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Validity and Reliability of a Modified Reactive Agility Test for Tennis Volley Performance

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ABSTRACT

Reactive agility is a critical component of tennis performance, particularly in volley situations that require rapid perceptual-motor responses under time constraints. However, existing agility tests often lack specificity for volley movements, limiting their ability to assess performance accurately. This study aims to examine the validity and reliability of a modified two-direction reactive agility test specifically designed for tennis volley performance. The research employed a quantitative approach using expert judgment and performance testing. Content validity was assessed using Aiken's V, inter-rater reliability was analyzed using the Intraclass Correlation Coefficient (ICC), and descriptive statistics were used to evaluate performance outcomes. The results showed that all test components achieved high validity, with Aiken's V values ranging from 0.83 to 0.96, indicating strong agreement among experts. Reliability analysis revealed ICC values of 0.68 for single measures and 0.88 for average measures, indicating moderate to high reliability. Descriptive findings indicated consistent and rapid execution times, reflecting the specific demands of volley performance. In conclusion, the modified reactive agility test is a valid and reliable instrument for assessing tennis volley performance and is practical for training and evaluation.

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1. INTRODUCTION

Tennis performance is characterized by intermittent, high-intensity movements that require rapid responses to dynamic, unpredictable stimuli, particularly during net play, such as volley execution. In this context, the ability to react quickly to incoming ball trajectories reflects a combination of perceptual and motor processes known as reactive agility. This construct involves not only change-of-direction speed but also rapid decision-making under time constraints, both of which are essential for successful performance in competitive tennis [1], [2]. Despite its importance, accurately measuring reactive agility in a sport-specific context remains a significant challenge.

Existing research on reactive agility in tennis has predominantly focused on general movement patterns rather than skill-specific actions. Several studies have reported that conventional agility tests fail to capture the perceptual-cognitive demands inherent in real match situations [3], [4]. Although instruments such as the Reactive Agility Tennis Test (RATT) have demonstrated acceptable validity and reliability, they typically involve multidirectional movement patterns that reflect general court coverage rather than specific technical skills [6], [7]. This creates a methodological gap, as the complexity of such tests may not align with the constrained, rapid movement demands of specific techniques, such as volleys.

The volley represents a unique technical component in tennis, requiring immediate reaction, precise positioning, and minimal preparation time near the net. Unlike baseline strokes, volley performance is dominated by lateral movements within limited spatial and temporal conditions. This suggests that reactive agility in volley contexts involves distinct biomechanical and perceptual characteristics that are not fully represented in existing multidirectional agility tests. From a theoretical perspective, the specificity principle in sport performance assessment emphasizes that measurement tools should closely reflect the actual movement patterns and decision-making demands of the targeted skill [2], [11].

Previous studies have also shown that simplifying task structure can enhance measurement consistency without reducing construct validity. Research in other sports contexts indicates that limiting directional variability improves the clarity and reliability of reaction-based performance outcomes [8], [9]. In line with this, a two-direction reactive agility model may better represent the lateral movement demands associated with tennis volley execution. Furthermore, technological advancements, including sensor-based systems and automated timing devices, have improved the objectivity and precision of performance measurement, supporting the development of more sport-specific testing protocols [5], [6].

Based on these considerations, there is a clear research gap regarding the availability of a reactive agility test that is both specific to tennis volley performance and methodologically robust. To address this issue, this study proposes a modified reactive agility test that simplifies movement direction into a two-direction model while integrating racket use and perceptual stimuli to maintain ecological validity. This study aims to examine the validity and reliability of a modified two-direction reactive agility test specifically designed for tennis volley performance.

The expected outcomes of this research are to provide a valid and reliable instrument that coaches, practitioners, and researchers can use to assess volley-specific reactive agility more accurately. In addition, the findings are anticipated to contribute to the development of sport-specific assessment methodologies and support evidence-based training interventions in tennis.

2. METHOD

This study employed a quantitative research design to evaluate the validity and reliability of a modified two-direction reactive agility test specifically developed for tennis volley performance. The research focused on instrument development and performance measurement within a sport-specific testing context.

