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Accuracy and Velocity of Forehand Groundstroke through Simulated Training: A Systematic Review

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ABSTRACT
Various literature outlines the significance of simulated training methods using medicine ball, variable resistance, weighted wrist band, and loaded tennis racquets on improving physical performance parameters in tennis. However there exist a dearth of systematic reviews on the specific effect of this training on tennis forehand performance determinants. The present systematic review attempts to investigate the effect of various simulated training; medicine ball, variable resistance (bands), weighted wrist bands, loaded tennis racquet, and external weights on forehand performance variables. The exploration was carried out on databases such as PubMed, Scopus, JSTOR, ERIC, Web of Science, PsycINFO, and Google Scholar. Out of the 271 publications identified through these searches and following the inclusion criteria and by using the Kmet assessment, 16 studies of fair to good quality were selected for inclusion in the systematic review. Out of 16 studies identified for systematic review, 8 studies significantly contributed to forehand performance variables using medicine ball interventions (effect size = 0.239 - 1.55). Other studies with weighted wrist band, resistance bands, and weighted racquet interventions were found moderate and trivial associations with forehand velocity (ES = 0.35) and accuracy (ES = -0.16). Out of various interventions used medicine ball training was found to be the most effective measure to improve the forehand performance.
Keywords: *Tennis Forehand, Tennis Groundstroke, Simulated Training, Medicine Ball, Variable Resistance, Loaded Racquets.*

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INTRODUCTION

Tennis is one of the most popular sports in the world, owing to the unique combination of aerobic and anaerobic activity that is pleasurable for all ages and skill levels [1]. It is a captivating and challenging sport, and has a rich history with its roots spanning centuries [2]. It combines elements of both team and individual play, offering various formats such as singles, doubles, and mixed doubles [3]. At the competitive level, tennis showcases the dynamic exchange of intricate strokes and serves by some of the world's most versatile athletes, all aimed at preventing opponents from legally returning the ball to secure a point [4]. This exchange of strokes, commonly referred to as groundstrokes, includes forehands, backhands, and dynamic trick like smashes and volleys [5].

Within this game, understanding and analysing performance characteristics are of paramount importance, not only for players but also for coaches and trainers in any sport. Among the countless skills essential for success on the tennis court, the forward hand grip stands out as a pivotal element in a player[6]. This skill, crucial for controlling ball placement, power, and spin, is often considered a defining factor in a player's ability to defeat their opponents. Electromyographic research on proficient tennis players, both professional and collegiate, has revealed that the most significant muscular engagement in the upper limb during tennis groundstrokes occurs in the wrist extensors specifically, the extensor carpi radialis brevis (ECRB), extensor carpi radialis longus (ECRL), and extensor digitorum communis [7]. The researchers suggested that these muscles play a crucial role in stabilizing the racket head during the acceleration and follow-through stages of the groundstroke by sustaining wrist extension and radial deviation [8].

The classification of forehand grips into eastern, semi-western, and western types significantly impacts swing mechanics, affecting ball behaviour post-impact. [9] noted a correlation between wrist injuries in amateur players and their choice of forehand grip, with 13% of 370 adults over 20 months reporting injuries related to these grips. Injuries occurring at the ulnar and radial sides of tennis players are linked to these grip types, consistent with [10] findings associating greater ulnar wrist flexion with increased vertical racket speed in western/semi-western grips. This emphasizes the necessity of considering grip positions when diagnosing and treating wrist injuries. Implementing preventive measures before injury onset is crucial; tailored exercises targeting specific regions can help athletes play without fear of injury.

The strategic utilization of the strokes, be it forehands or backhands, depends on a player's strengths, weaknesses, and the tactical demands of a particular match. Research reveals a preference among top-level players for forehands, underscoring its importance in the game[11]. The forehand drive, in particular, holds a pivotal role, enabling players to harness power, precision, and control in setting up subsequent shots. Understanding the intricate relationship between tennis forehand drive performance and anthropometric and physical variables can offer invaluable insights for players, coaches, and researchers alike[12]. A successive summation of forces is integral to successful performance of the tennis strokes. Transferring a ground reaction force up through the legs, hips, trunk and arm is critical in virtually all tennis strokes [13]. When this movement is inefficient, it can not only cause an error in stroke production, but also create the potential for injury.

