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ORIGINAL RESEARCH

The effects of combined training on tennis-specific performance in young tennis players

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Abstract

Tennis players engage in strength training to improve their tennis-specific skills and reduce the risk of injury during matches. However, this approach may not adequately develop tennis-specific skills and could potentially increase the risk of injury among young players. There is a need to examine new methods that will both support technical development and be easily tolerated by young tennis players. The aim of this study was to investigate the effects of tennis training combined with core exercises on the tennis-specific skills of young tennis players. Twenty young tennis players participated in this study. They were divided into two groups: the training group (n=10, age 14.30 years) and the control group (n=10, age 14.00 years). The training group (TRAIN) participated in a combined training program of core stability and tennis training, while control group (CONT) participated in tennis training program. Both groups trained for three sessions per week over eight weeks. Tennis performance was assessed at the baseline and after eight weeks. Forehand and backhand depth (p=0.005; ES=0.25), volley (p=0.009; ES=0.33), forehand and backhand accuracy (p=0.007; ES=1.39) and service performance (p=0.021; ES=1.78) improved significantly after training program in TRAIN group ($p < 0.05$). The changes in volley, forehand and backhand accuracy, service test scores were not significant after training program in CONT group ($p > 0.05$). The combined training program, utilizing portable and lightweight equipment near the training court, has been shown to effectively enhance tennis-specific performance. This model demonstrates significant benefits for the development of tennis-related skills.

Introduction

The participation rate of young athletes in high-level competitive sports has been increased (Adirim et al., 2003). For this reason, interesting in strength training has been increased among young athletes (Kraemer et al., 2003; Peterson et al., 2006; Reid & Schneiker, 2008; Suchomel et al., 2016). While traditional strength training contributes to development of young athletes' strength (Faigenbaum et al., 1996; Reid & Schneiker, 2008; Canós et al., 2022), the increased training loads have also increased the risk of injuries.

Undoubtedly, in adult tennis players, traditional maximal strength training contributes to the improvement of certain techniques related to explosive power in tennis (Reid & Schniker, 2008). Muscular and joint strength is essential for improving performance (e.g., increasing ball speed) and minimizing the risk of injuries by joints, ligaments, tendons, and other structures (Kovacs, 2006). However, in young players, this development remains incomplete, and there may be challenges in transferring the acquired strength to technical skills. Gul et al. (2017), reported that strength training applied to male tennis players aged 14-16 had no effect on tennis-spesific skills. Furthermore, the limited effectiveness of strength training in pre-adolescents, due to a lack of androgen hormones in their circulatory system, poses a challenge (AAP & CSM, 1983). Despite these physiological constraints and the risk of injuries, there is a growing interest in alternative strength training methods among the young players (Myer & Wall, 2006). In reality, to focus on sport-specific performance, rather than to increase muscle strength may more beneficial for their development (Roetert et al., 2009; Bashir et al., 2019).

Core stability training that enhancing core muscle strength, muscular endurance and neuromuscular control has two beneficial results. This method is not

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only developing strength but also offers advantages in movement efficiency and a lower injury risk (Hibbs et al., 2008). Studies have been shown that core training is a beneficial for specific movement patterns in tennis players (Fernandez-Fernandez et al., 2013). While some researchers have investigated core training's impacts on tennis serve performance (Barber-Westin et al., 2010; Fernandez-Fernandez et al., 2013), a recent study suggests that integrating core training with regular routines can safely boost players' dynamic balance and agility, thus enhancing overall performance (Bashir et al., 2019). A previous study indicates that core training may not significantly affect tennis service skills (Smart et al., 2011). Yıldız et al. (2019) demonstrated that functional training models surpass traditional methods in improving athletic performance in prepubertal tennis players. However, this study focused on functional parameters like agility, vertical jump, and balance, not on tennis-specific skills.

Table 1
Anthropometric characteristics of young players.