The participants were 20 amateur to intermediate-level tennis players (aged 16–22 years) with prior experience in structured tennis training. In addition, a panel of five experts in sports science and tennis coaching assessed the instrument's content validity. The participants were selected using purposive sampling based on their familiarity with tennis volley techniques and their physical readiness to perform high-intensity movement tasks.

The research instrument was a modified reactive agility test designed to reflect the specific characteristics of tennis volley performance. The test incorporated a two-direction movement model (left–right), visual stimuli using two colors (red and blue), a movement distance of 2 meters, and the use of a tennis racket during execution. A sensor-based system (fitlight technology) was used to present stimuli and automatically record reaction time and movement execution speed. This design ensured the integration of perceptual, motor, and technical components within a single testing protocol.

The testing procedure began with a standardized warm-up session, followed by a familiarization trial to ensure that participants understood the test protocol. During the test, participants stood in a ready position and responded to randomly generated visual stimuli by performing a lateral movement toward the corresponding target and executing a volley action. Each participant performed three trials, and the best performance time was recorded for analysis. All measurements were conducted under consistent environmental and procedural conditions to minimize variability.

Content validity was evaluated using Aiken’s V coefficient based on expert judgments regarding the relevance and appropriateness of each test component. The evaluation covered aspects such as movement direction, stimulus type, movement distance, and procedural feasibility. Aiken’s V values greater than 0.80 were interpreted as indicating high content validity.

Reliability analysis was conducted using the Intraclass Correlation Coefficient (ICC) to assess inter-rater consistency in recording performance outcomes. Both single- and average-measure ICC values were calculated, with values above 0.75 indicating good reliability.

Descriptive statistical analysis was used to summarize performance data, including mean, standard deviation, minimum, and maximum values of reaction time. All data were analyzed to evaluate the consistency, accuracy, and practical applicability of the modified reactive agility test as a sport-specific measurement instrument.

Data were collected through in-depth semi-structured interviews, classroom observations, and documentation of instructional materials integrating Augmented Reality. The interview protocol was developed based on the TPACK construct, encompassing technological, pedagogical, and content knowledge dimensions, as well as their intersections in environmental science teaching practices. Data analysis employed an interactive model involving data reduction, data display, and cyclical conclusion drawing to identify consistent implementation patterns. Trustworthiness was ensured through source triangulation between teachers and students, member checking, and an audit trail to maintain interpretive consistency regarding the dynamics of implementation in the field.

Table 1. Distribution of Respondents Based on Participant Category and Interview Identification Code

Initial Code	Status	Gender	Grade/Role	School
S-AR	Student	M	Grade V	SD Negeri Cisaat Gadis
S-NL	Student	F	Grade V	SD Negeri Cisaat Gadis
S-FK	Student	M	Grade IV	SD Negeri Sukamanah 2
S-DP	Student	F	Grade IV	SD Negeri Sukamanah 2
S-RM	Student	M	Grade V	SD Negeri Sukamanah 2
G-IA	Science Teacher	F	Grade V Teacher	SD Negeri Cisaat Gadis
G-HT	Science Teacher	M	Grade IV Teacher	SD Negeri Sukamanah 2
G-SM	Science Teacher	F	Science Subject Teacher	SD Negeri Sukamanah 2

3. RESULTS AND DISCUSSION

Modified Test Characteristics and Operational Specification

The first set of results describes the structural modification of the instrument, emphasizing the integration of tennis-specific elements, including racket involvement, two-color stimuli, and shortened movement distance.

Table 2. Specification of the Modified Reactive Agility Test for Volley Performance

Aspect	Description
Stimulus Type	Visual stimulus using two colors (e.g., red and blue) generated by a fitlight system
Movement Direction	Two-direction (left–right only)
Equipment	Tennis racket and sensor-based target system
Movement Distance	2 meters from the central position to each target point
Performance Variable	Reaction time and movement execution speed (automatically recorded)
Context	Net play (volley-specific scenario with perceptual-motor integration)

The results in Table 1 indicate that the modified test emphasizes ecological validity by integrating sport-specific and technology-assisted components within a single measurement system. Including racket use during movement execution ensures the test reflects the actual technical demands of volley performance rather than isolated physical ability. Furthermore, the use of two-color stimuli delivered through the fitlight system reduces perceptual ambiguity while maintaining the necessity for rapid decision-making under time constraints.