In the competitive realm of tennis, the ability to execute forehand strokes accurately, with high velocity and unwavering consistency, often proves decisive in game outcomes. Developing a formidable forehand is a coveted asset, allowing elite players to assert control over the points during a match due to its kinematic advantages and precision (Elliott, 2020). While previous research has acknowledged the significance of physical elements and their impact on young tennis players' performance based on their rankings [14], [15], few studies have explored the interplay between various physical components like speed, change of direction speed, and explosive strength [16], [17], [18].

Furthermore, anthropometric factors, including body height, limb length, and grip strength, can influence a player's capacity to generate power and control in their forehand drive, yet a consensus remains elusive regarding the most predictive components[19], [20]. A nuanced understanding of these factors can enrich the tennis learning process and contribute to talent identification models.

Biomechanical insights, too, play a pivotal role in enhancing the forehand stroke and reducing injury risks. Modern coaches employ strategies like continuous groundstroke practice and reinforcement drills to improve their players' forehand performance [21]. It's essential to recognize that tennis performance is an intricate amalgamation of psychological, physiological, technical, anthropometric, and tactical facets, each of which impacts future success [22].

While various studies have investigated the relationship between anthropometric, physical, and groundstrokes [16], [17], [23] focusing on the common tennis shots, limited research delves into the multifaceted factors influencing the forehand stroke. The scarcity of comprehensive studies addressing the prediction of forehand stroke performance highlights the need for practical solutions for coaches and trainers on which variables should be prioritized in training to enhance forehand stroke performance in tennis.

This research endeavours to explore the effects of various simulated training using medicine balls, resistance bands, loaded weight training, wristband weights with forehand drive tennis in tennis players. The findings of this investigation promise to provide valuable insights for players and coaches seeking to elevate their performance levels and for researchers aiming to uncover the key elements underpinning successful forehand drives in tennis. Thus, the primary objective of this systematic review is to compile data from independent studies and offer a robust estimation of the effects between tennis forehand performance and simulated training techniques.

MATERIAL AND METHODS

Inclusion/Exclusion Criteria

In the initial search of existing literature, the researcher encountered a moderate number of studies concentrating on the impact of simulated training methods such as medicine ball exercises, wristband weights, loaded weight training, and resistance bands on variables related to forehand groundstroke performance in tennis. Consequently, all available research, irrespective of quality, was incorporated. However, to ensure the review's credibility, transparency was emphasized, and evaluations were conducted impartially.

The criteria for selecting papers to be included in the systematic review were as follows: (1) manuscripts published in English; (2) articles presenting original research; (3) studies examining the forehand stroke; (4) studies utilizing various simulated training techniques aimed at enhancing forehand drive performance in tennis. Given the researcher's specific interest in forehand groundstrokes and the limited research available in this domain, only studies focusing on the forehand were considered. Studies falling outside the scope of this review were excluded if they were (1) case studies; (2) inconclusive regarding the impact of simulated training techniques on forehand stroke performance; (3) lacking reported methodology; or (4) involved comparative analyses of tennis variables with other sports.

