



The Effect of Motor Control Exercises on Certain Physical Variables and The Accuracy of Forehand and Backhand Stroke Skills in Table Tennis Players Under 13 Years Old

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Abstract

Table tennis is an individual sport that demands precise timing rapid movement diversity and exceptional hand eye coordination. The Success in this discipline requires athletes to execute coordinated fast paced and directionally variable movements within confined court spaces while maintaining fluidity and focus. The particularly critical for fundamental skills such as the forehand and backhand strokes. The study aimed to evaluate the efficacy of specific motor control exercises on physical capabilities and the accuracy of forehand and backhand strokes among specialized school table tennis U13 years old. The researchers employed a controlled experimental design utilizing pre test and post test measures across experimental and control groups. The sample consisted of 14 players U13 . Following the development of a motor control training regimen baseline tests were administered. The intervention was applied over a two month period followed by post-intervention testing. Statistical analysis indicated that the motor control protocol significantly enhanced movement speed motor response time eye arm coordination and the accuracy of both forehand and backhand strokes. Consequently the study recommends incorporating motor control exercises into training programs to optimize motor speed response mechanisms coordination and stroke precision for juvenile table tennis players.

Keywords: table tennis, motor control training, physical capabilities, motor response speed, eye-hand coordination, skill accuracy, forehand and backhand strokes, under-13 players, specialized schools.

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Introduction

Modern table tennis is an individual sport consisting of fast-pacing motor responses, precise timing and high adaptability to sensorimotor perturbations within a limited space. The modern competition is fast-paced and multidirectional, where the player must assimilate visual information under time pressures (< a few hundred milliseconds), process tactical solutions and dynamically execute complex movement patterns in response (Chen & Wang, 2021; Müller & Abernethy, 2020). Forehand and backhand strokes constitute the foundation of offensive and defensive action in the game because the performance is predicated on effective coupling of neural pathways, musculo-skeletal coordination along with consistent motor accuracy yield under dynamic conditions.

Due to the under 13 years age group being at its peak for neural plasticity which is a critical period of motor and neurological maturation (Al-Fatlawi & Kareem, 2024; Zhang et al., 2022) athletes in this pathway are best determined for more complex motor patterns, creating stable neuromuscular connections. However examples of traditional training methods do continue to separate skill repetition from movement scenarios that can limit transfer to the field (Al-Obaidi & Al-Saadi, 2023; Hasan & Khalaf, 2022). Ambitious introductions of motor control principles in the educative processes involved in select training regimens with three frequently optimized (or compromised) movement capacities (shot precision as well as delay in and quality of adaptive response under competition conditions) exist at talent development academies based on field observations. (Abdul-gani et al., 2024).

To fill this educational and scientific void, the present study aimed to design and implement a unique motor control training intervention for young table tennis players (U13). The aims are (1) to create game specific age-appropriate alternative motor control exercises, (2) observe the effects on selectively chosen physical and physiological variables, (3) see improvements in training group forehand and backhand accuracy with a comparison to a control group following a traditional approach. We hypothesized that the group receiving the experimental motor control protocol would show significantly greater improvements in reaction time, limb speed, eye-hand coordination and skill accuracy outcomes compared to those in the control group. The study was performed in the National Center for Sports Talent Development of Table Tennis in Baghdad from November 2025 to January 2026. (Kadhim & Mahmood, 2023).

Table tennis as we know it today is a low-latency high-speed individual sport featuring rapid readiness motor responses and exact timing (but poor spatial awareness) as well after-the-fact sensorimotor adjustment to timed simulated trajectories. Contemporary competitions are often characterized by quick multi directional rallies able to assess how individuals process visual information and respond tactically or execute a motor action under tight fraction of second time pressure (Chen & Wang 2021; Müller & Abernethy 2020). The forehand and backhand strokes are a base for the performance of aggressive and defensive in the game



building on success through functional integration between neural pathways musculo-articular coordination and patterns of motor precision under constantly varying dynamic conditions (Wahed Issa et al., 2024; Kadhim& Mahood, 2023).