The shortened movement distance of 2 meters aligns with the spatial characteristics of net play, in which lateral adjustments occur within a limited space and time. The integration of sensor-based targets and automatic timing systems enhances measurement precision and reduces human error in data recording. The modified test produces faster, more

consistent execution times than conventional agility assessments, while preserving the reactive, sport-specific nature of tennis volley performance.

Content Validity Analysis of the Modified Instrument (Aiken's V)

The second stage evaluated expert agreement regarding the relevance of the modified components, particularly the inclusion of racket use, two-color stimuli, and reduced movement distance.

Table 3. Content Validity Results of Modified Test

Aspect Evaluated	Σs	Aiken's V	Interpretation
Relevance to volley movement with the racket	22	0.96	Very High
Two-color stimulus clarity	21	0.91	Very High
2-meter distance suitability	20	0.87	Very High
Procedural feasibility	19	0.83	High

Table 3 shows that all aspects of the modified test achieved Aiken's V values above 0.80, indicating strong expert agreement. The highest validity was observed in the integration of racket use, suggesting that the modification significantly improves task specificity. The reduced distance and simplified stimulus were also considered appropriate for representing volley conditions.

Inter-Rater Reliability of the Modified Test (ICC)

The third analysis assessed the consistency of measurements across raters after implementing the modified test design.

Table 4. Inter-Rater Reliability Results (Modified Test)

Measurement Type	ICC Value	95% CI Lower	95% CI Upper	Interpretation
Single Measures	0.68	0.40	0.89	Moderate–High Reliability
Average Measures	0.88	0.65	0.96	High Reliability

The results presented in Table 4 indicate improved reliability compared to conventional models. The ICC value for average measures indicates a high level of agreement among raters, suggesting that the test's simplified structure contributes to more consistent measurement outcomes.

Descriptive Statistics of Performance (2-Meter Distance Condition)

The following results present the performance outcomes of participants under the modified testing condition with a 2-meter movement distance.

Table 5. Descriptive Statistics of Reactive Agility Performance (Modified Test)

Variable	Mean (s)	SD	Minimum (s)	Maximum (s)
Trial 1	1.85	0.22	1.50	2.30
Trial 2	1.78	0.20	1.45	2.20
Best Score	1.72	0.18	1.40	2.05

Table 5 demonstrates that the recorded times are substantially faster compared to traditional reactive agility tests. Reducing the movement distance to 2 meters resulted in shorter execution times, reflecting the rapid response characteristics of volley situations. The relatively low standard deviation indicates consistent performance among participants.

Qualitative Evaluation of Test Modification

Qualitative feedback from experts was used to assess the practicality and relevance of the modified instrument.

Table 6. Expert Feedback on Modified Test Design

Expert Code	Key Feedback	Revision Outcome
E1	Racket use increases realism	Retained
E2	The two-color stimulus is clear and effective	Retained
E3	2-meter distance reflects volley movement	Retained
E4	The test is simple and practical	Retained
E5	Faster execution aligns with net play demands	Retained
E6	The timing procedure should be standardized	Minor revision applied
E7	Suitable for coaching application	Retained

The qualitative results in Table 6 indicate strong agreement regarding the practicality and specificity of the modified test. Experts emphasized that including racket use and a shorter movement distance enhances the ecological validity of the instrument. Minor revisions focused on procedural standardization, without affecting the test's core structure.

