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Information Article

The Efficacy of Game-Representative Constraints Coupled with Motor Imagery Practice on Service Skill Acquisition in U-16 Tennis Players

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ABSTRACT

This study aims to evaluate the effect of game-like drills incorporating mental practice on acquiring the serve skill among junior tennis players under 16 years of age. The researcher employed a pretest-posttest experimental design using two groups: an experimental group (n = 8) and a control group (n = 8), totaling (N = 16) participants. Serving proficiency was evaluated across three core parameters: serve accuracy, serve speed, and technical performance, alongside a standardized mental skills scale. The 8-week intervention was administered to the experimental group across three weekly sessions, integrating game-like drills with structured mental practice modalities, while the control group adhered to the conventional training program.

The empirical findings demonstrated statistically significant improvements in serving skill parameters (accuracy, velocity, and technical execution) among the junior tennis players in the experimental group. Furthermore, significant enhancements were recorded in cognitive and psychological metrics—including motor imagery, attentional focus, and neuromuscular coordination—which positively influenced motor execution quality. The study recommends integrating game-like situational exercises into youth tennis training regimens to elevate serving velocity, accuracy, and technical form, while utilizing systematic mental practice protocols to optimize motor imagery, concentration, and neuromuscular control.

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1. Introduction

Tennis is an individual sport that relies on an integrated combination of physical, technical, and mental capabilities. Performance in tennis demands a high level of neuromuscular coordination and motor accuracy, alongside the capacity for rapid decision-making in dynamic and fast-paced game situations. The serve is one of the most fundamental skills in tennis, serving as the starting point for every rally and functioning as a direct offensive weapon capable of securing decisive points, particularly when executed with high technical efficiency, speed, and precision (Elliott, 2003, p. 17).

Sports training methodologies have evolved considerably in recent years, shifting from conventional physical and technical training paradigms toward the integration of modern approaches based on simulating actual match situations. These approaches are recognized as game-like drills, which aim to facilitate the transfer of learning from the training environment to competitive settings, thereby enhancing skill execution under match-like conditions (Al-Sayed, Qubaisi, & Hashem, 2025, p. 39).

Game-like drills represent modern sports training modalities designed to simulate authentic match play, facilitating athletic adaptation to competitive demands. This approach emphasizes the critical role of the training environment in augmenting performance by exposing the player to near-match conditions, which reinforces rapid decision-making and execution accuracy (Karl Davids, 2008, p. 18).

Game-like drills contribute to improving athletic skill performance by contextualizing skill execution within actual competitive environments. This facilitates the effective transfer of learning from practice to competition. Furthermore, such drills foster the development of cognitive and motor abilities—such as decision-making speed and neuromuscular coordination—while improving performance-related physical fitness components. They also increase training motivation through task diversity and engagement, which positively impacts overall performance, particularly among junior athletes who require realistic and integrated training modalities (Sallam, 2021, p. 22).

Concurrently, mental practice has emerged as a vital contemporary technique in athletic training. It relies on the cognitive rehearsal of motor actions without overt physical execution, thereby improving performance through the activation of motion-related neural pathways. Numerous studies have established that mental practice enhances motor skill development, particularly across junior age groups, by fostering concentration, increasing self-confidence, and improving performance accuracy (Moran, 2013, p. 74).

Mental practice is defined as the cognitive rehearsal of a motor performance in the mind without physical execution, activating the identical neural pathways engaged during actual performance. This method is highly effective in enhancing technical skill performance, particularly in sports demanding high precision, such as tennis (Guillot, 2008, p. 39).

Schinke (2018) highlighted that mental training strategies are fundamental in preparing athletes to make rapid and appropriate tactical decisions during matches. This process depends on the player's capacity to analyze play situations in real time and act accordingly. Mental training allows athletes to enhance these capacities through sustained focus and mental imagery, aiding them in making sound decisions during competition (Schinke, 2018, p. 17).

Journal of Sports Sciences
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Bertollo (2021) noted that mental training can assist athletes in overcoming psychological pressure and anxiety, which are common challenges in team sports. Managing anxiety and stress during critical moments substantially enhances an athlete's ability to make fast and effective decisions (Bertollo, 2021, p. 36).

Within this framework, examining the effectiveness of integrating game-like drills with mental practice techniques becomes essential for enhancing tennis skills, particularly the serve, given its decisive role in match outcomes. Furthermore, the junior category represents a critical phase for establishing foundational athletic skills, requiring advanced training methodologies aligned with their physical and mental characteristics. In light of the above, tennis serve proficiency clearly depends on an array of physical, technical, and mental factors. Utilizing modern approaches such as game-like drills and mental practice substantially improves performance, particularly in junior players. Hence, the significance of the present study lies in investigating the effect of integrating these two approaches on developing the serve skill in under-16 junior tennis players.

Research Problem

The serve in tennis is a fundamental skill that significantly influences overall performance. Its function extends beyond initiating play; it serves as a critical offensive weapon through which a player can impose their style of play and gain an early tactical advantage within a rally. Greater precision, velocity, and technical proficiency in the serve increase a player's capacity to control match dynamics and limit the opponent's ability to return the ball effectively.

Through the researcher's observations of under-16 junior tennis players, a clear deficit in serve execution was identified. This deficit manifests as poor ball placement accuracy within the service box, reduced serve velocity, and technical errors across the execution phases (including ball toss, backswing, impact timing, weight transfer, and follow-through). This directly impairs the junior player's capacity to utilize the serve as an effective offensive weapon during training and competition.