	CONT Group (n=10)	TRAIN Group (n=10)	p
Age (year)	14.3 ± 1.15	14.00 ± 1.05	0.529
Height (cm)	167.8 ± 7.67	166.6 ± 8.47	0.519
Body weight (kg)	58.64 ± 9.94	55.74 ± 15.49	0.272
BMI (kg/m^2)	20.85 ± 2.64	19.76 ± 3.54	0.406
Training age (year)	7.00 ± 0.86	6.90 ± 1.05	0.280
Core stability level (min)	1.18 ± 0.11	1.17 ± 0.08	0.940
International Tennis Number (score)	7.4 ± 0.9	7.5 ± 0.7	0.903

CONT: Control; TRAIN: Training; ITN: International Tennis Number; BMI; Body Mass Index, min: Minute

Tennis players primarily engage in strength training to enhance their specific skills and to decrease the risk of injury during a match. While there are studies in literature focusing on performance of young tennis players, the effectiveness of core training methods remains unclear. Current research suggests that this method may be easy, have a low risk of injury, and to provide rapid improvement. The purpose of this study is to investigate effects of combined training on tennis specific skills in young players.

Methods

Measures and Procedures

Twenty young players were included in this study (girls: 10, boys: 10). Young players were divided into two groups as the training group (n=10, age 14 years, body weight 55.74 kg, height 166.60 cm) and the control group, (tennis training) (n=10, age 14 years, body weight 58.64 kg, height 167.80 cm). Participants were divided by gender two groups to ensure randomization and gender equality. A number was given to each tennis player. All gender groups were randomly assigned to the training group and control groups, respectively. Thus, the gender distribution was equalized in groups. The age, training age, height, body weight, core stability level and BMI of the players are given in Table 1.

Experimental Design

The study was designed as experimental research. The sample group was created according to the purposive sampling method. Participants were included who not under any other sport training or exercise program, has not any injury and has tennis training' experiences. Participants were excluded who has another sport training or exercise routine, has an injury and has not tennis training experiences. The training group (TRAIN) and control group (CONT) participated in height, body mass measurement, tennis performance test and core stability test before the training period. After pre-training tests, the training group participated combined training (tennis training + core training), while the control group participated only tennis training. All training was conducted three days a week for eight weeks. All young players participated to tests within 1 week after training program. The combination of training was adjusted according to tennis technique/skill sensitivity. The players in training group were asked to come sixty minutes before to join core stability training. According to tennis training content, they were asked to go sixty minutes after tennis training in some weeks (Table 3). Participants were informed and explained about the purpose of the study and the tests. The research was conducted between May-August-2021 on hard court of Çanakkale Youth and Sports Provincial Directorate. The study was approved by Çanakkale Onsekiz Mart University Clinical Researches Ethics Committee (Date: 07.05.2020, Issue No: 18920478-050.01.04-E. 20000641673, Decision No: 2020-07). The written consent form was signed by their parents of the participants. Training was conducted summer period after Covid-19 pandemic. All tests were conducted by a certificated Tennis Trainer. Participants were asked to avoid strenuous activities prior to test days. One week before started training program all core stability exercises were demonstrated by trainer. The core stability was evaluated with the "sport-specific core muscle strength & stability plank test" in the baseline (Mackenzie, 2005). The core stability test requires maintain a prone bridge position for three minutes, with arms and legs raised alternately for 15 seconds in each stage of the eight stages. Core muscles function was evaluated according to the total duration of the completed stages (Table 1).

Tennis performance test

Tennis specific skills were assessed based on the Coach Playing Level test used by the tennis federation.

Forehand / Backhand Depth Evaluation: Tennis player makes ten strokes as one forehand and one backhand respectively. Points are awarded to the player for a total of ten strokes, based on the area where the ball landed.

Forehand / Backhand Accuracy Evaluation: Tennis player makes six parallel strokes. Points are awarded to the player for strokes, based on the area where the ball landed.

Volley Depth Evaluation: Tennis player makes ten strokes as one forehand one backhand. If the ball is caught in the net or goes out, the player is awarded 0 points.