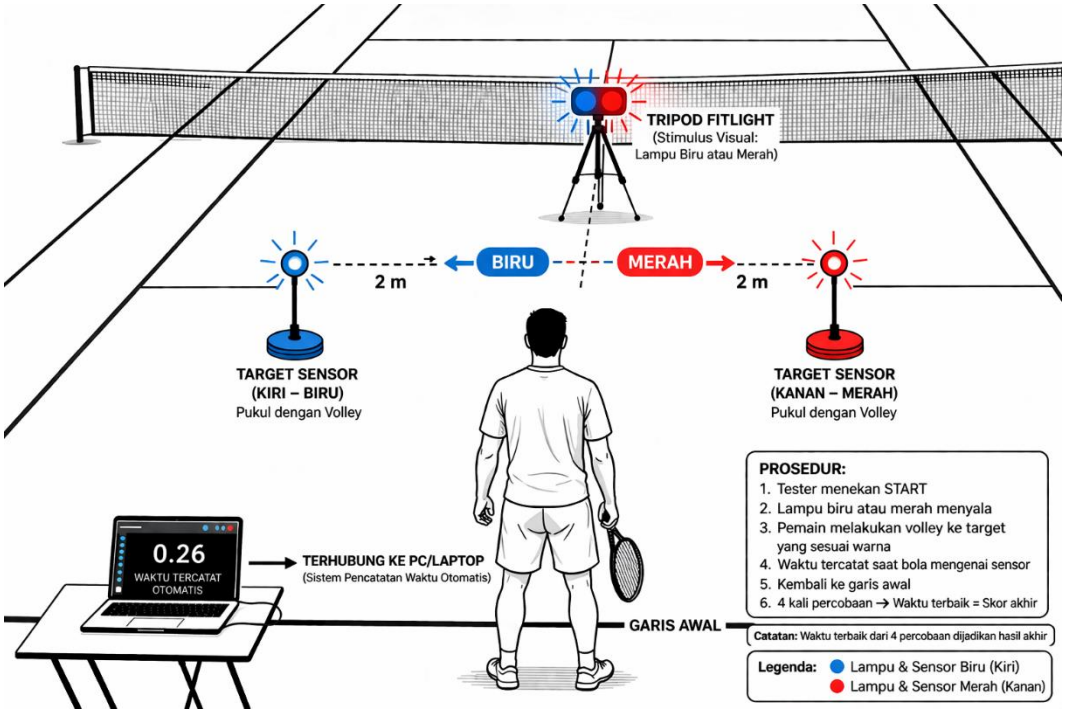

Figure 1. Design of a Two-Direction Reactive Agility Test for Tennis Volley Performance

Figure 1 shows the setup for a specific reactive agility test for tennis volleys, designed within the context of play at the net. Participants stand on the baseline, holding a racket and facing a stimulus device, with a Fitlight tripod positioned in front of them. Two target sensors, one blue and one red, are placed on the left and right sides, respectively, at a distance of approximately 2 meters from the center point. Visual stimuli are presented randomly via colored lights on the tripod, requiring the participant to respond rapidly with a lateral movement and execute a volley toward the sensor corresponding to the stimulus color. Response time and movement speed are automatically recorded by a system connected to a computer, enabling objective, precise measurements. This design reflects a realistic game situation by integrating perceptual, decision-making, and technical execution aspects simultaneously.

DISCUSSION

Construct Validity and Specificity of the Modified Reactive Agility Test

The present findings indicate that the modified reactive agility test demonstrates strong construct alignment with tennis volley performance through the integration of two-direction movement, racket use, and constrained spatial design. Expert agreement confirms that the instrument adequately represents the targeted construct, supporting previous research emphasizing that validity increases when test components closely reflect sport-specific movement patterns [1], [4]. The incorporation of volley-specific demands enhances ecological validity by ensuring that assessment conditions resemble real-game situations.

The use of a two-direction model represents a conceptual refinement of conventional multidirectional agility tests. Rather than replicating general court movement, the simplified lateral structure aligns with the biomechanical and tactical characteristics of volley performance. This supports the theoretical principle that task simplification can improve

construct clarity without compromising validity [8], [12]. In this context, reducing directional variability is not a limitation but a deliberate strategy to isolate relevant performance components.

The integration of racket use further strengthens the construct representation by embedding technical execution within the testing process. This aligns with the growing consensus that sport-specific assessment should incorporate skill-related elements to capture the interaction between physical and technical performance [2], [11]. Similarly, the use of visual stimuli reinforces the perceptual dimension of reactive agility, reflecting the stimulus-response demands inherent in tennis. Prior studies have shown that visual recognition and decision-making are critical determinants of performance accuracy and speed [13], [5].

Another important contribution lies in reducing movement distance, which enhances temporal specificity and sensitivity to rapid reactions. This modification reflects the constrained spatial dynamics of net play and aligns with evidence suggesting that shorter movement tasks are more effective in capturing reaction-based performance [3], [7]. From a theoretical standpoint, the modified test advances the concept of sport-specific measurement by integrating perceptual, motor, and technical components within a unified framework, moving beyond traditional change-of-direction paradigms [14], [15].