The researcher attributes these deficiencies to the reliance of certain training programs on traditional mechanical repetition without sufficient contextualization within actual play situations. Consequently, players execute the serve in isolation from match conditions, devoid of the psychological pressures inherent to competition. Although this may yield superficial improvements during training sessions, it does not ensure the transfer of performance gains to competitive match play.

Moreover, many junior players execute the serve without forming a clear cognitive representation of the movement prior to execution, lacking the ability to visualize ball trajectory, feel the timing of the strike, or regulate attention and concentration throughout performance. Thus, the absence of mental practice attenuates the effectiveness of skill acquisition, particularly in complex skills like the serve that necessitate precise integration of physical, technical, and cognitive domains.

The importance of game-like drills lies in providing an ecological training environment that mirrors competitive conditions, enabling players to execute skills within realistic contexts and enhancing execution accuracy and decision-making speed. Concurrently, mental practice allows athletes to mentally rehearse correct execution prior to physical performance, which reinforces correct motor pathways, enhances self-confidence, and minimizes technical errors.

Journal of Sports Sciences
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A review of literature in motor learning and mental training reveals that while numerous studies have addressed mental practice or situated training independently, there remains a critical need to examine the effectiveness of combining game-like drills with mental practice in teaching the serve to under-16 tennis players, especially given the formative nature of this age group.

Research Objectives

The present study aims to determine:

- The effect of the proposed training program on serve skills among junior tennis players.
- The effect of the proposed training program on mental skills among junior tennis players.

Research Hypotheses

- There are statistically significant differences between the pre-test and post-test measurements of the control group in serve skills and mental skills in favor of the post-test measurement among junior tennis players.
- There are statistically significant differences between the pre-test and post-test measurements of the experimental group in serve skills and mental skills in favor of the post-test measurement among junior tennis players.
- There are statistically significant differences between the post-test mean scores of the control and experimental groups in serve skills and mental skills in favor of the experimental group among junior tennis players.

Related Studies

1. **Taha Mohamed El-Sayed, Mostafa Zaghloul Qubaisi, and Aya El-Sayed Hashem (2025)** ،titled *"The Effect of a Motor Education Program Using Lead-Up Games on the Level of Tennis Serve Skill Performance in 9-Year-Old Children."* The study aimed to identify the effect of a motor education program via lead-up games on tennis serve execution among 9-year-olds. The researchers employed an experimental design with experimental and control groups. The sample was selected via purposive random sampling, comprising 50 children from the study population. The primary findings revealed that the proposed instructional lessons utilizing lead-up games yielded significant improvements in the tennis serve performance of the experimental group. The researchers recommended incorporating motor education programs utilizing lead-up games as effective instructional methods across various age categories.
2. **Mohamed Mushtaq Ahmed, Bashar Ghalib Al-Bayati, and Majid Khalil Khamis (2025)** ،titled *"The Effect of Multi-Implement Exercises on Improving the Performance of the Serve Return Skill in Tennis for Third-Year Students."* The study aimed to design multi-implement drills to enhance serve return performance and evaluate their impact. The researchers adopted an experimental two-group design with pre- and post-tests. The sample was randomly selected (via lottery across class sections) from sections B and C, totaling 70 students, reduced to 38 following the exclusion of 6 students due to attendance irregularities. The authors concluded that multi-implement drills exerted a positive effect on learning the tennis serve return, noting that auxiliary training aids acted as instructional enhancers that elevated skill acquisition efficacy. They recommended adopting multi-implement training in teaching the tennis serve return to physical education students.

Journal of Sports Sciences
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3. **Homam Basim Al-Samarrai (2022)** ،titled *"The Effect of Using Synchronous Teaching Styles on Learning the Serve Skill in Lawn Tennis Among Students of the College of Physical Education and Sports Sciences."* The study examined the effect of synchronous teaching styles (command, practice, and reciprocal) on learning the tennis serve among physical education students. An experimental design was utilized with 50 students from the College of Physical Education and Sports Sciences at the University of Baghdad during the 2017–2018 academic year. The researcher concluded that synchronous teaching styles (command, practice, reciprocal), alongside teacher-led instruction, exerted an effective impact on acquiring technical performance of the tennis serve.
4. **Iman Abdelaziz Sallam (2021)** ،titled *"The Effect of Special Exercises on the Serve Reception Skill for Under-16 Female Volleyball Players."* The research aimed to design corrective technical drills to improve serve reception and evaluate their efficacy. An experimental single-group design with pre-, intermediate-, and post-tests was employed. The study population comprised 64 under-16 female players across four teams in the Ismailia region; the sample consisted of 17 players from El Qanah Club. Key findings indicated that greater arm platform surface area and a lower center of gravity correlated with superior serve reception accuracy. The author recommended implementing the training program across various age groups due to its scientific contribution to technical and physical development.
5. **Mohamed Talaat Abo El-Maaty, Ahmed El-Sayed Ismail, and Sherif Mohamed Abdelmoneim (2020)** ،titled *"The Effect of Using Lead-Up Games on Learning the Serve Skill in Tennis."* The study aimed to assess the impact of lead-up games on learning the tennis serve. An experimental single-group pretest–posttest design was utilized with a sample of 20 first-year students from the Faculty of Physical Education at Sadat City University during the 2018/2019 academic year. Findings demonstrated that the instructional program incorporating lead-up games positively impacted the acquisition of the flat serve in the experimental group.
6. **Mohamed Hassan El-Desouky and Ahmed Ali Mousa (2020)** ،titled *"The Effect of Mental Training According to Distributed Practice Scheduling on Learning the Serve Skill in Tennis Among Students of the College of Physical Education."* The study aimed to identify the effect of mental training under distributed practice scheduling on learning the flat serve, and to evaluate differences between pre- and post-tests for both control and experimental groups. An experimental design was applied to a sample of 24 third-year physical education students at the University of Duhok (2019–2020), divided equally into two groups (n = 12 per group). The researchers concluded that mental training under distributed practice scheduling was significantly more effective than traditional instruction in acquiring the technical execution of the flat serve, and served as a primary factor in the experimental group's superiority.
7. **Saeed Ghani (2010)** ،titled *"The Effect of Mental Training Accompanying Physical and Technical Practice on Learning Serve Defense in Volleyball."* The study aimed to design instructional units combining physical/technical training with concurrent mental practice for serve reception in volleyball, and to evaluate their efficacy. An experimental randomized equivalent-groups design was

