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The Effect of Neuromuscular Training on Motor Response Speed in Tennis

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ORIGINAL STUDY

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Abstract

The integration of modern training techniques and methods—such as neuromuscular training, was identified as an advanced trends in sports science. This approach aimed to enhance the efficiency of both the nervous and muscular systems simultaneously through exercises that strengthened the connection between the brain and muscles, leading to improvements in the speed and accuracy of motor performance. This study examined the effect of neuromuscular training on the speed of motor response among tennis players, a sport that required rapid reaction and precise execution. The researcher noted a lack of Arabic studies that investigated the effect of such training on motor response speed among tennis players. Accordingly, the research problem was articulated in the following question: *What is the effect of neuromuscular training on motor response speed in tennis?*. The researcher employed an experimental approach using a single-group design with pre- and post-testing. The sample consisted of eight (8) players from the national youth tennis team. This experimental group was subjected to a specialized training program focused on enhancing balance, motor control, and reflexes. A series of tests were used to measure motor response speed, including the light reaction test, change-of-direction test, ball-and-racket interaction test, and a multi-target accuracy test. The results revealed statistically significant differences in favor of the experimental group in all four motor response tests, confirming the effectiveness of neuromuscular training in improving motor response speed. Based on these findings, the researcher recommended integrating this type of training into tennis player development programs to enhance technical performance and functional efficiency.

Keywords: Neuromuscular training, Motor response speed, Tennis

1. Introduction

Tennis is considered one of the sports that demand a high level of integration between physical and cognitive skills, due to the nature of its performance, which is characterized by speed, precision, and real-time interaction with dynamic field variables and multiple competitive situations. Motor response speed is regarded as a fundamental indicator of high performance in tennis, as the player must make rapid decisions and execute them with accuracy within extremely short timeframes, particularly during serving, receiving, and responding to both short and long shots (Kovacs, 2007).

In this context, the need has emerged to incorporate modern training techniques and methodologies, including neuromuscular training, as one of the advanced approaches in sports science. This form of training aims to enhance the efficiency of both the nervous and muscular systems simultaneously by engaging in exercises that strengthen the connection between the brain and muscles. These exercises improve the effectiveness of neural stimulation directed toward the muscles, thereby positively impacting the speed and precision of motor performance (Myer et al., 2006).

The concept of neuromuscular training is grounded in the development of sensorimotor abilities such as balance, movement control, dynamic stability, and the capacity to anticipate and respond to motor, auditory, and visual stimuli—skills that are closely aligned with the performance demands of tennis (Hewett et al., 2010). Recent studies indicate that the benefits of neuromuscular training programs extend beyond

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injury prevention; they also contribute directly to enhancing athletic performance, particularly in sports that require rapid reactions and immediate decision-making, such as tennis (Chaouachi et al., 2014).

Despite the abundance of studies examining the effects of various training methods on physical fitness components in tennis, there remains a clear knowledge gap in Arabic-language research specifically addressing the relationship between neuromuscular training and motor response speed. This highlights the significance of the present study, which seeks to explore the impact of this advanced training modality on one of the most critical performance elements in tennis. The findings aim to contribute a scientifically grounded perspective that can inform and enhance training program development for both athletes and coaches.

In this regard, the study by Al-Khalili (2017) examined the effects of neuromuscular coordination training on elements of response and movement speed, offering a framework that aligns closely with the present research in both its conceptual orientation and methodological design. Similarly, the study conducted by Abdulrahman (2015) focused on enhancing motor response in tennis through the application of modern training techniques, which share comparable objectives with neuromuscular training. Furthermore, the reference by Abu El-Ela and Abdel-Hamid (2013) serves as a foundational theoretical source, as it addresses key concepts related to neuromuscular coordination and the principles for designing structured training programs.

As for the study by Al-Sharkawy (2019), it focused on the effect of training the senses associated with movement on reaction time—a complementary aspect to the subject of this research. Furthermore, the study by Al-Sarhani (2021) specifically addressed neuromuscular training in the context of tennis, making it a highly relevant and valuable source for the present study.

