95 ± 0.94

The results indicated key differences between the two test conditions across both sessions. In Test Condition 1, the total time remained consistent at 1.91 ± 0.47 seconds in both sessions, whereas Test Condition 2 showed a slight decrease in total time, from 2.52 ± 0.53 seconds in Session 1 to 2.44 ± 0.57 seconds in Session 2, although this condition consistently took longer than Test Condition 1. Subject action accuracy in Test Condition 1 maintained a stable score of 7.25 ± 0.44 across both sessions. In contrast, Test Condition 2 demonstrated an improvement in subject action accuracy from 10.20 ± 1.01 score in Session 1 to 10.65 ± 0.93 score in Session 2, indicating higher accuracy and enhanced performance. The tester action accuracy improved in both conditions. However, the improvement in scores was more noticeable in Test Condition 1 (9.95 ± 1.00 in Session 1 to 10.30 ± 0.73 in Session 2), whereas Test Condition 2 showed a marginal increase from 9.80 ± 0.83 to 9.95 ± 0.94. Overall, these results suggest that while Test Condition 2 was more time-consuming, it resulted in better subject performance over time, which is possibly due to the increased task complexity.

RELIABILITY OF LIFE-SIZE REACTIVE AGILITY TEST (LSRAT)

The test–retest reliability statistics for all measured parameters, namely intraclass correlation coefficient (ICC), Pearson's correlation coefficient (*r*), coefficient of variation (CV), smallest worthwhile change (SWC), and usefulness rating across each test condition are shown in Tables 2 and 3, respectively. The total time showed consistently high reliability in both test conditions, with strong intraclass correlation coefficient (ICC = 0.91 and 0.93) and Pearson's *r* values (0.90 and 0.94), along with relatively low yet within the acceptable range CVs (CV = 0.12s and 0.10s). Therefore, the total time results for both test conditions showed 'almost perfect' rating as the ideal reliability level, which is more than 0.85 as suggested by Landis and Koch (1977). This indicates that the total time is a highly consistent measure across both sessions in both conditions. The usefulness of total time was rated 'marginal' to 'good' in the Test Condition 1 and 'OK' to 'good' in Test Condition 2, indicating that the total time is a stable and practically valuable measure.

Table 2. **ICC (95% CI), Pearson's r (95% CI), CV, SWC, and usefulness for total time, subject action accuracy, and tester action accuracy between Session 1 and Session 2 for Test Condition 1**

	ICC	Pearson's r	CV (%)	CV (s)	SWC0.2 (s)	Usefulness	SWC0.5 (s)	Usefulness
Total time	r = 0.91 (0.78–0.96) p < 0.001	r = 0.90 (0.69–1.12) p < 0.001	6.32	0.12	0.09	marginal	0.23	good
Subject action accuracy	r = 0.21 (–0.27–0.60) p = 0.19	r = 0.20 (–0.29–0.69) p = 0.40	2.83	0.21	0.09	marginal	0.22	good
Tester action accuracy	r = 0.48 (0.08–0.75) p = 0.01	r = 0.53 (0.10–0.95) p = 0.02	5.32	0.53	0.18	marginal	0.44	marginal

Note: CI = confidence interval; ICC = intraclass correlation coefficient; CV = coefficient of variation; SWC = smallest worthwhile change.

Table 3. **ICC (95% CI), Pearson's r (95% CI), CV, SWC, and usefulness for total time, subject action accuracy, and tester action accuracy between Session 1 and Session 2 for Test Condition 2**

	ICC	Pearson's r	CV (%)	CV (s)	SWC0.2 (s)	Usefulness	SWC0.5 (s)	Usefulness
Total time	r = 0.93 (0.83–0.97) p < 0.001	r = 0.94 (0.77–1.11) p < 0.001	4.54	0.10	0.11	OK	0.27	good
Subject action accuracy	r = 0.13 (–0.28–0.52) p = 0.28	r = 0.14 (–0.36–0.63) p = 0.57	8.52	0.88	0.20	marginal	0.49	marginal
Tester action accuracy	r = 0.33 (–0.13–0.67) p = 0.08	r = 0.32 (–0.15–0.79) p = 0.17	6.01	0.60	0.18	marginal	0.44	marginal

Note: CI = confidence interval; ICC = intraclass correlation coefficient; CV = coefficient of variation; SWC = smallest worthwhile change.

