

Impact of wall drill training on drive stroke performance in table tennis

JEKI HARYANTO¹, CLEMENS DRENOWATZ², ANDREAS NIKOLAKAKIS³, TAMARA LUKÁČOVÁ⁴,
PADLI⁵, DIDI SURYADI⁶, DESI PURNAMA SARI⁷, RUDYANTO⁸

^{1,5,7,8}Coaching Department, Faculty of Sport Science, Universitas Negeri Padang, INDONESIA

²Division of Sport, Physical Activity and Health, University of Education Upper Austria, AUSTRIA

³Department of Physical Education and Sports Science, Democritus University of Thrace, GREECE

⁴Department of Music, Art and Physical Education, Faculty of Education, University of Presov, SLOVAKIA

⁶Postgraduate of Sports Science, Universitas Negeri Yogyakarta, Yogyakarta, INDONESIA

Published online: June 30, 2025

Accepted for publication: June 15, 2025

DOI:10.7752/jpes.2025.06126

Abstract:

Problem statement: Table tennis is a fast-paced sport that depends on accurate selection and execution of key strokes. Drive shots are commonly used by players in competition. While many studies have analyzed stroke performance in table tennis, research on specific interventions to improve the drive shot remains limited. **Objective:** This study investigate the effect of wall drill training on accuracy, speed, and consistency of the forehand drive stroke in young adults. **Method:** The study included 30 participants (age: 19.27±0.58 years) enrolled in university table tennis courses. The intervention lasted 8 weeks, with two 50-min training sessions per week. Both, control and intervention group engaged in a similar amount of training but the intervention group performed wall drills specifically focusing on drive strokes while the control group engaged in regular table tennis play with a partner. Forehand drive stroke accuracy was evaluated via a validated and reliable test at the beginning and the end of the intervention period. **Results:** Even though there was an improvement in drive stroke performance across the entire study population the intervention group displayed a significantly more pronounced increase in forehand drive stroke accuracy than the control group ($p<0.01$). **Conclusions:** The results of the present study clearly indicate that wall drills are significantly superior to traditional table tennis practice methods for the effective development of the forehand drive stroke. Coaches, athletes, and teachers, therefore, can confidently adopt this innovative training method to further enhance the drive skills of their students and athletes.

Keywords: Stroke enhancement, training method, table tennis shot, stroke technique, table tennis performance

Introduction

Table tennis, as one of the most popular racket sports globally, has experienced rapid development in both technique and game tactics (Wei, 2022). As the popularity of sports continues to rise globally, table tennis has garnered increasing attention, particularly in recent years. Asia remains the epicenter of table tennis development, consistently leading the world in both competitive success and technical advancement. This regional dominance underscores Asia's pivotal role in shaping the standards and progress of the sport on a global scale (Z. Li & Li, 2016). Table tennis requires a high level of technical proficiency, especially in mastering a wide range of strikes and maneuvers. Athletes must develop precise control over different techniques, such as executing various strokes with accuracy and power, and performing complex movements that are essential for success in competition.

Mastery of these skills is crucial for achieving peak performance and outmaneuvering opponents in the sport (Oagaz et al., 2022; Qian et al., 2016), including the crucial drive stroke (Van Soest et al., 2010; Akbari et al., 2023). In every match, a player's ability to master basic techniques, particularly strokes, plays a crucial role in determining victory. Among the various techniques, the drive stroke stands out as a fundamental element that enables players to maintain the rhythm of attack while controlling the ball with precision (Haryanto & Becerra-Patiño, 2023). The ability to execute an effective drive stroke not only increases the likelihood of scoring points but also strengthens the player's dominance on the court. Therefore, the development of the drive stroke technique has become a critical focus in table tennis training. Athletes frequently dedicate significant time to practicing this stroke, aiming to refine and perfect their technique (Li et al., 2020), resulting in more fluid and precise movements over time (Chen et al., 2022).