1.1. Research problem

Despite the critical importance of motor response speed in the sport of tennis, and the emergence of neuromuscular training as one of the modern approaches aimed at enhancing the interaction between the nervous and muscular systems, there remains a noticeable lack of Arabic-language studies that have directly examined the impact of this type of training on motor response speed among tennis players. Accordingly, the research problem is formulated in the following question:

What is the effect of neuromuscular training on motor response speed in tennis?

1.2. Research objectives

1. To assess the baseline level of motor response speed among tennis players prior to the implementation of neuromuscular training.
2. To design and implement a training program based on neuromuscular training principles.
3. To evaluate the effect of the training program on motor response speed in tennis players.

1.3. Research hypothesis

Hypothesis 1:
There are no statistically significant differences in motor response speed among members of the experimental group before and after the application of neuromuscular training.

2. Methodology and procedures

2.1. Research methodology

The researcher adopted the experimental method, which is considered the most appropriate approach for examining causal relationships between variables, given its suitability for the nature of the present study. This study aims to investigate the effect of neuromuscular training on motor response speed among tennis players. Obeidat et al. (2010) emphasized that this method allows the design of an experimental group subjected to a targeted training program.

2.2. Research population and sample

The research population consisted of players from the national youth tennis team, who are considered among the elite athletes in this sport. Their inclusion ensures an appropriate representation of the high-performance level targeted by the study.

The research sample was selected using a purposive sampling technique and included eight (8) players from the national youth tennis team. A single-group experimental design was adopted, and all selected participants met the required criteria for participation in the proposed training program.

2.3. Instruments and devices used in the study

The researcher utilized a set of instruments and devices designed to serve the study's objectives and to ensure accurate and objective data collection. These are detailed as follows:

1. **Motor Response Time Measurement Device**
   An electronic device used to measure response time to visual or auditory stimuli with high

precision. It was employed to assess the players' motor response speed both before and after the implementation of the training program.

2. **Light Reaction Balls (Quantity: 8)**
   Specially designed balls that illuminate unpredictably. They are used to stimulate visual-motor response and to train the speed of reaction to external stimuli.
3. **Training Cones (Quantity: 10)**
   Used to define movement pathways during exercises and to structure neuromuscular training units.
4. **Digital Stopwatches (Quantity: 1)**
   With a precision of 1/100 of a second, these were used as a backup tool for manually timing performance during tests.
5. **Measuring Tapes**
   Employed to measure distances required for specific tests or exercises within the training program.
6. **Electronic Balance Devices (Balance Boards) (Quantity: 2)**
   Used to assess and improve balance and motor control as part of the neuromuscular training regimen.

2.4. Tests used in the study

To achieve the objectives of the study and to accurately measure motor response speed among tennis players, a set of standardized tests was employed. These tests are recognized for their high levels of validity and reliability in assessing this specific variable. The selected assessments were designed to capture both general motor response and sport-specific reactions related to tennis performance, as detailed below:

1. **Light Reaction Test Using a Visual Stimulus Device** as described by Brown and Ferrigno (2005)

- **Measured Variable:**
  The time elapsed between the appearance of the visual stimulus (light) and the athlete's response by pressing the designated button.
- **Unit of Measurement:**
  Seconds or milliseconds.
- **Scoring Method:**
  - Each athlete performs five trials.
  - The average response time across all attempts is calculated.
  - Final Score = Sum of all recorded times ÷ Number of trials.
- **Example:**
  Response times (in milliseconds): 320 – 290 – 310 – 300 – 280
  Final score = (320 + 290 + 310 + 300 + 280) ÷ 5 = 300 milliseconds

2. **Student's t-test (T-Test) for Measuring Response Speed and Change of Direction** developed by Pauole et al. (2000)

- **Measured Variable:**
  The total time required to complete the movement pattern, including forward and return transitions between designated points.
- **Unit of Measurement:**
  Seconds (s)
- **Scoring Method:**
  - The time is recorded from the initiation of movement to the completion at the final point.
  - The test is performed twice. Depending on the study objective, either the best time or the average of the two trials is used.
- **Example:**
  First trial: 9.3 seconds; Second trial: 9.0 seconds
  Final score = (9.3 + 9.0) ÷ 2 = 9.15 seconds
  Or, if the best result is selected: 9.0 seconds

3. **Motor Response Test Using Racket and Ball** presented by Kovacs (2007)