Conversely, action accuracy for the subject demonstrated low reliability across both conditions, with very low ICC values (0.21 and 0.13) and weak correlations, suggesting substantial measurement error and inconsistency. Although the CV was low in Test Condition 1 (0.21s), it increased markedly to 0.88s in Test Condition 2, further reducing its usefulness. However, the tester's action accuracy showed moderate reliability in Test Condition 1 (ICC = 0.48) but dropped to low reliability in Test Condition 2 (ICC = 0.33), with CV values around 5–6%, and usefulness was rated as 'marginal' across both test conditions. These results suggest that action accuracy measures, particularly for subjects, are not consistently reliable due to several possible factors which are age differences, differences in playing experience, or the complexity of the testing protocol.

The results presented in Tables 4 and 5 show the relationships between total time and action accuracy for both the subject and the tester across different sessions and test conditions. Under Test Condition 1, no significant correlations were found between the total time and either form of action accuracy in Session 1, Session 2, or in the mean of both sessions. Pearson's r values ranged from –0.05 to –0.24, with all p-values well above 0.05, indicating low and statistically non-significant relationships.

In contrast, several significant negative correlations were found under Test Condition 2. Specifically, the action accuracy for subject showed questionable to acceptable negative correlations with total time in Session 1 ($r = –0.68$, $p < 0.01$) and in the mean of Sessions 1 and 2 ($r = –0.75$, $p < 0.01$), suggesting that greater action accuracy was associated with faster performance. Although the correlation in Session 2 was poor ($r = –0.43$) and not statistically significant ($p = 0.06$), it followed the same trend. Similarly, the tester's action accuracy was negatively correlated with the total time in Session 1 ($r = –0.62$, $p < 0.01$) and poor in the session mean ($r = –0.51$, $p = 0.02$), indicating that quicker performance was linked with higher-rated tester action accuracy. No significant correlation was observed in Session 2 for tester's action accuracy.

In summary, the negative ICC values and wide confidence intervals for an ICC estimate for both test conditions is due to a small sample size. With few participants, the estimates between participants become imprecise. Other than that, the differences between conditions suggest that the nature of the task or experimental setup in Test Condition 2 may have promoted a performance trade-off between action accuracy and speed, likely due to greater complexity and demands of netball-specific actions that needed to be fulfilled by the participants in Test Condition 2 whereas Test Condition 1 did not exhibit such an effect. In addition, although Test Condition 1 was more defensive and Test Condition 2 emphasised more offensive actions, it did not affect the action accuracy for either the subject or the tester. This reflects real-game dynamics in netball when one team is in a position to attack and the opposing attacker must also react as a defender to prevent the opponent from attacking.

Table 4. **Pearson's r (95% CI) and p-values for correlations between total time and subject/tester action accuracy for Session 1, Session 2, and mean of Sessions 1 and 2 for Test Condition 1**

	Total time		
	Session 1	**Session 2**	**Mean of Session 1 and 2**
Subject action accuracy	r = –0.16 (–0.16–0.09) p = 0.49	r = –0.05 (–0.13–0.11) p = 0.85	r = –0.13 (–0.12–0.07) p = 0.57
Tester action accuracy	r = –0.12 (–0.33–0.20) p = 0.61	r = –0.24 (–0.29–0.10) p = 0.31	r = –0.19 (–0.28–0.12) p = 0.41

Note: CI = confidence interval.

Table 5. **Pearson's r (95% CI) and p-values for correlations between total time and subject/tester action accuracy for Session 1, Session 2, and mean of Sessions 1 and 2 for Test Condition 2**

	Total time		
	Session 1	**Session 2**	**Mean of Session 1 and 2**
Subject action accuracy	r = –0.68 (–0.49–0.15) p < 0.01	r = –0.44 (–0.38–0.00) p = 0.06	r = –0.75 (–0.36–0.14) p < 0.01
Tester action accuracy	r = –0.62 (–0.39–0.09) p < 0.01	r = –0.23 (–0.31–0.11) p = 0.33	r = –0.51 (–0.31–0.02) p = 0.02

Note: CI = confidence interval.

4. DISCUSSION

4.1. MAJOR FINDING

The purpose of this study was to evaluate the reliability of the Life-Size Reactive Agility Test (LSRAT) in netball and to determine the correlation between action accuracy and the overall agility performance by both subject and tester, as measured by total time. The main findings of this study revealed that the LSRAT demonstrated a high level of practically absolute and relative reliability for total time across both test conditions to different extents depending on the specific parameter in question. Moreover, with regard to the correlation between the total time and the subject action accuracy, very large relationships were found in Test Condition 1. While in Test Condition 2, it was the total time and the tester action accuracy. Conversely, only small to moderate correlations were observed for tester action accuracy in Test Condition 1, and subject action accuracy in Test Condition 2.