Research-findings have indicated a notable shift in shot preferences among elite women table tennis players, with an increased reliance on backhand strokes, as evidenced by the rise in backhand stroke positions from 55.0% to 58.1% (Wang et al., 2022). Concurrently, the use of flip strokes has significantly declined,

suggesting a strategic adaptation in response to evolving game dynamics. Furthermore, the fluctuations in ball placements for forehand and middle-to-long positions, coupled with the growing preference for backhand, highlight the need for targeted training strategies to optimize stroke efficacy in these critical areas. Additionally, research has analyzed the kinematic parameters of table tennis racquets during forehand and backhand topspin shots, revealing distinct differences in racquet trajectory, speed, and timing. These studies emphasize the varying technical demands of each stroke, providing valuable insights into the mechanics of topspin execution (Bańkosz & Winiarski, 2017). There has also been an increasing focus of research on enhancing ball motion control in table tennis through the application of deep reinforcement learning techniques.

These studies aim to refine stroke accuracy by targeting precise landing locations and optimizing the height of the ball over the net. By leveraging advanced algorithms, researchers are exploring how deep reinforcement learning can significantly improve performance and precision in table tennis (Yang et al., 2021). Enhancing lower limb muscle reaction is crucial for optimizing energy transfer efficiency in athletic performance. Special emphasis on ankle function within the kinetic chain can lead to significant improvements in overall performance, as the ankle plays a pivotal role in translating ground reaction forces into effective movement and power (He et al., 2021). The stroke technique depends on efficient eye-hand coordination, with the ability to deliver precise and powerful shots often determining match outcomes. This highlights the importance of strong eye-hand coordination for executing accurate and quick strokes (Firdaus & Mario, 2022; Yendrizal et al., 2023). Specifically, the eye serves as a visual detection tool, gathering information about the ball's position and movement, while the hand uses this data to execute precise shots (Piras et al., 2016; Padli et al., 2023).

Biomechanical variations have been identified in the topspin forehand stroke technique, particularly when the incoming ball exhibits different rotational characteristics. These variations significantly influence both body and racket kinematics, altering the execution of the stroke. The observed kinematic adjustments underscore the critical role of rotation in modulating the technical aspects of the topspin forehand stroke (Mao et al., 2023). Kinematic disparities in the lower limbs have been identified between diagonal shots (DS) and straight shots (SS) in the table tennis forehand stroke, with notable differences observed in racket movement between expert and novice players (Zhang et al., 2017).

These findings highlight the distinct biomechanical adaptations required for different shot trajectories and underscore the varying levels of technical proficiency between skill levels. Sensors combined with advanced classification methods have been employed to accurately recognize various table tennis strokes, which also facilitates the achievement of high levels of precision. These approaches demonstrate the effectiveness of integrating technology in analyzing and distinguishing between different stroke techniques (Ezzeldin et al., 2023).

Recent investigations have uncovered that C1 players (players with the most severe category of disability who usually play with the aid of a wheelchair) predominantly relied on backhand and forehand drives, as well as backhand lobs, whereas C5 (players with a severe category of disability who also play in a wheelchair but have better muscle function and control compared to players in classes C4 to C1.) players favored backhand and forehand pushes along with backhand topspin shots.

This variation in stroke preference reflects the differing tactical approaches and skillsets across player classifications (Guarnieri et al., 2023). Studies have consistently highlighted that success in competitive matches relies on a player's technical and tactical proficiency (Sun, 2015). Technical skills, including precise execution of strokes and effective use of equipment, are fundamental for consistent performance. Meanwhile, tactical skills, such as strategic shot placement and anticipation of opponents' moves, play a critical role in adapting to different match situations and gaining a competitive edge. The integration of both technical and tactical elements is essential for maximizing performance and achieving favorable outcomes in high-level competition (Yu, 2023).