- **Measured Variable:**
  The time interval between the release of the ball and contact with the racket.
- **Unit of Measurement:**
  Milliseconds (ms)
- **Scoring Method:**
  - A slow-motion camera or an electronic sensor is used to capture the response time with high precision.
  - Three to five trials are conducted, and the average time is calculated.
- **Example:**
  Trials: 280 ms, 300 ms, 270 ms
  Final score = (280 + 300 + 270) ÷ 3 = 283.3 milliseconds

4. **Multiple Target Reaction Drill** described by Zemková and Hamar (2010)

- **Measured Variable:**
  The number of successfully hit targets within a predetermined time interval (e.g., 30 seconds).
- **Unit of Measurement:**
  Number of targets hit
- **Scoring Method:**
  - The total number of targets successfully struck is recorded out of the total number of targets presented.
  - Accuracy rate can also be calculated using the following formula:
    Accuracy (%) = (Number of targets hit ÷ Total number of targets) × 100

- **Example:**
  20 targets appeared; the athlete successfully hit 16
  Accuracy = (16 ÷ 20) × 100 = 80%

2.5. Pilot Study

The pilot study is considered one of the most essential and necessary preparatory procedures for determining the scientific precision and practical feasibility of the proposed tests. It also serves to minimize errors and anticipate challenges that may arise during the implementation of the main experiment.

The researcher conducted the pilot study on Thursday, April 10, 2024, using a sample of two (2) youth players from Al-Amanah Sports Club. The purpose of the pilot was to train the supporting research team responsible for executing the training protocol, to identify and resolve any logistical difficulties they might encounter, and to determine the amount of time required to administer the study's designated tests.

2.6. Main Experimental Procedures

Pre-Test:
The researcher conducted the pre-test assessments on the outdoor field of the Al-Turath Academy Stadium at 4:00 p.m. on Saturday, April 12, 2024.

Post-Test:
The post-tests were conducted by the researcher in the outdoor area of the Heritage Academy tennis court at 4:00 p.m. on Sunday, June 15, 2024.

Statistical Methods:
The researcher employed the Statistical Package for the Social Sciences (SPSS) to process the study data, extracting the values for the arithmetic mean, standard deviation, and the paired-samples t - test.

2.7. Presentation, Analysis, and Discussion of Results

2.7.1. Presentation and Analysis of Pre- and Post-Test Results for the Variables Under Investigation

Table 1 presents the arithmetic means, standard deviations, mean differences, standard deviations of the differences, and significance levels for the comparison between pre-test and post-test measurements.

3. Discussion

The results of the statistical analysis revealed statistically significant differences between the pre-test and post-test means across all tests employed in this study. These differences were in favor of the post-test scores and indicated the effectiveness of the neuromuscular training in enhancing motor response speed among tennis players.

These results are attributed to the observation that the program's training interventions directly targeted the connections between the nervous and muscular systems. This likely enhanced the efficiency of neural signal transmission and improved the speed of motor command execution. This interpretation aligns with the findings of Behm and Sale (1993) who highlighted the role of neuromuscular training in enhancing motor responsiveness.

This interpretation is further supported by Kraemer and Ratamess (2004) who argue that neuromuscular exercises—such as plyometric drills and rapid reaction training—contribute to reducing reaction time and enhance the effectiveness of skill execution in sports that rely on rapid motor responses, such as tennis.

Similarly, the study by Zemková and Hamar (2010) demonstrated that incorporating drills involving diverse visual and auditory stimuli leads to significant improvements in neural processing speed. This enhancement is reflected in more precise motor responses, consistent with the observed increase in the number of successfully hit targets in the multiple-target test conducted in this study.

Moreover, the improvement observed in the T-test for directional changes supports the findings of Pauole et al. (2000) who demonstrate that training programs combining speed, balance, and directional shifts effectively enhance agility and motor responsiveness in individual sports.

Accordingly, these results underscore the importance of incorporating neuromuscular training into the conditioning programs of tennis players—particularly during phases targeting response speed, agility, and motor readiness—as such integration contributes significantly to improving technical proficiency and competitive performance.