Journal of Sports Sciences
ISSN: 2074 - 6032 ISSN-e: 2710 - 5016
Journal Homepage: https://pessj.uodiyala.edu.iq

utilized on a sample of 10 second-year physical education students at the University of Misan. Findings revealed significant differences between pre- and post-tests favoring the post-test for the experimental group, confirming the positive impact of concurrent mental practice on learning serve reception. The researcher recommended emphasizing mental training and expert modeling during the instruction of fundamental volleyball skills.

2. Research Methodology and Procedures

2.1Research Method

The researcher utilized the experimental method due to its appropriateness for the nature of the study, adopting a two-group pretest–posttest experimental design comprising an experimental group and a control group.

2.2Research Population and Sample

- **Research Population:** The research population comprised junior tennis players at the Specialized Tennis Center in Diyala, totaling 36 players in the under-16 age category.
- **Research Sample:** The sample was selected using the complete enumeration method, encompassing all 36 under-16 junior players from the Specialized Tennis Center in Diyala. The sample was allocated as follows:
    - **Pilot Study Sample:** Consisted of 20 junior players to establish the scientific parameters (validity and reliability) of the study instruments.
    - **Main Study Sample:** Consisted of 16 junior players, divided into:
        - **Experimental Group:** 8 junior players subjected to the proposed training program.
        - **Control Group:** 8 junior players subjected to the conventional training program.

Table 1 presents the breakdown of the research sample.

Table 1. Characterization of the Research Sample

Classification	Number of Junior Players	Percentage (%)
Pilot Study Sample	20	%55.56
Main Study Sample:		
Experimental Group	8	%22.22
Control Group	8	%22.22
Total Sample Size	**36**	**%100**

Statistical Characterization of the Research Sample

Baseline physical characteristics (age, weight, height) were measured to ensure sample homogeneity and control for confounding variables, as presented in Table 2.

Table 2. Descriptive Statistics of the Research Sample Across Baseline Variables Prior to the Experiment

Variables	Unit of Measurement	Mean	Standard Deviation (SD)	Skewness Coefficient	Kurtosis Coefficient
Age	Years	15.45	0.24	0.56	0.17
Weight	kg	66.80	1.38	0.84	0.63-
Height	cm	169.50	0.85	1.01	0.98

Table 2 demonstrates that baseline data for the total sample are normally distributed and non-dispersed. Skewness coefficients ranged from 0.56 to 1.01 (approaching zero), and kurtosis coefficients ranged between -0.63 and 0.98, indicating acceptable mesokurtic distributions and confirming the baseline homogeneity of the participants prior to experimental intervention.

Journal of Sports Sciences
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Data Collection Tools

- Tennis Mental Skills Scale (developed by the researcher).
- Tennis Serve Skill Tests.
- Proposed Game-Like Drills Program Incorporating Mental Practice (developed by the researcher).

First: Tennis Mental Skills Scale

The researcher constructed a mental skills scale for tennis players tailored to the participants (Table 1), comprising four subscales:

1. **First Subscale:** Clarity of Visual Imagery
2. **Second Subscale:** Kinesthetic Perception
3. **Third Subscale:** Attention and Concentration Control
4. **Fourth Subscale:** Mental Imagery of Correct Performance

Psychometric Properties of the Tennis Mental Skills Scale

- **Validity:**
  - **Content Validity (Expert Validity):** The scale items and subscales were submitted to a panel of seven professors specializing in sport psychology to assess their appropriateness and alignment with research objectives. Expert agreement ranged between 71.43% and 100%, leading to the retention of all items and subscales without modification.
  - **Internal Consistency Validity:** Calculated via Pearson correlation coefficients between individual item scores and their corresponding subscale scores, as well as between subscale scores and the total scale score (Table 3).

Table 3. Correlation Coefficients Between Item Scores, Subscale Scores, and Total Scale Score

No.	Subscale	Item Sequence	Correlation Coefficient (Item vs. Subscale)	Correlation Coefficient (Subscale vs. Total Score)
1	First: Clarity of Visual Imagery	7–1	0.915–0.751	0.869
2	Second: Kinesthetic Perception	13–8	0.893–0.697	0.798
3	Third: Attention and Concentration Control	20–14	0.869–0.789	0.816
4	Fourth: Mental Imagery of Correct Performance	28–21	0.912–0.764	0.879

Tabulated r at p = 0.05 is 0.433.

Table 3 indicates that all correlation coefficients between items, subscales, and the total score were statistically significant at p ‹0.05=verifying the internal consistency validity of the scale.