To enhance stroke technique proficiency in table tennis, robots are increasingly utilized as training aids. The incorporation of robotic trainers not only improves technical skill development but also engages students, who often express enthusiasm and satisfaction when interacting with these advanced training tools. This innovative approach provides a stimulating and effective way to practice and refine stroke techniques. (Tahki et al., 2022). Additionally, training models have been continuously advanced through technological innovations to support athletes' development. This progress aligns with global trends, as various countries compete to enhance their training methodologies and processes, striving to gain a competitive edge and optimize athletic performance (Siregar et al., 2019). This technological advancement also benefits Paralympic athletes, as their stroke movements are analyzed to offer valuable feedback. Such analysis helps identify areas for improvement, enabling tailored adjustments and enhancements in training that support their performance and progress (Yam et al., 2021).

Previous studies have extensively focused on enhancing table tennis players' skills, often utilizing robots to engage participants and make training more enjoyable. Research involving detailed kinematic and kinetic analyses of stroke movements has also been prevalent when improving stroke techniques (Lanzoni et al., 2021a). However, studies specifically addressing methods for improving drive skills remain scarce. Drive stroke is an

essential fundamental technique in table tennis, many players still struggle to master it consistently. This challenge often stems from the limitations of available training methods, which may not effectively support the development of the speed, accuracy, and power required to execute an optimal drive stroke. Conventional training methods, which frequently emphasize repetitive motion without sufficient variation, fail to provide the necessary stimulation to facilitate significant improvements in player performance.

As a result, many players are unable to maximize their potential on the court, which in turn affects their competitive performance. In this context, this study identifies a critical issue regarding how to enhance the quality of the drive stroke through more effective training methods, with a particular focus on the potential of wall drill training as an innovative solution to address these limitations.

The aim of this study was to evaluate the impact of wall drill training on drive stroke performance in table tennis players. Ultimately, the research aspires to provide empirical contributions to the development of table tennis training techniques, with the hope that the findings can be adopted by coaches and players to enhance the quality of training and on-court performance. The novelty of this research lies in its focus on wall drill training to improve drive stroke performance.

While robotic assistance training methods have been widely studied, wall drills offer a unique approach by providing structured, repetitive practice that targets specific aspects of technique refinement. Furthermore, this method allows to train a large number of participants at the same time in a traditional way. This study, therefore, fills a critical gap in the literature by providing empirical evidence on how wall drills can enhance the accuracy, speed, and consistency of drive strokes. By systematically evaluating this method, the research not only contributes new insights into the effectiveness of wall drills but also offers a practical and innovative solution for improving training outcomes.

Material & methods

Study design

The participants were male students from the Faculty of Sports Science at Universitas Negeri Padang, Indonesia, who were enrolled in the table tennis course. The study was initiated with the necessary permissions from the participants and the lecturer teaching the table tennis course.

Detailed information regarding the research plan, specifically the treatment to be administered to the experimental group, was provided to all participants and they all agreed to participate, acknowledging and accepting any potential benefits and drawbacks of undergoing additional training. Initially, the class consisted of 31 students; however, due to one student being ill and unable to participate, only 30 students consented to be involved in the research. All participants held the racket with their right hand and were in good health during the treatment.

Participants were assigned to a control or experimental group. The control group did not receive any special treatment and continued with the regular curriculum, which included the practice of drive strokes with their peers. The experimental group was subjected to a specific drill regimen involving hitting a ball against a wall with a target circle of 30 cm in diameter.

Following the pre-test and ranking of participants based on their forehand drive scores, participants were systematically allocated into two groups to ensure comparability. Participants were ranked from highest to lowest score, with ranks determining their group assignment. Specifically, those ranked 1, 3, 5, and so on up to 29 were assigned to the experimental group, resulting in 15 participants. Conversely, those ranked 2, 4, 6, up to 30 were placed in the control group, also comprising 15 participants. This method aimed to distribute participants with a range of skill levels across both groups, thereby minimizing pre-existing differences and minimizing the risk that observed effects on performance could be attributed to prior skill level rather than the intervention.