Therefore, the first hypothesis, proposing that the LSRAT would exhibit high reliability, was confirmed for total time. However, the second hypothesis, proposing strong correlations between overall agility performance and action accuracy, could not be confirmed without restrictions due to only small to moderate relationships to the total time for the subject action accuracy and the tester action accuracy.

4.2. RELIABILITY OF LIFE-SIZE REACTIVE AGILITY TEST (LSRAT)

Reliability findings for the total time align with previous studies on classic reactive agility tests using live testers (Sheppard et al., 2006). In the respective studies, high reliability for total time with very large to nearly perfect Pearson's r and ICC values (0.87–0.99) were reported (Chaalali et al., 2016; Gabbett et al., 2008, 2011; Scanlan et al., 2014; Sheppard et al., 2006; Veale et al., 2010). The high reliability results are influenced by several factors across team sports. Firstly, the athlete characteristics, including age differences (Dugdale et al., 2020; Hoffman, 2020; Veale et al., 2010), gender (Popowczak et al., 2020; Zwierko et al., 2022), and experience (Sheppard et al., 2006; Trajković et al., 2020; Young et al., 2011). Secondly, the athlete physical attributes such as balance, strength, flexibility, and speed (Mulyadi et al., 2024; Paprancová et al., 2024; Sattler et al., 2015; Zwierko et al., 2022). Thirdly, the strongest predictors of total time were decision-making and reaction time, especially in tests with high perceptual demands (Young & Willey, 2010; Scanlan et al., 2014). Lastly, as stated by Paprancová et al. (2024) and Sattler et al. (2015), different sports will emphasise different cognitive and physical components which may affect the test reliability.

Moreover, no known studies have applied a live tester (human stimuli) with netball-specific stimuli or examined the reliability of action accuracy for both subject and tester, making comparisons with the literature impossible. However, effective performance requires high action accuracy because poor choices result in tactical errors and decreased effectiveness during real game situations. However, several possible factors may result in unreliable action accuracy, for example an athletes' age and playing experience. Reliability improves with older athletes that have more playing experience. Thus, high-skill athletes exhibit more consistent action accuracy compared to low-skill or amateur athletes. Apart from that, the complexity of the testing protocol can reduce reliability unless athletes are well familiarised.

Other than that, the influence of the tester plays a crucial role in the reliability and validity of the reactive agility test result. According to Altmann et al. (2020) and Young & Willey (2010), the consistency of the tester during stimuli presentation is essential, particularly in live stimulus protocols because variability in tester timing will lead to measurement error. The use of experienced testers results in high test–retest reliability with ICC values (0.87–0.91) (Altmann et al., 2020; Sheppard et al., 2006; Veale et al., 2010; Young & Willey, 2010).

Besides ICC and CV, the usefulness of the total time and action accuracy for the subject as well as the action accuracy for the tester were also determined, using the smallest worthwhile change (SWC). When detecting a small effect ($SWC_{0.2}$), such changes might only be detected with regard to the total time, as the usefulness that was rated as 'marginal' in Test Condition 1 means higher CV values compared to the $SWC_{0.2}$, and 'OK' in Test Condition 2 means lower CV values compared to the $SWC_{0.2}$. Meanwhile, action accuracy usefulness measures for Test Conditions 1 and 2 relating to the $SWC_{0.2}$ were rated 'marginal' for both subjects and testers. This indicates that small effects may be masked by higher CV values compared to the $SWC_{0.2}$.

Conversely, moderate changes in performance ($SWC_{0.5}$) could be detected for all parameters, as the CV values were smaller than the $SWC_{0.5}$ for the total time in both test conditions, leading a 'good' rating. The CV values for subject action accuracy in Test Condition 1 were smaller than the $SWC_{0.5}$, which resulted in 'good' and 'marginal' ratings for Test

Condition 2, meaning that CV values were higher compared to the $SWC_{0.5}$. While the CV values were higher than the $SWC_{0.5}$ for the tester action accuracy for Test Condition 1 and Test Condition 2, leading to 'marginal' ratings for both conditions. Therefore, the LSRAT can be considered as useful for assessing netball players' performance, especially relating to the detection of moderate performance changes ($SWC_{0.5}$).