The study adopted a one-group pre-test–post-test experimental design, selected in view of the sample's characteristics and the practical constraints of field implementation. The primary objective was to assess the impact of the proposed training program on the same participants by comparing pre-test and post-test measurements. Several considerations prevented the inclusion of a control group, the most notable of which were as follows:

1. **Ethical considerations:** Given that the proposed training program was developmental in nature and offered clear benefits, it was deemed inappropriate to deprive any of the targeted participants of the opportunity to benefit from it

Table 1. Presents the differences in means and standard deviations, the calculated t value, the significance level (α), and the statistical significance of the differences between the pre-test and post-test scores of the experimental group on the variables under investigation.

Tests	Pre-Test Mean	Pre-Test Standard Deviation	Post-Test Mean	Post-Test Standard Deviation	Mean Difference	Standard Deviation of Differences	Sig	Statistical Significance
Motor Response Using a Light Reaction Device	300.0	7.91	270.0	7.91	–30.0	3.54	0.00	Significant
Response Speed and Change of Direction	9.3	0.16	8.7	0.16	–0.6	0.1	0.00	Significant
Motor Response Using Racket and Ball	290.0	7.91	265.0	7.91	–25.0	3.54	0.00	Significant
Rapid Targeting of Multiple Stimuli	14.6	1.14	17.6	1.14	3.0	0.0	0.00	Significant

Statistically significant at a degree of freedom (df) of 7 and a significance level (p-value) less than 0.05.

solely for the purpose of establishing a comparison.

2. **Field constraints:** It was not feasible to provide another group that was fully equivalent in characteristics (e.g., age, skill level, and experience) while maintaining control over its exposure to external variables throughout the duration of the experiment.
3. **Study objectives:** The research focused on changes occurring within the same group before and after implementing the program. This approach was deemed sufficient to address the research questions, given the effort to control variables as much as possible.
4. **Methodological compensation:** To strengthen the validity of the findings, a pretest–posttest design was employed, in addition to comparing the results with standard benchmarks and with findings from previous studies conducted in similar contexts.

4. Conclusions

In light of the study's findings and the results of the statistical analysis, the following conclusions can be stated:

1. Neuromuscular training proved to be statistically effective in improving motor response speed among tennis players, as demonstrated by statistically significant improvements in reaction time, agility, and the precision of motor performance that appear across the post-test measurements.
2. A substantial enhancement is observed in players' performance on both the light reaction test and the racquet-and-ball response test, which indicates that the training program effectively contributes to the development of neural processing speed and motor responsiveness to visual stimuli.
3. The results of the T-test for directional changes reveal a clear improvement in the players' ability to move, recover, and react to the ball in various situations, which indicates enhanced agility and spatial responsiveness.
4. The improvement in the number of accurately hit targets in the multiple-target test reflects the increased focus and quicker decision-making, thereby strengthening the players' cognitive-motor integration.

5. Recommendations

Based on the findings of this study, the following recommendations are proposed:

1. Integrate neuromuscular training into the core training programs for tennis players across all age categories, given its demonstrated effectiveness in enhancing motor readiness and technical performance.
2. Incorporate visual and auditory stimuli into exercises designed to improve response speed, as such stimuli help stimulate the brain's information processing and enhance the speed of motor reactions.
3. Conduct further field-based research on diverse samples (based on gender, age, or performance level) to determine the extent to which this type of training is effective in improving other components such as balance, coordination, and shooting accuracy.
4. Utilize advanced tools and technologies for measurement, such as reaction devices and light signal systems, to enhance the precision of assessments and ensure greater objectivity in evaluating motor variables.
5. Provide training for coaches—both male and female—on the design and implementation of scientifically grounded and effective neuromuscular training programs.

Conflicts of interest

None.

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethical approval

This manuscript approved by Al-Turath Tennis Academy on (01/04/2025)

Author's contributions

All contributions of this study were done by the researchers (Asst. Lect. Abdullah Adnan Mohamed) who get the main idea and work on writing and concluding also with number of experts, Asst. Prof. Dr. Maytham Saadi Ali in Statistics, Dr. Ahmed Taha in revision, Asst. Lect. Inam Al-Azzawi in translating.