Intervention

The experimental group's training lasted for 8 weeks, with two times per week, each session lasting 50 minutes. Each training session commenced with a 10-minute warm-up period, followed by 40 minutes of core training (hitting the ball against the wall target), and concluded with a 10-minute cool-down period. The study consisted of 16 sessions in total, with the first session dedicated to the pre-test and the last session to the post-test. The control group engaged in their regular practice routine 2 times a week with each session lasting 50 minutes during this period without any additional specific drills. Warm-up (10 minutes):

The warm-up included dynamic stretching and light cardiovascular exercises to prepare the participants' muscles and cardiovascular system for the main training session. Main Training (40 minutes): Participants in the experimental group performed targeted drills, aiming to hit a 30 cm diameter circle on the wall. This was intended to improve their accuracy and consistency in drive strokes. Cool-down (10 minutes):

The cool-down involved static stretching and relaxation exercises to aid in muscle recovery and prevent injury. Both the intervention and control groups performed the same warm-up and cool-down exercises. Details of the exercises used in the intervention and control group are shown in table 1.

Table 1. Training program used by experimental group in this study

Training phase	Intervention Group	Control Group	Duration
Warm-up	Jogging Dynamic stretching such as: Arm Circles, Leg Swings, Torso Twists, Walking Lunges, and Hip Circles		10 minutes
Main exercise	Hitting the ball against the wall using the forehand drive technique. Hitting the ball against the wall using the backhand drive technique. Alternately hitting the ball against the wall using the forehand and backhand drive techniques. Alternately hitting the ball against the wall using the forehand and backhand drive techniques with a partner (5 people in 1 experimental group). All three groups performed the same activities.	Practicing drive stroke drills with their peers.	40 minutes
Cool-down	Light Jogging Walking Upper body, and lower body Stretching		10 minutes

Instrument

Precision of forehand drive stroke

Accuracy data for the forehand drive strokes were collected using the Forehand Drive Stroke Accuracy Test developed by Tomoliyus (2017), which has been shown to be valid and reliable. Participants were required to perform 50 forehand strokes towards a predetermined target, with scores ranging from 0, 1, 3, or 5. A score of 5 indicated the highest accuracy, while a score of 0 was assigned for shots that missed the target, hit the net, or fell off the table. The test was administered with the assistance of a ball observer and a scorekeeper, and the final score for each participant was the sum of all shot results. The target area for the drive stroke can be seen in Figure 1 with all measurements of the area being displayed in centimeters. A ball launcher machine (Huipang HP07) was used as a feeder in this test to ensure the consistency of the ball speed and height to all participants. The ball speed was set to a moderate level, and the repetition rate of the ball from the machine was also adjusted accordingly. This study used Donic star balls with 3-star quality and all participants used their personal rackets during training as well as during the pretest and posttest.

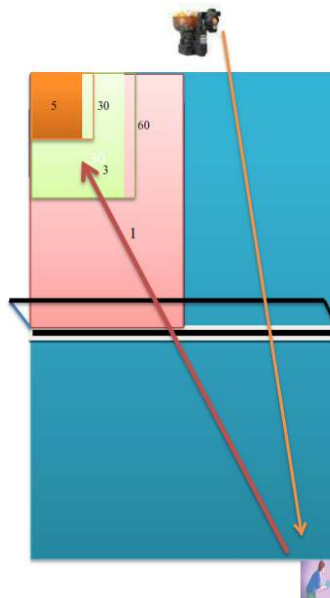


Figure 1. The target area of forehand drive stroke accuracy test and the score. Source: (Tomoliyus, 2017)

Statistical analysis

Means with standard deviation are used for descriptive statistics. Normality and homogeneity of the data was confirmed via Shapiro Wilk and Levene's tests ($p > 0.05$), respectively. Subsequently, a mixed between-within 2 x 2 ANOVA was used to evaluate differences in the development of the backhand drive. Data analysis was carried out using SPSS 29.0.