- **Reliability:** Scale reliability was determined using Cronbach's alpha coefficient for individual subscales and the overall instrument (Table 4).

Table 4. Reliability Coefficients of the Scale Subscales

No.	Scale Subscales	Item Sequence	Subscale Reliability (α(	Total Scale Reliability (α(
1	First: Clarity of Visual Imagery	7–1	0.902	0.916
2	Second: Kinesthetic Perception	13–8	0.897	
3	Third: Attention and Concentration Control	20–14	0.864	
4	Fourth: Mental Imagery of Correct Performance	28–21	0.912	

Journal of Sports Sciences
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Table 4 shows high reliability coefficients across all subscales and the total instrument, confirming high test reliability.

Second: Tennis Serve Skill Tests

Scientific references and testing manuals in tennis were consulted to select and establish appropriate tests for assessing serve performance variables, as detailed in Table 5.

Table 5. Tennis Serve Skill Tests

Tests	Unit of Measurement
Tennis Serve Accuracy Test	Points
Serve Velocity Test	km/h
Technical Performance of the Serve Test	Points

Psychometric Properties of the Serve Skill Tests

Validity and reliability were determined using the pilot study sample (n (20=from January 6, 2026, to January 13, 2026:

- **Discriminant Validity (Extreme Groups Method):** Calculated by comparing the upper and lower quartiles using an independent samples t-test (Table 6).

Table 6. Differences Between Upper and Lower Quartiles in Tennis Serve Skill Tests

Tests	Unit of Measurement	Upper Quartile (n (5=Mean ± SD	Lower Quartile (n (5=Mean ± SD	Calculated t-value
Tennis Serve Accuracy Test	Points	1.03 ± 18.70	0.93 ± 15.20	*4.12
Serve Velocity Test	km/h	0.98 ± 115.60	0.47 ± 110.05	*5.23
Technical Performance of the Serve Test	Points	0.81 ± 24.90	0.29 ± 21.70	*6.45

*Tabulated t-value at p 0.05=is 2.776. *Statistically significant.*

Table 6 confirms statistically significant differences between the upper and lower quartiles across all tests (p ‹(0.05>demonstrating the high discriminative validity of the tests.

- **Test–Retest Reliability:** Assessed via test–retest administration with a 7-day interval (Table 7).

Table 7. Test–Retest Reliability Coefficients for Tennis Serve Skill Tests

Tests	Unit of Measurement	First Application Mean ± SD	Second Application Mean ±SD	Correlation Coefficient (r(
Tennis Serve Accuracy Test	Points	2.01 ± 16.90	2.21 ± 17.00	*0.92
Serve Velocity Test	km/h	2.36 ± 113.00	2.59 ± 112.50	*0.95
Technical Performance of the Serve Test	Points	1.28 ± 23.35	1.25 ± 23.60	*0.90

*Tabulated r at p 0.05=is 0.433. *Statistically significant.*

Table 7 displays high and statistically significant test–retest correlation coefficients (r ‹(0.95–0.90=verifying strong measurement reliability.

Third: Proposed Game-Like Drills Program Incorporating Mental Practice

1. **Program Objectives:** To enhance serve performance (accuracy, velocity, technical execution) in junior tennis players through game-like drills combined with mental practice.
2. **Program Design Principles:**
   - Aligning with the developmental characteristics of under-16 athletes.
   - Progression from simple to complex tasks.
   - Exercise variety and engagement.

Journal of Sports Sciences
ISSN: 2074 - 6032 ISSN-e: 2710 - 5016
Journal Homepage: https://pessj.uodiyala.edu.iq

- Linking technical execution to competitive game contexts.
- Integrating overt physical execution with mental imagery.
- Accounting for individual differences among players.

3. **Program Duration and Structure:**
   - **Total Duration:** 8 weeks.
   - **Weekly Frequency:** 3 sessions per week.
   - **Total Sessions:** 24 training units.
   - **Session Duration:** 75–60 minutes.
4. **Training Session Structure:**

Table 8. Training Session Structure

Section	Duration	Content
Warm-up	15–10min	General exercises + tennis-specific drills
Mental Practice	10–5min	Serve visualization (visual + kinesthetic imagery)
Main Part	45–35min	Game-like drills focused on the serve
Cool-down	10–5min	Cool-down + mental relaxation

5. **Mental Practice Protocol:**
   - **Pre-Execution:** Visualizing court dimensions and the service box, picturing ball trajectory, and imagining correct serve mechanics.
   - **During Practice:** Coupling mental imagery with overt execution, mentally rehearsing the movement after each attempt.
   - **Post-Execution:** Cognitive review of execution and mental error correction.
6. **Examples of Game-Like Drills:**
   - *Targeted Area Serve Drill:* Dividing the service box into designated zones. Objective: Accuracy. Intensity: Moderate. Repetitions: 10–15 attempts. Rest: 30–45 s.
   - *Time-Constrained Serve Drill:* Executing serves within a limited time window. Objective: Speed and focus. Intensity: High. Repetitions: 8–10 attempts. Rest: 45–60 s.
   - *Serve + Play Phase Drill:* Executing a serve followed by an immediate rally or playing out the point. Objective: Match contextualization. Intensity: High. Repetitions: 6–8 repetitions.
   - *Competitive Serve Drill:* Peer competition on accuracy and speed. Objective: Increasing motivation. Intensity: Progressive.
7. **Training Load Intensity:**
   - Progressive increase from 60% to 85%.
   - Intensity progression across training weeks.
   - Gradual reduction in rest intervals.