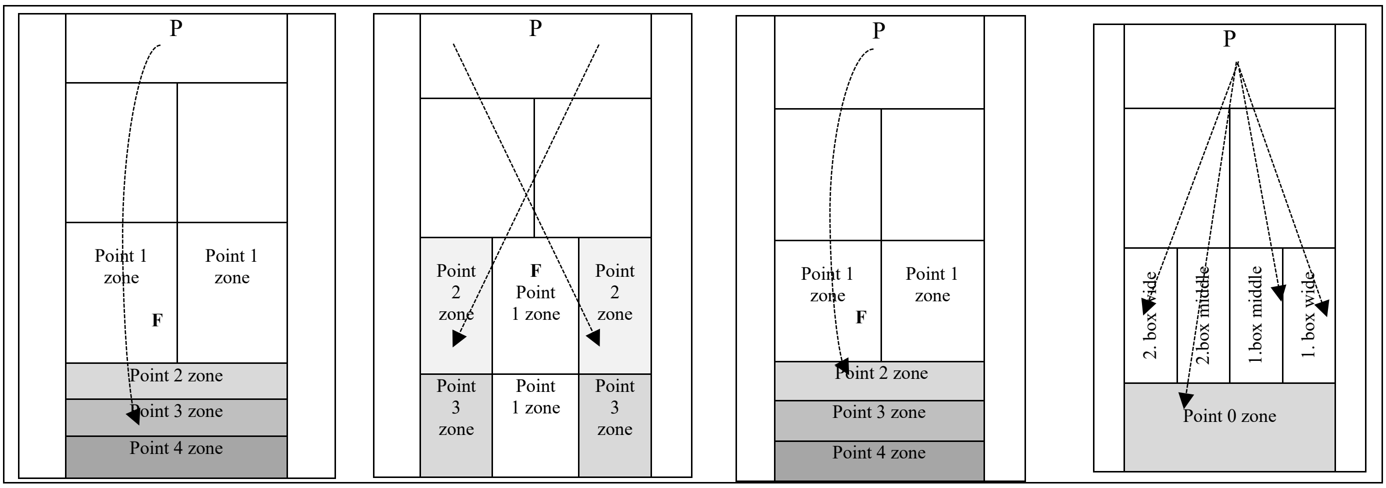
Service Evaluation: The participant makes 12 serves. The first 3 serves are reduced to the wide area of the first service box, the second 3 serves to the middle area of the first service box, the third 3 serves to the middle of the second service box, and the last 3 serves to the wide area of the second service box (Figure 1).

Combined training program

Combined training was created from core stability exercises and tennis training. All combined training was started with a 10-minute warm-up, and was ended with a five-minute cool down phase.

Core stability training program: Core stability training was created from the exercises in the training program organized in previous studies (Fernandez-Fernandez et al., 2013; Kibler et al., 2006; Willardson, 2007). Six exercises were selected for each training season from the exercises given in the Table 2. The procedure was explained before the training process by researcher for per exercise. Trainer adjusted load of training for each training season. In core stability exercises, the intensity was adjusted by increasing the duration and number of repetitions. Core stability training continued for ≈ 25 minutes.

Tennis training: Young tennis players in both groups were included in tennis training, which included forehand and backhand depth exercises, volley exercises, forehand and backhand accuracy (cross and parallel) stroke exercises, and service exercises. Tennis training of all groups continued for ≈60 minutes. It started with the warm-up phase (≈10 minutes) and ended with the cool down (≈5 minutes). All young tennis players participated in tennis training 3 days a week.



Figures 1. Tennis performance tests.

Table 2
Core stability training exercises.