Results

The total sample was equally divided into control and intervention group, resulting in 15 participants in each group. There were no significant differences in age, anthropometric characteristics and training experience between participants in the control and intervention group (Table 2). Except for one participant who was overweight (BMI = 25.7 kg/m²) all participants had a BMI within the normal weight range (18.9 kg/m² < BMI < 25 kg/m²).

Table 2. Characteristic of Participants. Values are Mean $\pm$ standard deviation.

	Intervention Group	Control Group
Age (years)	19.2 $\pm$ 0.6	19.3 $\pm$ 0.6
Height (cm)	163.5 $\pm$ 6.3	162.5 $\pm$ 4.7
Body Weight (kg)	62.1 $\pm$ 5.5	59.9 $\pm$ 6.6
BMI (kg/m ²)	23.2 $\pm$ 1.2	22.6 $\pm$ 1.8
Years of Training (years)	2.5 $\pm$ 0.8	1.9 $\pm$ 1.0

Due to the group assignment, there were no differences in baseline drive accuracy. Across the entire study population, drive accuracy increased significantly (Wilks Lambda = 0.900, $p < 0.01$) but the improvement was significantly higher in the intervention group as indicated by a significant time by intervention effect (Wilks Lambda = 0.245, $p < 0.01$) (Figure 2).

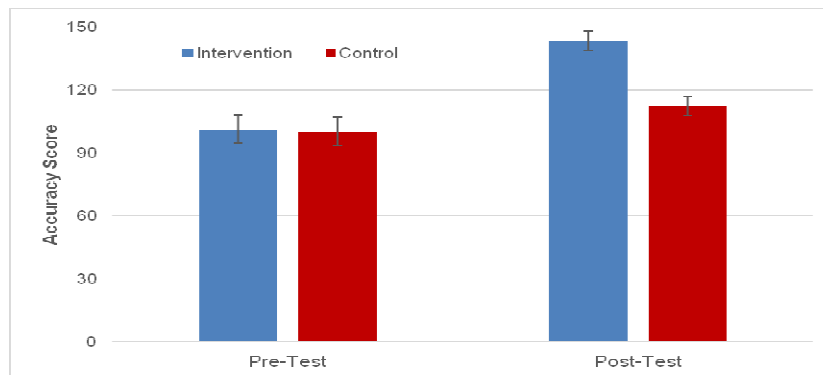


Figure 2. Drive stroke accuracy score. Value are means with 95% confident intervals.

Discussion

The research findings indicate a more pronounced improvement in drive stroke performance following the implementation of wall drill training among the participants. This enhancement aligns with previous studies that demonstrate that consistent coach feedback during training can lead to significant modifications in the follow-through motion of the backhand stroke in table tennis (North et al., 2019). Such findings underscore the importance of targeted training interventions and continuous feedback in optimizing technique and overall performance in the sport. The critical importance of racquet speed at the moment of impact further validates the need for targeted training methods. Incorporating wall drill exercises, which focus on repetitive drive strokes, can help players develop the precise control and speed needed to execute effective drive shots, ultimately enhancing their overall technical proficiency (Bańkosz & Winiarski, 2017). Moreover, another study explored the effects of eye-closed and weighted training (EWMT) on the stroke performance of adolescent table tennis players. Forty-eight players were divided into two groups: an experimental group that underwent 10 weeks of EWMT and a control group that received standard training. Similarly to the findings of the present study it was shown that training methods improved performance but EWMT was associated with greater improvements in accuracy and stability, particularly in backspin strokes, even though there was no notable difference in ball speed between the groups (Cao et al., 2020).