The youth age under 13years is a key time period for motor and neurological development and athletes competing in this period have been shown to acquire complex motor patterns and stable neuromuscular connections (Al-Fatlawi & Kareem, 2024; Zhang et al., 2022) since from this moment on neural plasticity reaches its maximal levels. But still, training workshops on using these skills in a separated context from the functional movement one (from where they originated) still remains a dominant practice and lead to restriction of transfer gain only on field performance (Al-Obaidi & Al-Saadi, 2023; Hasan & Khalaf, 2022). Methodological issues in acquirement of shot accuracy, slow adaptive responses and poor sensorimotor integration interacting during competition situations on the field are face due to limiting motor learning protocols to talent development academies. (Issa et al., 2024)

Method and Materials

The design selected for the study was a two-group (experimental and control) design with pre-test post-test, which is particularly appropriate to examine the effect of an independent variable (motor control exercises), on dependent variables while controlling other confounding variables (Campbell & Stanley, 1963). This design enabled a strong pre vs post intervention comparison to be conducted, thereby augmenting the internal validity of the conclusions.

Population And Sample

The study sample included 18 players of both genders; they were under 13 years old, and registered at the National Center for the Development of Sporting Talent in Table Tennis (Baghdad), all within the competitive season (2024–2025). A random sampling method was applied and 14 players (77.7% from the population) were selected and randomly divided into two equal groups, an experimental group (n=7) and a control group (n=7). To ensure pre-test homogeneity, a skewness analysis was conducted for the variables of weight, height, and age; the results showed that all values did not exceed (± 1), indicating a normal distribution and high homogeneity among the sample members (Table 1). Players with recent musculoskeletal injuries or intermittent training experience were excluded to ensure homogeneity in training background.

Table 1. Homogeneity of the Research Sample in Demographic and Basic Physical Variables

Variable	Unit	Mean	Median	Standard Deviation	Skewness Coefficient
Body Mass	kg	46.82	46	3.571	0.688
Height	cm	154.33	154	6.804	0.145
Age	year	12.16	12	0.885	0.542



Equipment and Tools Used

Physical Equipment and Tools

- Regulation table tennis paddles (10).
- Standard table tennis tables (4).
- Official balls approved by the International Table Tennis Federation (50).
- Kisia digital stopwatches (2).
- Digital heart rate monitor and pulse oximeter.
- Dell laptop and Sony video analysis monitor.
- Measuring tape, medical scale, and cones.
- Automatic ball-throwing machines with adjustable speed and timing.

Tests Used and Their Scientific Description

The tests were selected based on a review of the literature and were presented to a committee of experts (n = 15) in the fields of training assessment and table tennis those tests that achieved an agreement rate of large than 80% were adopted. The scientific basis of the tests was verified as follows:

First: Physical and Motor Tests

1. Motor Response Time Test (Nelson): Measures the ability to respond quickly to a visual stimulus. The subject stands in the center of a 20×2-meter area. The examiner gives a visual signal (moving their arm to the right or left), and the player sprints at maximum speed toward the opposite sideline and stops the clock. The fastest time from three attempts in each direction is recorded. The reliability coefficient is $r = 0.825$, and the objectivity coefficient is $r = 0.914$.
2. Hitting Arm Speed Test : Measures the speed and accuracy of the offensive response . The ball-serving machine is set to a speed of 6 m/s and serves 10 balls at one-second intervals. Performance is scored based on accuracy of landing on the opponent's table (2 points for a correct ball, 1 point for a mis-hit, 0 for a miss). The maximum score is 20 points. Reliability coefficient ($r = 0.881$).
3. Arm–Eye Coordination: A measure of sensorimotor integration through throwing and catching a tennis ball against a wall 5 meters away (right-to-right, left-to-left, opposite hand) Maximum score: 15. Correlation coefficient ($r = 0.863$).
4. Test of Agility: a test to measure the ability to change direction rapidly. Rectangular course (4×3×4.80 m); time expressed in seconds Reliability coefficient ($r = 0.895$).
5. Dynamic Flexibility Test (Lower & Lateral Touch) Allows to measure the range of motion of the spine and lower joints through flexion-extention-rotation movements of



the trunk, trying to touch specific markers using a special scale in less than 30 seconds. Correlation coefficient ($r = 0.887$).