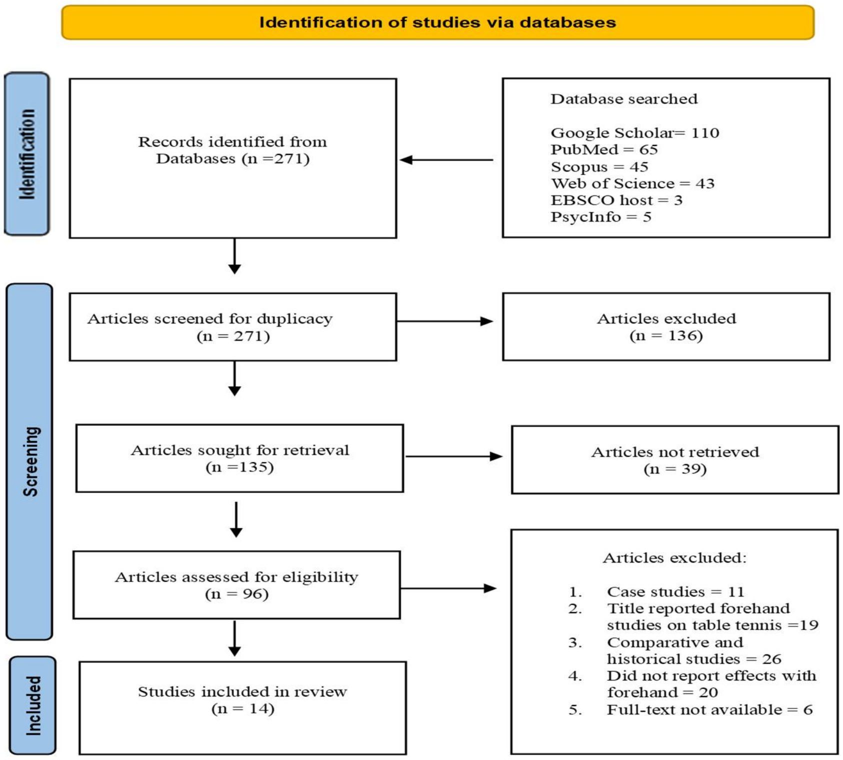

Figure 1 Flowchart of the literature search for systematic review on forehand groundstrokes with rationals of exclusion, According to The PRISM 2020; guidelines for reporting systematic reviews

Search Strategy

The methodology involved a systematic search across various databases such as PubMed, EBSCO Host, PsycINFO, Scopus, Google Scholar, ERIC, JSTOR, and Web of Science to collect abstracts relevant to the topic of the tennis forehand stroke. The search was conducted using specific keywords: "forehand drive," "tennis groundstrokes," "experimental studies in tennis," "tennis forehand drive," “simulated training,” "forehand accuracy," "forehand drive performance," "medicine ball and forehand drive," "resistance band and forehand drive," and "physical standards of forehand drive." Boolean search operators, 'AND' and 'OR,' were employed to refine the search results. Additionally, a manual search strategy was implemented, focusing on topics related to Tennis and forehand drive, simulation training used for forehand drive, loaded training, and accuracy. This comprehensive approach ensured a thorough exploration of available literature without resorting to plagiarism.

Selection Process

The researcher initiated the investigation into their required study on August 13, 2023, spanning multiple databases. All studies concerning the forehand, simulated training and its relevant parameters were compiled into a designated folder. Subsequently, the abstracts of these accumulated studies were integrated into a database, and any studies deemed irrelevant were eliminated from consideration. Two independent experts specializing in Sports biomechanics then conducted a comprehensive assessment of the studies, determining their alignment with the criteria for inclusion in the systematic review. These papers were categorized based on their direct relevance to the inclusion criteria as 'yes,' potential relevance as 'maybe,' or lack of relevance as 'no.' Following this categorization, the pertinent abstracts were further scrutinized for a comprehensive full-text review.

Qualitative Analysis

Each study's methodology and quality was thoroughly assessed and documented. To evaluate the selected studies, criteria established by [24] was utilized, consisting of 14 specific questions. These questions pertained to various aspects such as the study's objectives, design, subject selection methods, random allocation in interventions, outcome measures, analytical techniques, variance reporting, results, and conclusions. Scores were assigned to each study based on these questions: 'no' earned 0 points, 'partial' earned 1 point, and 'yes' earned 2 points. Studies received 2 points for accurately describing the research question and study design (Questions 1-2). Questions 3 and 4, which covered methodology and participant characteristics, generally earned 2 points, though a score of 1 was given when participant information was insufficient. Questions 5 to 7, focusing on participant randomization and double-blinding, scored low across most studies, obtaining 1 or 0 points. However, Question 8, concerning outcome reporting, typically received 2 points since outcomes or assessment methods were adequately reported. Question 9 awarded 2 points when studies showed an appropriate sample size; otherwise, scores of 1 or 0 were given when the exact size was not specified. Questions 10 and 11, related to analytic methods and variance estimates, generally scored 2 points. For Question 12, studies received 2 points if they reported any confounding variables. A score of 1 was given if confounding variables were briefly mentioned, and 0 if no confounding was acknowledged. Finally, Questions 13 and 14, focusing on result and conclusion reporting, awarded 2 points if these sections were succinctly stated. The total possible score for each study was 28 (14 questions x 2 points), with each question having a maximum score of 2. The final score for each article was calculated by summing the 'yes' answers multiplied by 2 and the 'partial' answers multiplied by 1, then dividing this total by the total possible score. Kmet scores falling within certain ranges were categorized as follows: <50% as poor, 50%-60% as fair, 67%-83% as good, and >84% as excellent [24]. This detailed scoring system provided a comprehensive assessment of each study's quality and methodology.