Exercises	Description	Weeks (Rep or Sec)							
		1	2	3	4	5	6	7	8
Back extension	The bench is positioned in front of the hips. After the hands are joined in front of the body, the body is left down. Backward from the end point, the trunk is lifted upwards.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep
Prone plank	Feet together, spine brought into neutral position. Palm and forearm touch the ground. The position is maintained by keeping the head, trunk and legs straight on the toes.	2x30 sec	2x40 sec	2x50 sec	2x60 sec	3x30 sec	3x40 sec	3x50 sec	3x60 sec
Side bridge	The hand is placed on the upper part of the hip. The hips are then lifted off the ground and aligned with the rest of the body, straight line from feet to head.	2x20 sec	2x30 sec	2x40 sec	2x50 sec	3x20 sec	3x30 sec	3x40 sec	3x50 sec
Bird dog (for right/left side)	Shoulders and hips are kept parallel to the floor. The right arm and left leg are raised. The nape is extended and the chin recessed into the chest to look down	2x10 rep	2x15 rep	2x20 rep	2x30 rep	3x10 rep	3x15 rep	3x20 rep	3x30 rep
Russian twist (for right/left side)	Sit with knees bent, feet taut and heels on the floor. The hands are held in front of the chest and the torso is bent backwards until you feel the abdominal muscles engage. The body is slowly turned from right to left.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep
Cable torso rotation (for right/left side)	The cable fixed to the right is held with both hands, with the left arm straight and taut across the body. By simply moving the arms, the cable is pulled to the opposite side until the right arm is straight.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep
Stability ball supine bridge (for right/left side)	Both heels are placed on the stability ball. Hips are lifted off the mat, forming a straight line between shoulders, hips and feet.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep
Medicine ball twisting wall (for right/left side)	Stand with the right/left shoulder to the side of the wall. The medicine ball is held with both hands at hip level. The body is turned towards the wall, the ball is thrown and caught.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep
Resistance band forward-Backward	The resistance band is fixed somewhere at chest level and the other side of the band is placed on the chest. To create more stabilization, the resistance band is held with both hands above the head in front of the chest and pulled forward and backward.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep
Dumbbell side bend	Hold dumbbells with palms facing legs. The knees are slightly bent and the trunk is bent as far to the right as possible. Core muscles are tightened with feet shoulder-width apart.	2x10 rep	2x15 rep	2x20 rep	2x25 rep	3x10 rep	3x15 rep	3x20 rep	3x25 rep

rep: Repetition, sec: Second

Statistical Analysis

Statistical analysis of research results was made using the SPSS (SPSS, 26v, Inc., Chicago, IL, USA). Shapiro-Wilk test was used to control the normal data distribution and Levene's test was used to evaluate the equality of variances. Nonparametric tests were used when the sample consisted of a small number of participants. Mann Whitney U test was used to determine the significance level of the difference between training group and the control group. Nonparametric Wilcoxon test was used to determine the significance of the difference between pre and post-training values in control and training group. In all analyzes, the level of significance was accepted as $p<0.05$ with 95% confidence level. The effect size (ES) were calculated Cohen ES (> 0.2 small, 0.5 moderate, > 0.8 large) (Cohen, 1988).

Results

Descriptive statistics results for the Training Group and Control Group are shown in Table 4.

In the baseline, there was no significant difference in forehand/backhand depth (p= 0.879), accuracy (p= 0.820), volley depth (p= 0.543) and service score (p= 0.850, *Table 4*), also in core stability (p= 0.940, *Table 1*).

According to post-training test data, there was a significant improvement in the forehand-backhand accuracy (p= 0.007, CI = 0.639 - 0.978), forehand-backhand depth (p= 0.005, CI = -0.042 - 0.936), volley depth (p= 0.009, CI = -0.536 - 0.905) and service (p= 0.021, CI = -0.076 - 0.934) in TRAIN group after the program (Table 5).

Whereas in the CONT group, there were significant difference in forehand-backhand depth between pre and post-tests (p= 0.005, CI = 0.738 - 0.984, *Table 5*). The changes in volley depth (p= 0.121, CI = 0.291-0.956), forehand and backhand accuracy (p= 0.812, CI = 0.097 - 0.944), service (p= 0.952, CI = -0.511 - 0.907) were not statistically significant after training in CONT group (p > 0.05). Moreover, there was only significant difference in forehand-backhand accuracy (p= 0.009) between TRAIN group and CONT group in after training (Table 5).

The combined training minimally effected forehand-backhand depth (ES= 0.25) and volley depth (ES= 0.33). Conversely, forehand-backhand accuracy (ES= 1.39) and service performance (ES= 1.78) were affected largely from combined training.