4.3. CORRELATES OF AGILITY PERFORMANCE

The secondary aim of this study was to determine how total time correlates to action accuracy. In Test Condition 1, no significant correlations were found between total time and action accuracy for either subject or tester in any session with all *p*-values > 0.05. This indicates that speed and action accuracy do not influence the total time, and these variables may be unrelated (i.e. independent) to each other in this test condition. However, in Test Condition 2, strong negative correlations were observed between total time and both subject and tester action accuracy, particularly in Session 1 ($r = –0.68$ to $–0.62$, $p < 0.01$). This indicates that higher action accuracy is associated with shorter total time, suggesting a potential relationship between cognitive performance and physical execution in this condition.

Moreover, when analysing the mean of both sessions, the correlation between subject action accuracy and total time remained significant ($r = –0.75$, $p < 0.01$). Though slightly weaker, tester action accuracy was also observed ($r = –0.51$, $p = 0.02$). This reinforces the idea that better action accuracy may lead to improved performance in terms of the total time.

These results suggest that Test Condition 2 may better capture meaningful performance differences, which may involve a speed–accuracy trade-off. Subjects who performed faster also made complete score on action accuracy, suggesting a clearer task structure or a better alignment between physical execution and cognitive strategy demands. In contrast, the lack of such associations in Test Condition 1 may reflect inconsistencies or limitations in the test design, which prevented it from reliably capturing the relationship between speed and action accuracy ability.

4.4. LIMITATIONS AND FUTURE RESEARCH

This study revealed high test–retest reliability for total time in both test conditions of the LSRAT. However, lower reliability was evident for action accuracy measures for both subject and tester in both test conditions. To address this, at least one familiarisation session is recommended before actual data collection to improve consistency and reduce variability. Moreover, the single-beam timing gate system was used due to constraints in obtaining dual-beam timing gate system in Malaysia and purchasing this dual-beam timing gate system is very costly. The single-beam timing gates may be more prone to error than dual-beam timing gates. Thus, future studies should consider the use of dual-beam timing gates to enhance measurement accuracy and expand testing protocols to include multiple paths that are randomly triggered when a participant reaches a particular point in the drill, so that additional performance variables can be determined.

With regard to the latter, the construct validity of the LSRAT should also be addressed by future research by investigating whether the test can discriminate between players of varying performance levels. Furthermore, further studies can also include deceptive movements, such as feints, in the tester's passing movements to enhance the test's ability to reflect perceptual–cognitive demands, as such movements have been shown to improve discrimination between performance levels compared to standard passing movements (Paul et al., 2016). This approach could increase the influence of perceptual–cognitive factors on the total time as well. However, as tester delivery can potentially affect the test results (W. B. Young & Willey, 2010), future procedures should include standardised training for testers in order to ensure players' reliable execution of passing movements, either with or without feints.

Lastly, the limitation of the study is the use of only adolescent female players. This is due to the sufficient training period of the adolescent female players who will be involved in major tournaments in the future. Therefore, the selection of players from various age groups should be considered for future studies which will provide different study results.

4.5. PRACTICAL APPLICATIONS

The Life-Size Reactive Agility Test (LSRAT) provides a reliable method to assess netball players' reactive agility performance in an ecologically valid sport-specific environment. Therefore, coaches and researchers can confidently use total time as an indicator to evaluate performance changes over time or between test conditions. The low reliability of action accuracy measures suggests that they may not be suitable for standalone assessments. However, the significant correlations in Test Condition 2 highlight that action accuracy can influence performance, particularly when cognitive demands are higher. These findings align with previous literature (Trecroci et al., 2018), emphasising the importance of cognitive factors, such as reactive agility, in distinguishing between elite and sub-elite players.

The differences between the two test conditions may also reflect variations in cognitive or physical demands. For example, Test Condition 2 might involve more complex action tasks, leading to the observed correlations between action accuracy and total time. This is consistent with previous findings by Scanlan et al. (2014), who found that sport-specific reactive agility tests measure different qualities compared to generic tests. Therefore, sport-specific reactive agility test, verified protocols that align with the athlete's skill level and training objectives should be given priority when choosing suitable tests. Moreover, in the future coaches should cover both the cognitive–perceptual and the physical aspects of reactive agility in their training plan, and progress should be tracked and interventions should be modified on a regular basis (Alim et al., 2023; Hassan et al., 2022; Mulyadi et al., 2024).

From a practical perspective, the application of a high-speed camera and dual-beam timing gate system is recommended to determine other timing variables such as decision-making time, response time, and movement time. However, meaningful results and necessary data on total time can be immediately measured with a single-beam timing system. When working with less-skilled or non-ranked netball players, physical aspects represented by the movement time should be considered as the primary contributor to total reactive agility performance. Therefore, these aspects should be included in netball-specific reactive agility training programmes.