Main Study Execution

The main experiment was conducted from January 15, 2026, to March 19, 2026:

- **Pre-Test Measurement:** Administered on January 15, 2026, across all variables for the 16 participants (8 experimental, 8 control) at the Specialized Tennis Center in Diyala.

Table 9. Equivalence Between Control and Experimental Groups in Serve Skills and Mental Skills Prior to the Experiment

Tests	Unit of Measurement	Control Group (n (8=Mean ±SD	Experimental Group (n (8= Mean ± SD	Calculated t-value	Significance Level

Journal of Sports Sciences
ISSN: 2074 - 6032 ISSN-e: 2710 - 5016
Journal Homepage: https://pessj.uodiyala.edu.iq

Tennis Serve Accuracy Test	Points	1.59 ± 17.50	1.59 ± 17.90	0.50	Not Significant
Serve Velocity Test	km/h	± 112.60 2.86	2.86 ± 113.10	0.35	Not Significant
Technical Performance of the Serve Test	Points	1.36 ± 23.45	1.36 ± 24.00	0.81	Not Significant
Mental Skills Scale	Points	1.54 ± 96.85	1.96 ± 95.75	1.24	Not Significant

Tabulated t-value at p 0.05=is 2.145.

Table 9 indicates no statistically significant differences between the two groups across baseline variables (t ،1.24–0.35=p ،(0.05<confirming pre-intervention group equivalence.

- **Intervention Implementation:** The experimental group (n (8=completed the 8-week proposed program (January 17, 2026, to March 18, 2026; 3 sessions/week), while the control group (n (8=followed the conventional club training program.
- **Post-Test Measurement:** Conducted on March 19, 2026, for all variables at the Specialized Tennis Center in Diyala under standardized conditions.

Statistical Methods

Data were processed using: Arithmetic Mean, Standard Deviation, Median, Skewness Coefficient, Kurtosis Coefficient, Pearson Correlation Coefficient, Frequency, Percentage, and Student's t-test.

.3Results and Discussion

First: Presentation and Discussion of the First Hypothesis

Hypothesis 1 states: "There are statistically significant differences between the pre-test and post-test measurements of the control group in serve skills and mental skills in favor of the post-test measurement among junior tennis players."

Table 10. Significance of Differences Between Pre- and Post-Test Means for the Control Group in Serve Skills and Mental Skills Scale (n(8=

Tests	Unit of Measurement	Pre-Test Mean ± SD	Post-Test Mean ± SD	Calculated t-value	Significance Level
Tennis Serve Accuracy Test	Points	± 17.50 1.59	± 20.90 2.04	2.21	Not Significant
Serve Velocity Test	km/h	± 112.60 2.86	± 116.80 2.55	*2.48	Significant
Technical Performance of the Serve Test	Points	± 23.45 1.36	± 25.70 1.52	2.17	Not Significant
Mental Skills Scale	Points	± 96.85 1.54	± 105.00 1.87	2.08	Not Significant

*Tabulated t-value at p 0.05=is 2.365. *Significant at p.0.05>*

Table 10 reveals:

- Statistically significant differences between pre- and post-tests for the control group in serve velocity favoring the post-test (t،2.48=p.(0.05>
- No statistically significant differences between pre- and post-tests in serve accuracy, technical performance, or mental skills (t،2.21–2.08=p.(0.05<

These findings align with Richard A. Schmidt (2019), who noted that traditional training modalities relying on repetitive drills without variation or contextual simulation

Journal of Sports Sciences
ISSN: 2074 - 6032 ISSN-e: 2710 - 5016
Journal Homepage: https://pessj.uodiyala.edu.iq

yield limited physical improvements (such as strength and velocity) but fail to significantly enhance fine motor skills or cognitive aspects of motor execution.

The results are also consistent with Weinberg (2023), who demonstrated that mental skills, including imagery and focus, do not develop effectively through conventional training alone, but require targeted mental practice and psychological intervention programs. The absence of structured mental training restricts cognitive gains, thereby constraining overall skill development.

The researcher attributes these findings to the limited impact of conventional training, where significant gains were confined to serve velocity—a parameter influenced by physical attributes like muscular strength that improve with repetition. Conversely, accuracy, technical performance, and mental skills require integrated pedagogical and cognitive training strategies, such as game-like drills and structured mental rehearsal.

Second: Presentation and Discussion of the Second Hypothesis

Hypothesis 2 states: "There are statistically significant differences between the pre-test and post-test measurements of the experimental group in serve skills and mental skills in favor of the post-test measurement among junior tennis players."

Table 11. Significance of Differences Between Pre- and Post-Test Means for the Experimental Group in Serve Skills and Mental Skills Scale (n(8=

Tests	Unit of Measurement	Pre-Test Mean ± SD	Post-Test Mean ± SD	Calculated t-value	Significance Level (p(
Tennis Serve Accuracy Test	Points	± 17.90 1.59	± 24.90 2.01	*7.42	0.000
Serve Velocity Test	km/h	± 113.10 2.86	± 122.20 2.61	*6.95	0.000
Technical Performance of the Serve Test	Points	± 24.00 1.36	± 29.80 1.39	*8.10	0.000
Mental Skills Scale	Points	± 95.75 1.96	± 124.50 1.37	*19.85	0.000

*Tabulated t-value at p 0.05=is 2.365. *Significant at p.0.05>*

Table 11 demonstrates statistically significant differences between pre- and post-tests for the experimental group across all variables (serve accuracy, serve velocity, technical performance, and mental skills) favoring the post-test (t‹19.85–6.95=p.(0.05>

These findings concur with Taha Mohamed El-Sayed, Mostafa Zaghloul Qubaisi, and Aya El-Sayed Hashem (2025), which showed that developing the tennis serve depends substantially on integrated training programs combining technical execution with contextual match simulation, resulting in marked improvements in accuracy, velocity, and technical proficiency.