Table 3
Core stability and tennis skill training combination.

Core stability Exercises	Tennis skill drills	Weeks															
		1		2		3		4		5		6		7		8	
		Core	Skill	Core	Skill	Core	Skill	Core	Skill	Core	Skill	Core	Skill	Core	Skill	Core	Skill
Back extension	Service	x	x		x	x	x			x	x			x	x		
Prone plank	Forehand/backhand depth		x	x	x	x			x	x		x	x			x	x
Side bridge	Volley drills	x			x	x		x	x			x	x		x	x	
Bird dog (for right/left side)	Forehand/backhand accuracy		x	x		x	x			x	x			x	x		
Russian twist (for right/left side)	Game	x			x	x			x			x	x			x	x
Cable torso rotation (for right/left side)	Lob		x	x			x	x		x	x			x	x		
Stability ball supine bridge (for right/left side)	Forehand backhand mix	x		x	x			x	x			x	x			x	x
Medicine ball twisting wall (for right/left side)	Hit and catch	x		x			x	x			x	x	x	x		x	x
Resistance band forward-backward	Drippling		x	x			x	x	x	x	x			x	x		x
Dumbbell side bend	Simple groundstroke	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x

Table 4

Results of TRAIN group and CONT group at the baseline and post-training.

	TRAIN Group (n=10)					CONT Group (n=10)					
	Mean	SD	Median	Min.	Max.	Mean	SD	Median	Min.	Max.	*p* (inter-groups)
Baseline											
Depth (point)	29.40	6.05	29.50	22.00	42.00	29.20	8.96	37.00	31.00	47.00	0.879
Accuracy (point)	26.90	7.50	26.50	15.00	43.00	25.00	6.27	32.00	23.00	42.00	0.820
Volley depth (point)	16.30	2.94	15.50	13.00	23.00	18.00	4.50	19.50	14.00	33.00	0.543
Service (point)	28.90	7.96	28.00	20.00	42.00	29.20	8.23	34.50	30.00	45.00	0.850
Post -training											
Depth (point)	37.60	5.18	37.00	31.00	47.00	35.60	9.64	32.50	20.00	56.00	0.343
Accuracy (point)	33.20	5.95	32.00	23.00	33.00	25.10	5.64	26.00	13.00	33.00	0.009*
Volley depth (point)	21.10	6.19	19.50	14.00	42.00	19.10	5.66	20.50	10.00	27.00	0.649
Service (point)	35.70	4.66	34.50	30.00	45.00	29.90	6.24	31.00	19.00	38.00	0.062

*CONT: Control Group; TRAIN: Training Group; SD: Standard Deviation; Min: Minimum; Max: Maximum. * p<0.05.*

Table 5

P value (time-group), effect size data in TRAIN Group and CONT Group.

Variables	CONT group	TRAIN Group	
	P value (time-group)	*P value (time-group)*	*Effect Size (ES)*
Depth (point)	0.005**	0.005**	0.25
Accuracy (point)	0.812	0.007**	1.39*
Volley depth (point)	0.121	0.009**	0.33
Service (point)	0.952	0.021**	1.78*

*CONT: Control Group, TRAIN: Training Group, *: Large Effect Size, **: p<0.05*

Discussion

Our main findings indicate that combined training with core stability and tennis enhances specific performance of young tennis players. Additionally, the absence of injuries and pain from this training suggests that it is well-tolerated by athletes. Previous studies have primarily focused on service speed of young tennis players (Ferrauti & Bastiaens, 2007; Fernandez-Fernandez et al., 2013; Fett et al., 2020; Barber-Westin et al., 2010; Behringer et al., 2013; Fernandez-Fernandez et al., 2016).