Second: Skill Tests

1. Forehand Accuracy Test: The opponent's half of the table is divided into 5 zones using tape. The player hits 15 forehands on balls served at an average speed. Points are awarded based on landing accuracy (5 points for the center zone decreasing to 1 point for the outer zones) Correlation coefficient ($r = 0.886$).
2. Backhand accuracy test: The protocol is repeated with the backhand (10 attempts) Only successful attempts are counted Correlation coefficient ($r = 0.891$).

Scientific foundations of the tests

- Validity: Content validity was assessed by presenting the tests to subject matter experts tests that achieved an agreement rate of $\geq 80\%$ were adopted.
- Reliability: A test-retest method was applied after 3 days and Pearson's correlation coefficient was calculated, with values ranging from 0.825 to 0.895 all of which were statistically significant at the ≤ 0.05 level indicating high reliability.
- Objectivity: The inter rater reliability coefficient was used during the re-application with values ranging from 0.906 to 0.946 reflecting the clarity of the instructions and the objectivity of the recording.

Pilot Study

Before the main study, a couple of pilot studies were conducted in which:

1. 10 & 13 November, 2025: Pilot of sample ($n=4$) to assess tests efficiency in relation to the equipment; support-team capability and determine time needed.
2. November 15th, 2025: to make evaluation difficulties with the exercises, how much and when they'll occur and wherein the education devices fit. The results of the current investigation required a slight adjustment, in that the rest periods between repetitions were modified to avoid the accumulation of lactic fatigue.

Main Study Procedures

- Baseline Tests: Performed on November 25, 2025 after the completion of a pretest standardized warm-up (10 minutes), and once environmental conditions and the experimental procedure were stable.
- Intervention: Trained for 3 times a week (24 total sessions between November 26, 2025 and January 26, 2026) on Friday Monday Wednesday. The core focus of the session was from 15 to 20 minutes post warm-up and consisted of motor control and flexibility exercises: cross-coordination exercises; cognitive: timing exercises



using visual cueing rapid reorientation cerebral cortex stimulation progressive kinetic chain movements. Control did the traditional training routine (general physical conditioning, skill repetition, aerobic fitness) but without systematic motor control elements.

- Post-tests: After the training, on January 27, 2026; same conditions as pre-test to ensure measurement. See Appendix (1)

Statistical Methods

The SPSS statistical package, version 27, was used, and the following tests were applied:

- Percentage, mean, standard deviation, median and skewness coefficient
- For reliability and validity Pearson's correlation coefficient
- t-test for the independent samples (for equivalence and comparison of pre- and post-tests).
- Paired samples t-test (within groups, pre- and post-test differences)
- Measure of the strength of association in terms of effect size (Cohen's d).

Results

Table 2. Analysis of Pre-Test Equivalence Between the Two Groups

Variable	Experimental Group (M ± SD)	Control Group (M ± SD)	Calculated t-value	Sig.	Significance
Motor Response Speed	4.12 ± 0.182	4.17 ± 0.265	0.381	0.212	Non-significant
Striking Arm Speed	15.92 ± 0.753	15.74 ± 0.911	0.373	0.245	Non-significant
Visual-Motor Coordination	6.38 ± 1.214	6.25 ± 1.087	0.195	0.368	Non-significant
Forehand Stroke Accuracy	45.82 ± 3.577	45.68 ± 4.375	0.060	0.295	Non-significant
Backhand Stroke Accuracy	5.11 ± 0.927	5.17 ± 0.811	0.119	0.277	Non-significant

Table 3. Pre-Post Differences for the Experimental Group

Variable	Pre-test (M ± SD)	Post-test (M ± SD)	Mean Difference	t-value	Sig.	Cohen's d
Motor Response Speed	4.12 ± 0.182	3.65 ± 0.086	0.47	8.545	0.000	3.12
Striking Arm Speed	15.92 ± 0.753	8.42 ± 0.914	7.50	10.121	0.000	8.91
Visual-Motor Coordination	6.38 ± 1.214	11.62 ± 0.843	5.24	9.065	0.000	5.02