5. CONCLUSIONS

In conclusion, the results demonstrate that the total time is a reliable and useful performance measure across both test conditions for reactive agility in netball, while action accuracy is less appropriate due to its high variability. Several possible factors that cause unreliable action accuracy are differences in playing experience, age of the participants, or the complexity of the testing protocol. The significant correlations observed in Test Condition 2 also suggest the effectiveness of the test environment in evaluating combined speed and performance accuracy in action tasks. These findings support the integration of both cognitive factors and physical components in sport performance evaluations.

Author Contributions: Fitry Azrul bin Nor Saafri performed the data collection, analysed the data, and prepared for and wrote the original draft; Halijah binti Ibrahim supervised the research. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Acknowledgements: The authors wish to express their gratitude to all the young netball players who devoted their time to this research. We also wish to thank Associate Professor Dr Hosni bin Hasan, MARA University of Technology, Malaysia for lending the timing gate system equipment throughout the data collection work and Puan Noor Azian Fakurazi for helping in the proofreading the article.

Conflicts of Interest: The authors declare no conflict of interest.

REFERENCES

Alim, A., Tomoliyus, Refiater, U. H., & Gani, I. (2023). Sensor-based reactive agility measurement tool for net game group sports: Content validity. *Retos*, *51*, 167–171. https://doi.org/10.47197/retos.v51.100564

Altmann, S., Neumann, R., Ringhof, S., Rumpf, M. C., & Woll, A. (2020). Soccer-specific agility: Reliability of a newly developed test and correlates of performance. *Journal of Strength and Conditioning Research*, *36*(5), 1410–1416. https://doi.org/10.1519/JSC.0000000000003635

Altmann, S., Ringhof, S., Neumann, R., Woll, A., & Rumpf, M. C. (2019). Validity and reliability of speed tests used in soccer: A systematic review. *PLoS ONE*, *14*(8), 1–38. https://doi.org/10.1371/journal.pone.0220982

Altmann, S., Spielmann, M., Engel, F. A., Neumann, R., Ringhof, S., Oriwol, D., & Haertel, S. (2017). Validity of single-beam timing lights at different heights. *Journal of Strength and Conditioning Research*, *31*(7), 1994–1999. https://doi.org/10.1519/JSC.0000000000001889

Atkinson, G., & Nevill, A. M. (1998). Statistical methods for assessing measurement error (reliability) in variables relevant to sports medicine. *Sports Medicine*, *26*(4), 217–238. https://doi.org/10.2165/00007256-199826040-00002

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

Dugdale, J. H., Sanders, D., & Hunter, A. M. (2020). Reliability of change of direction and agility assessments in youth soccer players. *Sports*, *8*(4), 2–11. https://doi.org/10.3390/sports8040051

Gabbett, T., & Benton, D. (2009). Reactive agility of rugby league players. *Journal of Science and Medi-*

cine in Sport, *12*(1), 212–214. https://doi.org/10.1016/j.jsams.2007.08.011

Gabbett, T., Jenkins, D., & Abernethy, B. (2011). Relationships between physiological, anthropometric, and skill qualities and playing performance in professional rugby league players. *Journal of Sports Sciences*, *29*(15), 1655–1664. https://doi.org/10.1080/02640414.2011.610346

Gabbett, T., Kelly, J., & Sheppard, J. (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

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*, *10*(11), 176–193. https://doi.org/10.3390/sports10110176

Hoffman, J. R. (2020). Evaluation of a reactive agility assessment device in youth football players. *Journal of Strength and Conditioning Research*, *34*(12), 3311–3315. https://doi.org/10.1519/JSC.0000000000003867

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*(1), 159–174. https://doi.org/10.2307/2529310

Meir, R., Holding, R., & Hetherington, J. (2014). Impact of the two-handed rugby ball carry on change of direction speed and reactive agility: Implications for sport specific testing. *International Journal of Sports Science and Coaching*, *9*(5), 1181–1190. https://doi.org/10.1260/1747-9541.9.5.1181

Mulyadi, R. W. M., Tomoliyus, Alim, A., Rismayanthi, C., Nugroho, W., Wiedarjati, D. K., & Yulianto, W. D. (2024). Validity and reliability of technology-based reactive agility tennis test (RATT). *Retos*, *60*, 534–538. https://doi.org/10.47197/retos.v60.107975