Authors	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Score (%)
Barber-Westin et al., (2010)	2	2	2	2	1	0	0	2	1	2	0	2	2	2	71.4
Genevois et al., (2014)	2	1	0	2	0	0	0	2	1	2	0	0	1	2	46.4
Negro et al., (2023)	2	2	2	2	2	0	0	2	2	2	2	2	2	2	85.7
Delgado-Garcia et al., (2019)	2	2	0	2	1	1	1	2	1	2	2	1	1	2	71.4
Powar & Olson, (2023)	2	1	1	2	2	0	0	2	0	2	0	2	2	2	64.3
Genevois et al., (2013)	2	2	2	2	2	0	2	2	2	2	1	1	2	2	85.7
Colomar et al., (2020)	2	2	2	2	2	0	2	2	2	2	2	1	2	2	89.3
Roetert et al., (1996)	2	1	1	1	0	0	0	2	2	2	1	0	2	2	57.1
Terraza-Rebollo & Baiget, (2021)	2	2	2	2	2	1	2	2	2	2	0	2	2	2	89.3
Erzeybek et al., (2020)	2	2	2	2	0	0	0	2	2	2	1	1	2	2	71.4
نيا et al., (2022)	2	2	1	1	2	0	0	1	1	1	0	0	1	1	46.4
Rossi et al., (2015)	2	2	1	1	1	0	0	2	1	2	1	0	2	2	60.7
Siagian et al., (2021)	2	2	2	1	1	0	0	2	1	2	1	0	2	1	60.7
Terraza-Rebollo et al., (2017)	2	2	2	1	2	0	0	2	1	2	1	1	2	2	71.4

Table 1 Quality assessment of the studies Included

Data Extraction

Studies spanning the period from 1990 to 2023 were meticulously reviewed to identify relevant research for inclusion. After thorough examination of various literature sources, a total of 14 studies met the criteria and were ultimately selected for the systematic review. To streamline data collection, a tailored spreadsheet was constructed using Microsoft Excel. This spreadsheet was designed to systematically document crucial aspects of each study, encompassing (a) study design, (b) participant details including gender, age, training background, performance level, and competitive experience, (c) study objectives, (d) types of simulated training involved such as medicine ball exercises, resistance bands, loaded and weighted training, isokinetic testing, overhead medicine ball throws, agility exercises, repeated sprint ability assessments, and muscle stiffness evaluations, (e) the statistical tests utilized, (f) specific tennis variables assessed (such as accuracy and velocity), (g) methodologies employed, and (h) the outcomes derived from the studies. This comprehensive approach ensured thorough data extraction and organization for the systematic review.

RESULT

Systematic Literature Search

In the process of conducting a Systematic Review, we initially considered 271 studies from various sources, including PubMed, Scopus, JSTOR, ERIC, Web of Science, PsycINFO, and Google Scholar, to assess their suitability for inclusion. Following this initial review, a certain number of studies met the inclusion criteria out of the initial 271. Subsequently, after further detailed evaluation 14 papers were selected for the systematic review. It's worth noting that all of these chosen studies either involved experimental research or demonstrated the impact of training on forehand drive performance.

The systematic review included a set of 14 studies related to stimulated training [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38].

A quality assessment was conducted for every study in which 4 studies were came in excellent criteria [26], [29], [31], [37], 4 in good criteria [25], [27], [28], [36], 4 in fair criteria [32], [33], [34], [35] and 2 in poor criteria [30], [38].