The results further corroborate Saeed Ghani (2010), who highlighted that mental practice (imagery) enhances motor performance via neural pathway activation, thereby improving neuromuscular coordination and accuracy, with combined physical–mental training producing superior outcomes relative to isolated methods.

Similarly, these findings support Karl Davids (2008), who reported that game-like drills represent highly effective modalities for enhancing skill performance in open-skill sports, fostering motor perception, rapid decision-making, and execution accuracy under match-like constraints.

The researcher attributes these outcomes to the proposed training program, wherein game-like drills established a representative learning environment that facilitated the

Journal of Sports Sciences
ISSN: 2074 - 6032 ISSN-e: 2710 - 5016
Journal Homepage: https://pessj.uodiyala.edu.iq

transfer of skill acquisition to authentic match contexts, while mental practice enhanced movement visualization, sharpened attentional focus, and stabilized the correct motor execution pattern.

Third: Presentation and Discussion of the Third Hypothesis

Hypothesis 3 states: "There are statistically significant differences between the post-test mean scores of the control and experimental groups in serve skills and mental skills in favor of the experimental group among junior tennis players."

Table 12. Independent Samples t-Test Results and Percentage Improvement Between Control and Experimental Groups in Post-Test Measurements

Tests	Unit of Measurement	Control Group (n (8= Mean ± SD	Experimental Group (n (8= Mean ± SD	Calculated t-value	Significance Level (p(	Improvement Rate (%)
Tennis Serve Accuracy Test	Points	± 20.90 2.04	2.01 ± 24.90	*4.02	0.000	%19.14
Serve Velocity Test	km/h	116.80 2.55 ±	2.61 ± 122.20	*3.96	0.000	%4.62
Technical Performanc e of the Serve Test	Points	± 25.70 1.52	1.39 ± 29.80	*5.72	0.000	%15.95
Mental Skills Scale	Points	105.00 1.87 ±	1.37 ± 124.50	*23.65	0.000	%18.57

*Tabulated t-value at p 0.05=is 2.145. *Significant at p.0.05>*

The results in Table 12 and Figure 1 demonstrate statistically significant differences at p 0.05>between the post-test means of the experimental and control groups across all measures (serve accuracy, serve velocity, technical performance, and mental skills) in favor of the experimental group (t‹23.65–3.96=p ‹(0.05>with improvement rates ranging from 4.62% to 19.14%.

These findings align with Schmidt (2025), who confirmed that training approaches based on situational variety and authentic ecological task constraints foster motor learning and enhance the transfer of training to competition.

The results are also consistent with Weinberg (2023), who indicated that developing mental skills directly elevates technical execution—particularly in fine precision skills such as the tennis serve. Athletes utilizing mental practice exhibit superior movement regulation and fewer technical errors, explaining the substantial gains in accuracy and technical performance observed in the experimental group.

Furthermore, the results support Davids (2008) and Mohamed Talaat Abo El-Maaty, Ahmed El-Sayed Ismail, and Sherif Mohamed Abdelmoneim (2020), which demonstrated that game-like drills are among the most effective instructional strategies in open sports, enhancing perceptual-motor abilities and decision-making under competitive pressure. Such interventions yield marked skill gains over conventional instruction, consistent with the experimental group's superiority across all tested parameters.

The researcher concludes that the superior performance of the experimental group is directly attributable to the integrated program structure: game-like drills provided a

Journal of Sports Sciences
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realistic practice context facilitating learning transfer, while mental practice reinforced cognitive movement representation, heightened attentional control, and stabilized optimal motor pathways.