Paprancová, A., Paška, Ľ., Krčmár, M., Czaková, N., & Novotka, F. (2024). Factors influencing reactive agility in male football players. *Journal of Physical Education and Sport*, *24*(9), 1171–1176. https://doi.org/10.7752/jpes.2024.09241

Paul, D. J., Gabbett, T. J., & Nassis, G. P. (2016). Agility in team sports: Testing, training and factors affecting performance. *Sports Medicine*, *46*(3), 421–442. https://doi.org/10.1007/s40279-015-0428-2

Perić, I., Gilić, B., & Sekulić, D. (2021). Investigating reliability and validity of the tests of change of direction and reactive agility in patients after knee surgery. *Sports Science and Health*, *11*(2), 175–181. https://doi.org/10.7251/SSH2102175P

Popowczak, M., Domaradzki, J., Rokita, A., Zwierko, M., & Zwierko, T. (2020). Predicting visual-motor performance in a reactive agility task from selected demographic, training, anthropometric, and functional variables in adolescents. *International Journal of Environmental Research and Public Health*, *17*(15), 1–13. https://doi.org/10.3390/ijerph17155322

Sattler, T., Sekulić, D., Spasić, M., Perić, M., Krolo, A., Uljević, O., & Kondrič, M. (2015). Analysis of the association between motor and anthropometric variables with change of direction speed and reactive agility performance. *Journal of Human Kinetics*, *47*(1), 137–145. https://doi.org/10.1515/hukin-2015-0069

Scanlan, A., Humphries, B., Tucker, P. S., & Dalbo, V. (2014). The influence of physical and cognitive factors on reactive agility performance in men basketball players. *Journal of Sports Sciences*, *32*(4), 367–374. https://doi.org/10.1080/02640414.2013.825730

Scanlan, A., Tucker, P., & Dalbo, V. (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

Scanlan, A., Tucker, P., & Dalbo, V. (2015). The importance of open- and closed-skill agility for team selection of adult male basketball players. *The Journal of Sports Medicine and Physical Fitness*, *55*(5), 390–396.

Sheppard, J., & Young, W. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences*, *24*(9), 919–932. https://doi.org/10.1080/02640410500457109

Sheppard, J., Young, W., Doyle, T., Sheppard, T., & Newton, R. (2006). An evaluation of a new test of reactive agility and its relationship to sprint speed and change of direction speed. *Journal of Science and Medicine in Sport*, *9*(4), 342–349. https://doi.org/10.1016/j.jsams.2006.05.019

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), 1–10. https://doi.org/10.3390/ijerph17113839

Trecroci, A., Longo, S., Perri, E., Iaia, F. M., & Alberti, G. (2018). Field-based physical performance of elite and sub-elite middle-adolescent soccer players. *Research in Sports Medicine*, *27*(1), 60–71. https://doi.org/10.1080/15438627.2018.1504217

Trecroci, A., Milanović, Z., Rossi, A., Broggi, M., Formenti, D., & Alberti, G. (2016). Agility profile in sub-elite under-11 soccer players: Is SAQ training adequate to improve sprint, change of direction speed and reactive agility performance? *Research in Sports Medicine*, *24*(4), 331–340. https://doi.org/10.1080/15438627.2016.1228063

Veale, J., Pearce, A., & Carlson, J. (2010). Reliability and validity of a reactive agility test for Australian football. *International Journal of Sports Physiology and Performance*, *5*(2), 239–248. https://doi.org/10.1123/ijspp.5.2.239

World Netball (n.d.). *Rules of netball 2024 edition*. https://netball.sport/game/the-rules-of-netball/

Young, W. B., & Willey, B. (2010). Analysis of a reactive agility field test. *Journal of Science and Medicine in Sport*, *13*(3), 376–378. https://doi.org/10.1519/JSC.0b013e318215fa1c

Young, W., 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., Gilic, B., & Sekulic, D. (2020). Validity, reliability and correlates of futsal-specific pre-planned and non-planned agility testing protocols. *Kinesiologia Slovenica*, *26*(2), 25–34. https://doi.org/10.52165/kinsi.26.2.25-34

Zwierko, M., Jedziniak, W., Popowczak, M., & Rokita, A. (2022). Reactive Agility in competitive young volleyball players: A gender comparison of perceptual-cognitive and motor determinants. *Journal of Human Kinetics*, *85*(1), 87–96. https://doi.org/10.2478/hukin-2022-0112

Received on August 4, 2025
Accepted on October 3, 2025