Author	Sample Size	Age (Years) ± SD	Stimulated Training Variables	Outcomes
Barber-Westin et al., (2010)	15, Male and Female	13.0 ± 1.5 years	Medicine Ball and Resistance Belt	Significant enhancements were observed in both initial assessments, as 67% of participants demonstrated an increase in their forehand test scores, with a mean difference of 0.9 ± 1.1 (-0.75 to 1.75) between the pre-test and post-test.
Negro et al., (2023)	35, Male and Female	44 ± 10.9 years	Wristband Weights	The accuracy of the experimental group saw a significant improvement after the program, with an increase of 51.4% and a substantial effect size of 1.3 ($p < .001$). However, there were no notable changes in hitting speed, which only increased by 1.2% with a smaller effect size of 0.12 ($p = .62$).
Delgado-Garcia et al., (2019)	21, Male	33.7 ± 4.6 years	Medicine ball of 2kg.	The use of a medicine ball on the dominant side exhibited a positive correlation with the speed of the fastest forehand, with a correlation coefficient of 0.52 and a p-value of 0.017.
Powar & Olson, (2023)	2, Male	18 ± Year, training age	Medicine Ball	Significant positive correlations were observed between Isokinetic wrist flexor peak torque (7.493 ± 0.763), Isokinetic wrist extensor peak torque (7.307 ± 1.494), and Isokinetic wrist extensor average torque (6.920 ± 1.128) with the forehand stroke, showing very high associations ($r = 0.82$, $p = 0.05$; $r = 0.81$, $p = 0.05$; $r = 0.81$, $p = 0.05$), respectively. On the other hand, a substantial negative correlation was observed between O.MBT (6.875 ± 0.877) and the forehand stroke ($r = -0.86$, $p = 0.05$).
(Genevois et al., 2013)	44, Male	26.9 ± 6 7.5 years	Medicine Ball and Over Weight Racket	An analysis of covariance demonstrated a notable group impact on the post-training velocity ($F = 14.373$; $p < 0.001$; partial h2 = 0.42; indicating a substantial effect). As depicted in Figure 2, further assessments indicated that the speed in the Handled Medicine Ball (HMB) and Overweight Racket (OWR) groups was significantly greater than that in the Regular Tennis Training (RTT) group ($p < 0.001$ and $p = 0.001$, respectively). Moreover, the post-training speed was notably superior in the HMB group when compared to the OWR group ($p = 0.01$)."
Colomar et al., (2020)	17, Male and Female	16.5 ± 1.3 years	Wearing 50, 100, 150, 200 g weights or no weights at all	Serve, forehand, and backhand accuracy showed moderate improvements with effect sizes of 23.04% (ES = -0.49), and minor enhancements with effect sizes of 6.06% and 7.33% (ES = -0.14 and -0.16) when compared to the baseline.
Roetert et al., (1996)	60, Male and Female	14.95 ± 1.30 years	Medicine Ball	The four power assessments from the medicine ball tosses displayed a positive correlation with all 16 measurements obtained from the Cybex equipment for assessing trunk strength, with correlation values falling within the moderate to high range, ranging from 0.48 to 0.83.
Terraza-Rebollo & Baiget, (2021)	10, Male and Female	15.3 ± 1.2 years	Medicine Ball and Resistance Training	No significant differences were observed in ball velocity (MB serve: $F_{3,27} = 1.076$, $p = 0.376$, MB forehand: $F_{3,27} = 1.451$, $p = 0.250$; MB backhand: $F_{3,27} = 1.633$, $p = 0.205$; SC serve: $F_{3,27} = 2.847$, $p = 0.056$; SC forehand: $F_{3,27} = 0.984$, $p = 0.415$; SC backhand: $F_{3,27} = 1.772$, $p = 0.176$) (Table 3), and accuracy (MB serve: $p = 0.633$; MB forehand: $p = 0.843$; MB backhand: $p = 0.530$; SC serve: $p = 0.300$; SC forehand: $p = 0.988$; SC backhand: $p = 0.651$) (Table 4) following each recovery period (Post, Post24, and Post48), as well as when comparing all strokes to the baseline, for both training methods.
Erzeybek et al., (2020)	73, Male and Female	22.05 ± 2.09 years	Resistance Training	The experimental group saw a notable increase in their pinch left, pinch right, hand, and shoulder strength scores from the initial assessment to the follow-up test.
(نیا et al., (2022)	20, Male	11-14	Elastic Bands (Resistance Training)	The findings indicated that both Plyometric Training (PT) and Resistance Training (RT) led to significant improvements in tennis performance, agility, speed, muscle strength, anaerobic power, and explosive power.
Rossi et al., (2015)	12, Male	26.0 ± 3.5 years	Overweight Rackets	The repeated measures ANOVA showed that weight distribution had no significant impact on the impact ball velocities, both before training [$F(2,22) = 0.220$; $p = 0.80$] and after training [$F(2,22) = 1.727$; $p = 0.20$].
(Siagian et al., 2021)	10		Medicine Ball	This study concludes that medicine ball twist toss exercises and forearm pronation exercises have a positive impact on enhancing the performance of the tennis forehand drive.