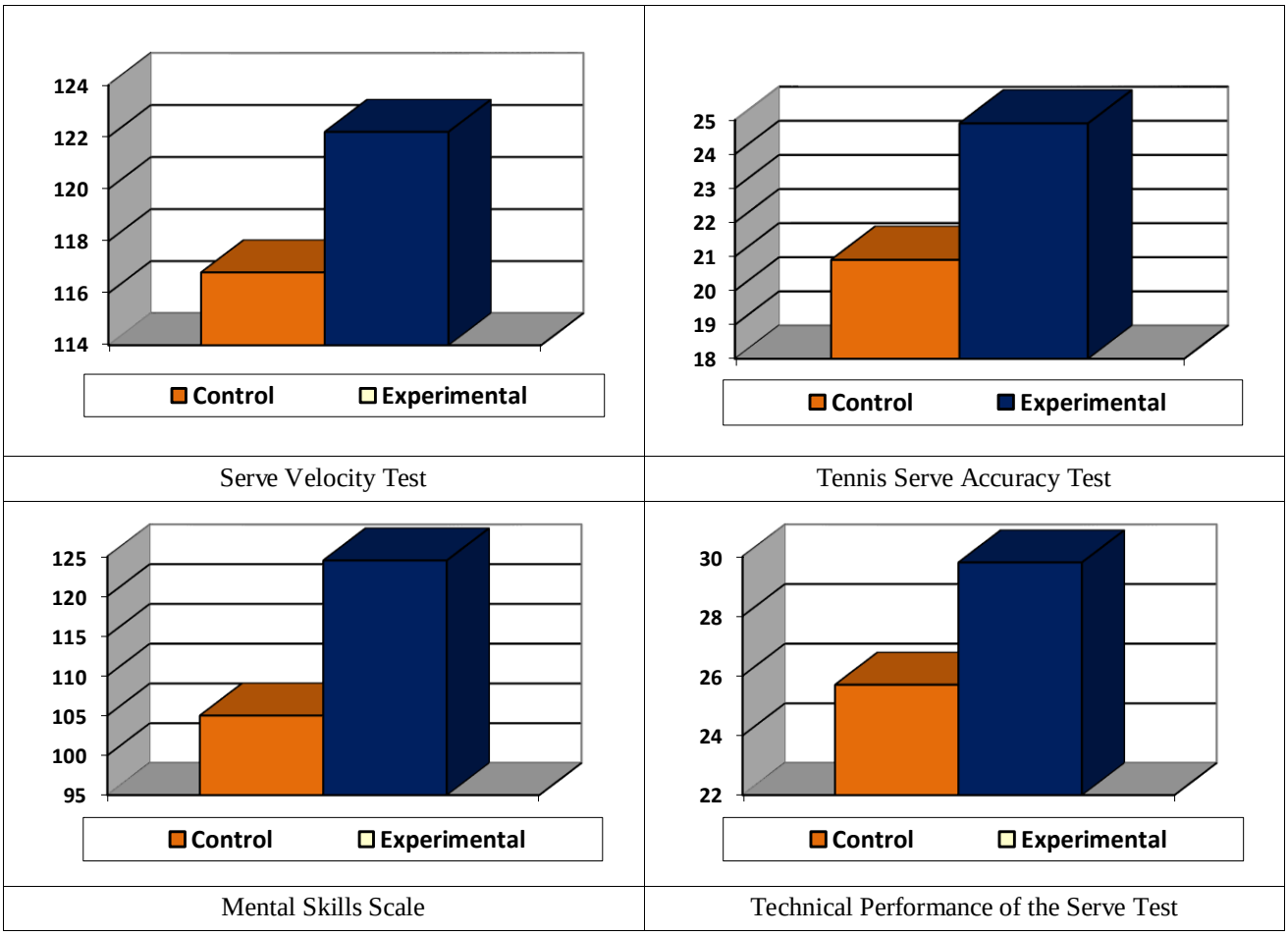

Figure 1. Means of the Control and Experimental Groups in Serve Skills and the Mental Skills Scale for Junior Tennis Players

4. Conclusion

In light of the research objectives and hypotheses, within the limits of the study sample and methodology, and based on the statistical analysis and findings, the researcher reached the following conclusions:

- The training program based on game-like drills utilizing mental practice demonstrated statistically significant improvements in serve skills (accuracy, velocity, and technical performance) among under-16 junior tennis players.
- The experimental group achieved a marked increase in mental skills—such as motor imagery, concentration, and neuromuscular coordination—which was positively reflected in the quality of technical execution.
- The control group's results indicated that improvements across most serve skill tests and the mental skills scale were limited or not statistically significant, demonstrating the limited efficacy of conventional training methods in developing technical and mental performance.

Journal of Sports Sciences
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Journal Homepage: https://pessj.uodiyala.edu.iq

- Improvement rates in the experimental group ranged between 4.62% and 19.14% in serve skills and reached approximately 18.57% on the mental skills scale, highlighting the tangible effectiveness of the proposed training program.
- The findings underscore the importance of integrating technical and cognitive domains in athletic training, as this reinforces motor learning, enhances player motivation, and consolidates skill acquisition more effectively than traditional training methods.

Recommendations

Based on the research findings and within the scope of the derived conclusions, the researcher recommends the following:

- Integrating game-like drills into training programs for junior tennis players to enhance serve accuracy, velocity, and technical performance.
- Utilizing mental practice to improve motor imagery, concentration, and neuromuscular control, thereby optimizing both technical and cognitive performance.
- Designing integrated training programs that combine physical, technical, and mental components to achieve rapid and sustainable performance improvements.
- Developing age-appropriate training programs tailored to under-16 athletes, ensuring progressive exercise difficulty and incorporating engaging tasks to maintain athletic motivation.
- Utilizing augmented feedback and video analysis to monitor performance and provide real-time correction of technical errors.
- Providing coaching education on designing situational drills coupled with mental practice to facilitate the transfer of acquired training skills into actual competitive match play.
- Conducting future research to evaluate the impact of the program on other tennis skills or across different age categories, as well as investigating the combined effect of mental training and situated drills on athletes' psychological variables and physical endurance.

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Appendix (1): Tests of Fundamental Skills in Tennis

First: Tennis Serve Accuracy Test

- **Test Name:** Tennis Serve Accuracy Test in Designated Target Areas.
- **Objective:** To assess the player's accuracy in directing the serve into designated target zones within the tennis court.
- **Equipment:** Regulation tennis court, tennis rac
- kets, tennis balls, target marking tape within the service box, and a score recording sheet.

Execution Protocol:

- The player stands behind the baseline.
- The player performs 10 serve trials directed toward the diagonally opposite service box.
- The service box is divided into specific target zones (right, center, left).
- Points are awarded based on serve placement accuracy.

Scoring System:

- Ball lands inside the designated target zone = 3 points.
- Ball lands inside the service box but outside the designated target zone = 2 points.
- Fault (ball lands outside the service box or in the net) = 0 points (Reid & Elliott, 2013).