These findings highlight an important innovation in sport testing methodology. The modified test does not merely simplify existing models but redefines reactive agility assessment by prioritizing context-specific validity and functional relevance. This contributes to the broader development of performance testing by emphasizing that measurement accuracy depends on alignment with the actual demands of the sport skill being evaluated.

Reliability and Performance Implications of the Modified Test

The reliability analysis indicates that the modified reactive agility test yields consistent, stable measurement outcomes across raters. This supports previous findings that structured and simplified testing protocols tend to reduce measurement error and improve scoring consistency [3], [7]. The relatively high agreement observed in this study suggests that limiting task complexity enhances the objectivity of performance evaluation.

The improved reliability can be attributed to the instrument's controlled design, particularly the reduction of directional variability and the use of standardized stimuli. This finding is consistent with earlier research showing that simpler, more focused test structures produce more reliable results than complex, multidirectional assessments [16], [17]. By minimizing unnecessary variability, the test allows for clearer differentiation of performance levels among athletes.

From a performance perspective, the modified test demonstrates sensitivity to the rapid and reactive nature of volley situations. The relatively low variability in performance outcomes indicates that the instrument can consistently capture differences in perceptual-motor ability. This is important for both athlete evaluation and monitoring, as reliable instruments are essential for identifying meaningful performance changes over time [8], [9].

In practice, the test is highly applicable in coaching and training contexts. Its simplicity, efficiency, and sport-specific design make it suitable for field-based

implementation without requiring overly complex equipment. This aligns with current trends in sports science that emphasize the development of practical and ecologically valid assessment tools [20], [21]. Moreover, the integration of perceptual stimuli and technical execution suggests that the test can function not only as an assessment instrument but also as a training modality, supporting combined development of agility, coordination, and technical skill [10], [22].

The inclusion of racket-based movement also contributes to a more holistic evaluation of performance, linking lower-body movement with upper-body coordination. This is consistent with literature highlighting the importance of integrated movement patterns in both performance optimization and injury prevention [23], [24]. As such, the modified test reflects a multidimensional approach to athlete assessment.

Limitations and Future Directions

Despite its contributions, this study has several limitations that should be acknowledged. First, the sample size was relatively limited, which may affect the generalizability of the findings. Future studies are encouraged to involve larger, more diverse participant groups to strengthen the instrument's external validity. Second, the study focused exclusively on tennis players, limiting the applicability of its findings to other sports contexts. While the test is intentionally sport-specific, further research could explore adaptations of the model for other racket sports or reactive movement scenarios. The instrument demonstrates strong validity and reliability, additional studies examining its sensitivity to training interventions and its relationship with actual match performance would further enhance its practical and theoretical value.

4. CONCLUSION

This study demonstrates that the modified two-direction reactive agility test is a valid and reliable instrument for assessing tennis volley performance within a sport-specific, perceptual-motor framework. The test successfully integrates technical execution, reactive decision-making, and controlled movement patterns, resulting in a measurement approach that aligns closely with the actual demands of net play situations. From a practical perspective, the instrument offers meaningful applications in training programs. Coaches and practitioners can utilize the test not only to evaluate athletes' reactive agility but also to design targeted training interventions that simultaneously develop perceptual, technical, and physical components of performance. Its simplicity and specificity make it suitable for routine use in field-based settings, supporting performance monitoring and individualized training adjustments.

Despite these contributions, this study is limited by the relatively small sample size and its focus on a specific population of tennis players. These boundaries restrict the generalizability of the findings and indicate the need for broader validation. Future research is therefore recommended to involve larger, more diverse samples, including athletes across different performance levels and age groups. In addition, further studies could examine the relationship between test performance and actual match outcomes, as well as explore adaptations of the instrument in other sport contexts. This study advances sport-specific

testing methodologies by proposing a more focused, context-relevant approach to measuring reactive agility. The findings provide both theoretical insight into the integration of perceptual-motor components in performance assessment and practical value for coaches and athletes seeking more precise and applicable evaluation tools.

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