Table 4. Pre-Post Differences for the Control Group



Variable	Pre-test (M ± SD)	Post-test (M ± SD)	Mean Difference	t- value	Sig.	Cohen's d
Motor Response Speed	4.17 ± 0.265	3.98 ± 0.052	0.19	3.166	0.005	0.92
Striking Arm Speed	15.74 ± 0.911	12.26 ± 1.747	3.48	5.989	0.002	2.15
Visual-Motor Coordination	6.25 ± 1.087	8.13 ± 1.153	1.88	5.053	0.002	1.68
Forehand Stroke Accuracy	45.68 ± 4.375	50.95 ± 3.417	5.27	4.870	0.003	1.42
Backhand Stroke Accuracy	5.17 ± 0.811	6.23 ± 0.581	1.06	3.408	0.005	1.49

Table 5. *Post-Test Comparison Between the Two Groups*

Variable	Experimental Group (M ± SD)	Control Group (M ± SD)	t-value	Sig.	Significance
Motor Response Speed	3.65 ± 0.086	3.98 ± 0.052	8.250	0.000	Significant
Striking Arm Speed	8.42 ± 0.914	12.26 ± 1.747	4.776	0.003	Significant
Visual-Motor Coordination	11.62 ± 0.843	8.13 ± 1.153	5.986	0.001	Significant
Forehand Stroke Accuracy	61.39 ± 2.571	50.95 ± 3.417	5.982	0.001	Significant
Backhand Stroke Accuracy	7.85 ± 0.624	6.23 ± 0.581	4.668	0.003	Significant

Discussion

Results of the tests its can observe that the control group demonstrated statistically significant improvement throughout all variables, which is a reasonable expectation due to the multiplying effects of repeated training, direct supervision and natural physiological adaptation spanning at least two months. This correlates with the principle of skill repetition, which sets up fundamental motor patterns devoid of complexity at a neural level to produce refined coordination and sensorimotor processing speed. Some of the latest findings suggest that there is no optimal transfer from traditional training in high-speed sports as it underlines quantity over motor quality (Al-Obaidi & Al-Saadi, 2023; Hasan & Khalaf, 2022).

Jumps in the Experimental Group: The Mechanisms Neuro-Motor Control

The experimental group performed much better; in fact, the difference is statistically significant and substantial, an indication of the systematic nature of the intervention. This is due to a neurological and biomechanical pathway involving multiple mechanisms:

1. Motor cortical reorganization Guided ,active motor control engage in areas of the primary motor cortex and cerebellum, which induce new neural pathways to be formed, facilitate speed of signal transmission between the central nervous system and target musculature (Al-Fatlawi & kareem,2024).
2. Enhanced sensorimotor feedback: That is high-precision timing and fast reorientation exercises help improve the ability of visual perception and motor response, reduce reaction time, and accurately correct the movement during performance (Chen & Wang, 2021).



3. Motor chain linkage optimization: The exercises focus on trunk, arms and hands, and feet synergy (Zhang et al., 2022), by developing through functional exchange of kinetic energy and reducing the loss of energy caused by dissociative movements between strokes.
4. Neuromuscular flexibility: Improved with assignment to progressive training for higher velocity and coordination of muscle action which is more efficient (Müller & Abernethy, 2020).

All these results support the last trends in sports training science emphasizing that a systematic introduction of motor control into youth training programs either shortens practice time demands or decreases motor variability, both of which increase athlete preparedness for fast-paced competitions (Al-Obaidi & Al-Saadi, 2023; Hassan & Khalaf, 2022).

Scientific Comparison and Training Applications

The comparison shows a rather tangible performance benefit for the experimental group, attesting to the pedagogical benefits of the protocol. In practical terms, one should incorporate motor control exercises in the first stages of the training session (Right after the warming up phase), where difficulty is still low and deterioration of learning acquisition functions due to fatigue or some other external causes are non-existent yet. Additionally, multidirectional visual and auditory stimuli should also be utilized to mimic what would happen in the actual game, therefore maximizing the positive transfer from training to performance. (Abdulameer & Ismail, 2024)

Limitations and Future Directions

Despite the robustness of the results, limitations of the study included a small sample size ($n=14$), a short intervention length (8 weeks) and that long-term effects on health behaviors after completion of the program were not measured. In addition, due to the lack of some three-dimensional biomechanical analysis, it is difficult to accurately interpret movements using field tests. Thus, future researches comparing motor control protocols (ecological, dynamic, cognitive) to identify the most suitable one for each age group and skill level suggested with advanced motion analysis improvement; larger sample studies and tracking of players performance by a competitive season long retention.