Journal of Sports Sciences
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Journal Homepage: https://pessj.uodiyala.edu.iq

Second: Serve Velocity Test

- **Test Objective:** To measure ball velocity during the serve, functioning as a direct indicator of muscular strength and power.
- **Equipment:** Radar speed gun, tennis court, tennis balls, and a racket.
- **Procedures:** The radar speed gun is positioned behind the player or behind the baseline.
- **Execution Protocol:** The player performs 10 serves at maximum velocity while maintaining proper technical execution.
- **Scoring System:** The velocity of each serve is recorded in kilometers per hour (km/h). The score is calculated as either the peak velocity or the mean of the best 3–5 trials.

Third: Technical Performance of the Serve Test

- **Test Objective:** To evaluate the technical execution quality of the serve across its biomechanical movement phases.
- **Equipment:** Video camera (preferably high-speed video), technical assessment evaluation form, tennis court, racket, and balls.
- **Procedures:** The player is video-recorded while executing the serve; the recorded footage is subsequently evaluated by expert adjudicators.
- **Execution Protocol:** The player executes 10 serve trials, and the best 5 trials are selected for technical evaluation.

Technical Evaluation Components:

Each movement phase is scored on a rating scale (e.g., 1–5 points):

- Ready position / Stance
- Racket grip
- Ball toss
- Backswing / Preparation phase
- Impact / Strike phase
- Weight transfer
- Follow-through

Scoring System:

- Points are awarded for each technical component (e.g., 1–5 points per component).

Journal of Sports Sciences
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Journal Homepage: https://pessj.uodiyala.edu.iq

- Total test score = 35 points.

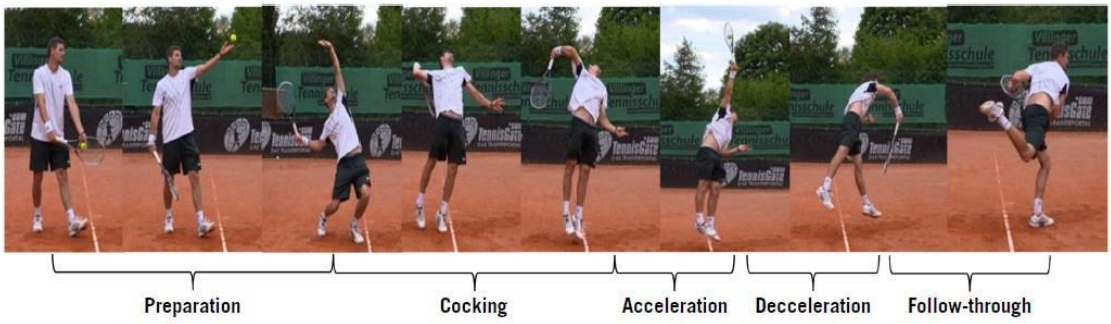

Figure 1: The different phases of the serve.

Appendix (2): Sample Training Unit

Warm-up (10 min)

- Light jogging + general dynamic stretching exercises.
- Tennis-specific drills targeting serve movement mechanics.

Mental Practice (5 min)

- Visualizing successful serve execution.
- Imagery of the ball trajectory.

Main Part (40 min)

- Target-oriented serve drills (10 attempts).
- Serves under pressure / time constraints (8 attempts).
- Serve + playout point drill (6 repetitions).

Cool-down (5 min)

- Active cool-down.
- Cognitive post-performance review and mental relaxation.

Appendix (3): Tennis Mental Skills Scale (Final Version)

No.	Scale Items	Strongly Agree	Agree	Sometimes	Disagree	Strongly Disagree
First Subscale: Clarity of Visual Imagery						
1	I can clearly visualize the layout of the tennis court during the serve.					
2	I visualize the trajectory of the ball prior to executing the serve.					
3	I mentally picture the exact spot where the ball will land inside the service box.					
4	I can visualize my body movements during the execution of the serve.					
5	I clearly visualize the detailed movement of my arm and racket.					
6	I can accurately visualize the launch angle of the ball.					
7	I visualize the opponent's position on the court during the serve.					
Second Subscale: Kinesthetic Perception						
8	I feel my body movements in my mind as if I am actually executing the serve.					
9	I can imagine the amount of muscular force required to strike the ball.					
10	I accurately visualize the precise					

Journal of Sports Sciences
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Journal Homepage: https://pessj.uodiyala.edu.iq

	timing of ball impact.					
11	I internally sense the movement rhythm during mental serve execution.					
12	I can kinesthetically perceive the movement of my feet during the serve.					
13	I imagine the forward transfer of body weight during the strike phase.					
Third Subscale: Attention and Concentration Control						
14	I can focus prior to executing the serve without being distracted.					
15	I maintain full control over my thoughts during serve execution.					
16	I ignore external distractions during mental imagery.					
17	I quickly regain my focus if I lose concentration during performance.					
18	I focus my attention exclusively on the serve target.					
19	I control the direction of my attentional focus during mental practice.					
20	I can sustain my concentration throughout the entire serve execution process.					
Fourth Subscale: Mental Imagery of Correct Performance						
21	I visualize the ideal serve execution before physical performance.					
22	I use mental imagery to correct my technical errors.					
23	I mentally rehearse correct execution multiple times.					
24	I visualize myself executing a successful serve.					
25	I use mental imagery to improve my serve placement accuracy.					
26	I visualize all phases of the serve as an integrated movement sequence.					
27	I utilize mental imagery to enhance my overall technical level.					
28	I imagine myself serving with confidence and success during competitive matches.					