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Appendix 1

Components of the Training Session (60 Minutes)

Part	Duration	Content
Warm-Up	10 minutes	General exercises and activation drills, such as light jumping, brisk walking combined with arm rotations, and dynamic stretching.
Main Part	40 minutes	Neuromuscular training, including reaction drills, balance exercises, coordination tasks, and quick-response activities.
Cool-Down	10 minutes	Stretching exercises, deep breathing, and progressive muscle relaxation techniques.

Appendix 2

Weekly Detailed Training Program

Weeks 1–2: Neuromuscular Activation Phase

- Battle Ropes Drills: 3 sets × 20 seconds
- Balance Training on a Stability Board with Tennis Ball Passing
- Light Reaction Exercises: Touching illuminated targets on a light board or Blaze Pods
- Coordination Drills Using an Agility Ladder
- Swiss Ball Exercises: Includes passing, stabilization, and light shooting movements

Weeks 3–5: Stimulation and Intensification Phase

- Multidirectional jumps on coloured floor markers (visual reaction training)
- Surprise Reaction drill with a partner: the partner suddenly throws the ball in an unexpected direction, requiring interception with a racquet
- Interaction with multi-coloured balls (each colour prompts a specific response: hit, evade, or catch)
- Sprint and Stop drills: triggered by auditory or visual cues
- Fast-paced plyometric exercises: such as box jumps followed by immediate reactive catching

Weeks 6–8: Skill Integration Phase

- Performing response drills in realistic game scenarios (e.g., striking the ball following a specific light or sound cue)
- Quick exchange simulation drills using balls that rebound at unpredictable speeds
- Footwork exercises combined with ball striking (mimicking short-point rallies)
- Targeted shots at specific targets that suddenly appear in different areas of the net
- Cognitive-motor integration drills: issuing dual commands to the player with unexpected shifts in requirements (e.g., colour + direction)

تأثير التدريب العصبي-العضلي على سرعة الاستجابة الحركية في لعبة التنس

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المستخلص

يُعَدّ دمج الأساليب والتقنيات التدريبية الحديثة ـ مثل التدريب العصبي-العضلي ـ من الاتجاهات المتقدمة في علم الرياضة. إذ يهدف هذا النهج إلى تعزيز كفاءة كل من الجهازين العصبي والعضلي في آنٍ واحد من خلال تمارين تقوي الصلة بين الدماغ والعضلات، مما يؤدي إلى تحسين سرعة ودقة الأداء الحركي. تناولت هذه الدراسة أثر التدريب العصبي-العضلي في سرعة الاستجابة الحركية لدى لاعبي التنس، وهي لعبة تتطلب استجابة سريعة وتنفيذاً دقيقاً. وقد لاحظ الباحث ندرة الدراسات العربية التي تناولت أثر هذا النوع من التدريب على سرعة الاستجابة الحركية لدى لاعبي التنس. وبناءً على ذلك صيغت مشكلة البحث في السؤال الآتي: ما أثر التدريب العصبي-العضلي في سرعة الاستجابة الحركية في التنس؟ اعتمد الباحث المنهج التجريبي باستخدام تصميم المجموعة الواحدة ذات الاختبارين القبلي والبعدي. تألفت عينة البحث من ثمانية (8) لاعبين من المنتخب الوطني للشباب في التنس. خضعت هذه المجموعة التجريبية لبرنامج تدريبي متخصص يركز على تنمية التوازن والتحكم الحركي وردود الأفعال. ولقياس سرعة الاستجابة الحركية استُخدمت مجموعة من الاختبارات، شملت اختبار الاستجابة للضوء، واختبار تغيير الاتجاه، واختبار التفاعل بين الكرة والمضرب، واختبار الدقة متعددة الأهداف. أظهرت النتائج وجود فروق ذات دلالة إحصائية لصالح المجموعة التجريبية في جميع الاختبارات الأربعة، مما يؤكد فاعلية التدريب العصبي-العضلي في تحسين سرعة الاستجابة الحركية. وبناءً على هذه النتائج أوصى الباحث بدمج هذا النوع من التدريب في برامج إعداد لاعبي التنس لتعزيز الأداء الفني والكفاءة الوظيفية.

الكلمات المفتاحية: التدريب العصبي-العضلي، سرعة الاستجابة الحركية، التنس