Conclusions

1. The targeted motor control program produced significant changes in specifically selected physical, physiological and skill-related variables in table tennis players aged under 13 years.



2. Scores for motor reaction time, swing speed, eye-hand coordination and accuracy of forehand and backhand strokes in the experimental group were significantly higher and with large effect sizes compared to the control group.
3. Motor Control Training (MCT) is a fundamental methodological pillar of the preparation for young athletes since it promotes neuromuscular adaptation, increases the accuracy of sports skills and therefore increases their readiness to compete in high-velocity racket-based sports.

Recommendations

1. Regularly implement as part of training programs for developing table tennis players by dedicating 15–20 min of each training session to guided functional movement exercises.
2. Utilize movement protocols that are sequential and cognitively challenging to enhance neuromuscular response rate, reaction time, stroke refinement in critical periods of athletic maturation.
3. Coach others on how to use basic principles of neuromuscular control and perform exercises in such a way that they mimic the competitive environment, utilizing multidirectional and time-variable stimuli.
4. Longitudinal approaches to investigate transfer of motor intervention effects to real-life competition performance and potential prevention of musculoskeletal injuries in younger age-groups.

Appendix

Motor Control Exercises for Table Tennis Players				
No.	Exercise	Objective	Performance Method	Equipment
1	Balance with Hitting	Improve balance and neuromuscular control	Stand on one foot while hitting the ball with the racket alternating feet every 10 hits	Racket, ball, table tennis table
2	Wall Ball Passing	Develop hand eye coordination	Hit the ball toward the wall and control its rebound	Racket , wall ball
3	Motor Timing Exercise	Improve timing and accuracy	Hit the ball after only one bounce	Racket, table tennis ball , table tennis table
4	Side Movement	Develop agility and motor control	Move right and left while hitting the ball	Racket, table tennis ball , table tennis table
5	Hitting Toward Targets	Increase motor accuracy	Direct strokes toward specific targets on the table	Racket , table tennis ball, cones
6	Grip Change	Improve neural control	Change the racket grip during slow rallies	Table tennis racket , table tennis ball
7	Toss and Hit	Develop motor coordination	Toss the ball with the free hand, then hit it	Table tennis racket , table tennis ball



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8	Backhand Only	Develop backhand stroke control	Use only the backhand side during play	Table tennis racket , table tennis ball , table tennis table
9	Rotation Before Hitting	Link body movement with the stroke	Perform a half-turn rotation before hitting the ball	Table tennis racket , table tennis ball
10	Force Control	Improve force perception	Hit the ball using different force levels	Table tennis racket , table tennis ball
11	Forward and Backward Movement	Control longitudinal movement	Move forward and backward while hitting the ball	Table tennis racket , table tennis ball , table tennis table
12	Quick Response	Improve reaction speed	Respond to the coach's signals during play	Table tennis racket , table tennis ball
13	Movement Around the Table	Improve control during movement	Move around the table while continuously hitting the ball	Table tennis racket , table tennis ball
14	Ball Height Control	Improve trajectory accuracy	Perform strokes with different ball heights	Table tennis racket , table tennis ball
15	Timed Speed Exercise	Increase speed and coordination	Hit the greatest possible number of balls within a set time	Table tennis racket , table tennis ball , stopwatch
16	Irregular Rebound	Develop motor adaptation	Hit the ball after rebounding from an inclined surface	Table tennis racket , table tennis ball , inclined board
17	Sudden Direction Change	Improve neural control	Change the direction of the stroke suddenly	Table tennis racket , table tennis ball
18	Spin Control	Control ball spin	Perform strokes with topspin and backspin	Table tennis racket , table tennis ball
19	Non-Dominant Hand	Stimulate the nervous system	Hit the ball using the non dominant hand	Table tennis racket , table tennis ball
20	Combined Exercise	Achieve advanced motor coordination	Perform a light jump followed by a direct stroke	Table tennis racket , table tennis ball



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