(Terraza-Rebollo et al., 2017)	20, Male and Female	15.5 ± 0.9 years	Medicine Ball and Elastic Bands	Significant differences in forehand hitting speed (effect size = 0.239; statistical power = 0.430) were solely evident in the L group's progress, with a 6.29 km/h increase observed between the pre-test and post-test (p = 0.035; 95% confidence interval: 0.501 to 12.07 km/h).

Table 2 Representation of systematic review of simulated training using variable resistance for forehand accuracy and velocity

Out of 14 studies 7 had male and female participants [25], [26], [28], [31], [33], [39], [39] and other 7 had only male participants [27], [29], [30], [32], [34], [34], [35], [38].

Eight papers reported an average age spanning from 13 to 28 years old, referenced across various studies [25], [26], [28], [29], [30], [33], [34], [39]. In two of the studies, the age range was explicitly outlined [38], [39]. One study specifically indicated the mean age as the training age [32]. However, in another study, the mean age was not specified Additionally, two studies highlighted an older demographic, with mean ages in the later thirties and forties [27], [31].

In 4 studies mean height was not defined [25], [33], [35], [38] and in other 10 studies mean height ranged from 168 to 179 cm [25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38]. Additionally, in 10 studies, the sample size fell below 30 participants, which is notably below the recommended minimum sample size of 30 for research [40]. Conversely, only 4 studies had a sample size exceeding 30 individuals. The Body Mass Index of the subjects was mentioned in 2 of the 14 studies, while the body weight of the participants was displayed in only 3 studies.

Additionally, in 8 studies mean weight of the subjects was not mentioned and in other 6 studies it was 69.3 ± 7.7 kg, 74.7 ± 8.4 kg, 75.90 +- 2.56kg, 67.0 ± 8.1 kg, 72.28 kg, 61.4 ± 7.6 kg. Besides, in five studies playing level was stated as junior tennis players, national ranked junior tennis players, beginner level, pre-adolescence tennis players and recreational tennis players[25], [28], [31], [33], [38], while in 2 studies playing level was not found[35], [39] and in remaining 7 studies playing level was shown by their International Tennis Number, training age and by experience in years.

Simulated training was provided through medicine ball, elastic bands, wrist band weights, over weight rackets and through resistance training program[25], [26], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36], [37], [38]. However, the assessment of tennis forehand drive performance varied across every study.

[25] found substantial improvements, with a 67% increase in forehand test scores and an 80% increase in backhand test scores, yielding an effect size of 1.04. [30] reported significant correlations between forehand groundstroke speed and the maximum distances achieved in one-handed lateral medicine ball throws of varying weights (1.5kg, 2kg, 3kg, 4kg, 5kg) with correlations of 0.59, 0.43, 0.44, 0.45, and 0.57 respectively. However, no significant correlation was found between forehand groundstroke speed and the maximum distances achieved in two-handed lateral medicine ball throws.

The study of [31] saw a notable increase in accuracy solely within the experimental group (51.4%, effect size = 1.3, $p < .001$). However, no notable changes were observed in hitting speed (1.2%, effect size = 0.12, p = .62) across any group.

Throws using the medicine ball on the dominant side showed a positive correlation with the speed of the fastest forehand r= 0.52, p= 0.017 [27]. The research by[32]revealed a notably strong negative correlation between overhead medicine ball throws and tennis forehand (6.875 ± 0.877) (r = 0.93; p = 0.05).

[29] found the forehand drive accuracy displayed a notable distinction between groups in the post-training score (F = 2.22; p = 0.06; partial h2 = 0.10; medium effect). While no discrepancies emerged between the overweight racket and regular tennis training groups, both groups exhibited scores that trended lower compared to the Handled medicine ball group (p = 0.04 and p = 0.02, respectively).