A recent study also revealed that even slight variations in racket orientation angle at ball-impact significantly influence shot accuracy. Consistency in racket angle is crucial for precise and reliable shots, making it essential for training programs to focus on maintaining stable racket orientation during play. This emphasis on racket control can lead to improved shot precision and overall performance (Lanzoni et al., 2021b). Additionally, the use of sensor-assisted tools can enhance an athlete's ability to hit the shuttlecock, as evidenced by studies in badminton showing a strong correlation between sensor data and shot accuracy (Malik & Jain, 2023). This suggests that similar technology could be employed in table tennis to improve the precision of drive strokes by providing detailed feedback and insights into stroke mechanics. Moreover, an experimental study explained that increasing body strength can accelerate ball spin speed, enhance the body quality and stability of players, and improve stroke accuracy in table tennis. The study further demonstrated that basic skills training in table tennis plays a positive role in the physical development of players and the precision of their strokes (Y. Chen et al., 2024).

Findings from the notational analysis of Paralympic table tennis matches highlight the importance of tailoring training programs to the specific needs of players, particularly in the distribution of shots and stroke types across different classes of physical impairment. The frequent use of backhand and forehand drives in Class 1 players underscores the relevance of incorporating wall drill exercises in training, as these drills can enhance drive stroke performance by simulating the stroke patterns observed in competitive settings (Guarnieri et al., 2023). In addition, the interplay between cognitive processing speed and emotional intelligence plays a critical role in determining stroke accuracy, underscoring the necessity for coaches and practitioners to integrate these psychological components into their training regimens. By focusing on enhancing both cognitive processing speed and emotional intelligence, training programs can be tailored to optimize table tennis performance. Moreover, a study indicates that employing the collaborative learning model, whether with or without the use of auxiliary tools, had a positive impact on enhancing the accuracy of the forehand stroke. Therefore, the use of tools to enhance the ability in various types of strokes in table tennis should be encouraged (Shukur et al., 2022).

The study encounters several limitations that could affect the generalizability and accuracy of its results. First, the small sample size of 30 participants, with only 15 in each group, might not fully represent the larger population, which could compromise statistical power and increase the risk of Type I or Type II errors. Additionally, the narrow age range of participants in this small sample may not reflect the diverse characteristics found in a broader population, potentially impacting the relevance of the findings. In addition, these findings could be influenced by performance level and may differ in elite table tennis players. Moreover, focusing solely on practicing the drive technique against a wall may overlook other essential elements of table tennis, such as opponent interaction, technique variation, or strategic play, thereby restricting the overall evaluation of the intervention's effectiveness.

The significant improvement observed from wall drive training has several practical implications for table tennis practice and training programs. Integrating wall drive drills into regular training regimens can effectively enhance players' consistency and accuracy in executing drive techniques. This finding emphasizes the value of targeted technical drills, suggesting that coaches should design specific exercises to address particular skills and needs of players. Additionally, wall drive training can serve as a valuable independent practice tool, allowing players to refine their technique autonomously outside of regular training sessions. Coaches should also focus on optimizing the methodology and intensity of these drills to maximize their benefits. Furthermore, the observed improvements underscore the importance of ongoing assessment and adjustment of training techniques to align with players' developmental goals. This study also paves the way for further research into how wall drive training interacts with other technical aspects and its broader impact on overall performance in table tennis.

Conclusions

This study demonstrates that wall drill training results in a more pronounced improvement of the accuracy, speed, and consistency of drive strokes in table tennis players compared to traditional practice methods. A structured 8-week intervention, involving bi-weekly sessions was already sufficient to achieve a notable improvement in drive stroke performance in the intervention group. Statistical analyses confirmed that the enhancements in accuracy were substantial and statistically significant ($p < 0.01$). These findings underscore the effectiveness of incorporating wall drill training into regular practice routines. Coaches, athletes, and educators should consider integrating this training method to advance drive stroke skills and overall performance in table tennis. For future research, it would be beneficial to investigate how wall drive training interacts with other technical aspects of table tennis and its impact on overall game performance. Further, studies could explore the long-term effects of wall drive training on different player skill levels and the potential benefits of combining this technique with other training modalities. Additionally, research could focus on optimizing the parameters of wall drive training, such as duration and frequency, to maximize its effectiveness and applicability across various player demographics.

Conflicts of interest

The authors have no conflict of interest.

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