Slight (23.04%; ES = -0.49) and minimal (6.06 and 7.33%; ES = -0.14 and -0.16) impact sizes were noted in serve, forehand, and backhand accuracy when using 100 gram weights as opposed to the initial conditions [26].

In the [33] study, there was a positive correlation between the four power-assessing medicine ball tosses and all 16 measures evaluating trunk strength on the Cybex equipment (r values ranged from 0.48 to 0.83, indicating a moderate to high range). The effect sizes for the medicine ball tosses varied from 1.09 to 1.55, all falling within Cohen's high range of practical significance. No notable distinctions ($p > 0.05$) were observed across all strokes in terms of ball speed and precision following each method and recovery period when compared to the initial baseline condition [39].

In findings of [38] both resistance training and plyometric training yielded no notable disparity. Both methods enhanced Agility, Speed, Strength, Anaerobic Power, Explosive Power, and Tennis Performance Test (ITN test). Research investigating the impact of exercises involving medicine ball twist tosses and forearm pronation on enhancing the tennis forehand drive found that weight distribution did not significantly affect the impact ball velocities before (PRE) or after (POST) the exercises. The study showed

no notable impact on ball velocities in both the pre-exercise (PRE) phase ($F(2,22)=0.220$; $p = 0.80$) and post-exercise (POST) phase ($F(2,22)=1.727$; $p = 0.20$) [35].
The study of [36] only found noteworthy variations in forehand hitting speed within the experimental group that utilized both medicine ball throws and elastic bands, displaying significant differences (ES = 0.239; $1-\beta = 0.430$).

Discussion

This systematic review aims to explore the impact of diverse simulated training methods, including medicine ball exercises, variable resistance (bands), weighted wrist bands, loaded tennis racquets, and external weights, on variables related to forehand performance. The researcher selected 14 studies for the systematic review, assessing the overall quality of these studies using the Kmet scoring system, which ranges from poor to excellent. The researcher found that simulated training using medicine ball with different weights had a significant impact on the performance of forehand drive in tennis (1.5kg, 2kg, 3kg, 4kg, 5kg) with correlations of 0.59, 0.43, 0.44, 0.45, and 0.57 respectively [30], similarly, the speed of the fastest forehand showed a positive correlation ($r= 0.52$, $p= 0.017$) with medicine ball throws on the dominant side. [27]. Additionally, according to [39] study, there were no notable variations ($p > 0.05$) observed in terms of ball velocity and accuracy across all strokes following each method and recovery time, when compared to the initial baseline situation. Although a study which used resistance bands as to improve forehand drive performance found resistance training improves Agility, Speed, Strength, Anaerobic Power, Explosive Power and Tennis Performance Test(ITN test) [38]. Moreover, while using wristband weights in one study founds improvement in forehand accuracy following the program (51.4%, effect size = 1.3, $p < .001$), whereas there were no notable alterations observed in hitting speed (1.2%, effect size = 0.12, $p = .62$) within this group [31]. Also, in one study where loaded weights were used small changes (23.04%; ES = -0.49) and minor effects (6.06% and 7.33%; ES = -0.14 and -0.16) were observed in serve, forehand, and backhand accuracy when employing 100 gram weights compared to the initial conditions [26]. Furthermore, in the research where weight distribution involved adding weight to the end cap, throat, and top cap of the racket, no notable impact of weight distribution on ball velocities before (PRE) [$F(2,22)=0.220$; $p = 0.80$] and after (POST) [$F(2,22)=1.727$; $p = 0.20$] was identified [34].

CONCLUSION

The systematic review aimed to examine the influence of various simulated training techniques, such as medicine ball exercises, resistance bands, wristband weights, and loaded training, on tennis forehand groundstrokes. The primary focus was to understand the impact of these factors on the performance of the tennis forehand. The findings of the systematic review indicate that, despite being a widely utilized stroke, the forehand groundstroke has been relatively understudied. Moreover, the connection between stroke performance and simulated training techniques remains to be fully established. The researcher acknowledged certain limitations within the systematic literature review process and provided future directions and recommendations for further exploration in this domain. These insights are intended to benefit players, coaches, and field experts, enhancing their understanding of tennis strokes and ultimately contributing to improved tennis performance.

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