An increase in ball speed is considered a key determinant of success in tennis; however, hitting accuracy is equally critical for optimal performance. This study did not aim to assess changes of service speed; instead, it focused on evaluating the depth and accuracy of the service skills. The findings revealed that service performance was the most significantly improved parameter following the combined training intervention (ES = 1.78). Conversely, no improvement in service scores was observed in the control group. Notably, internal rotation is recognized as fundamental movement contributing to effective serving performance in tennis (Kraemer et al., 1995) and prior research has recommended including core stabilization exercises in training programs to enhance tennis performance (Ellenbecker et al., 2004; Roetert et al., 2009).

Trunk rotation during tennis serve is critical component of strength development and the transfer of energy from the lower to the upper extremities into kinetic chain (Ellenbecker et al., 2004). Fett et al., (2020) have suggested that upper body training programs, which play a vital role in tennis, can increase service performance. In our study, the core stability exercises and tennis technical exercises, selected based on research results and recommendations, effectively enhance the service performance of the players.

The accuracy in tennis is defined as the error based on distance between a target and the ball's landing position (Delgado-Garcia et al., 2019). Many tennis tests measure performance by dividing the court into zones, each representing different levels of accuracy (Davey et al., 2003; Strecker et al., 2011). Forehand and backhand strokes are crucial groundstrokes in the game. In our study, the accuracy of both forehand and backhand strokes increased when compared to the control group ($p<0.05$, Table 5). Moreover, forehand and backhand accuracy was the second- most affected parameter by the combined training (ES= 1.39). The accuracy of the forehand stroke is enhanced through the integration of upper extremity segments and the internal rotation of the arm (Elliott et al., 1997).

In the forehand technique, the rebound phase utilizes the energy stored during the muscle's concentric contraction in the forward swing phase (Elliott et al., 1999). This energy is retained in the strained muscles and tendons. It is suggested that specific training could enhance the utilization of elastic and neural reinforcement during the stretch-shortening cycle in forehand strokes, potentially affecting rotational speed (Genevois et al., 2013). The findings of our study suggest that core stability exercises, such as medicine ball rotation wall drills, may aid in tennis performance. Cam et al., (2013) indicated that forehand strokes linked to higher number of points, whereas more points are lost backhand strokes played as the final shot. At the professional level, backhand strokes are played less frequently than forehand strokes (Johnson & McHGugh, 2006; Pellett & Lox, 1997). Additionally, our exercise selection considered the use of both dominant and non-dominant hands during groundstrokes. Our within-group analysis showed improved stroke accuracy in TRAIN group ($p < 0.05$, Table 5), while no significant change was observed in the control group. This supports the effectiveness of combined training over practicing tennis skills alone. The fact that this result was not obtained in the control group that only practiced tennis skills supports the results of combined training.

While numerous factors influence the success of a stroke, our findings indicate that core stability exercises positively impact the accuracy of ground strokes in tennis. Given that tennis predominantly engages muscles on dominant side of the upper body (Kraemer et al., 1995), this aspect was considered when selecting core stability exercises. According to this result, the forehand and backhand depth score increased in TRAIN group. However, the combine training had only a minimal effect on forehand-backhand depth (ES= 0.25). Interestingly, there was a significant difference in forehand-backhand depth between pre and post-tests in CONT group ($p = 0.005$, Table 5). Consequently, the combined training program appears to have had effects comparable to tennis training alone on the development of ground stroke depth, suggesting that stroke depth may not be directly linked to core strength. Other factors undoubtedly influence stroke depth, but current research does not provide clear insights into these factors for young tennis players.

This combined training had a minimal effect on volley depth (ES= 0.33), indicating that volley performance was not significantly impacted by this type combined training. Previous research has shown that the extensor carpi radialis muscle is more active than the flexor carpi radialis during volleys (Chow et al., 1999). However, the extent to which shoulder muscles, in addition to forearm and wrist muscle, contribute to this is still unclear.

Limitations

There are some limitations in this study. Although the small size may raise concerns, the specific focus of the research justifies its adequacy. Specialized training studies often require detailed data collection, necessitating smaller samples, especially in sport science, where technical skills and performance are closely analyzed. Furthermore, the homogeneity of the participants and the high level of experimental control ensure that meaningful and significant findings can be obtained even with smaller sample sizes. The comprehensive evaluation of the training program's impact, combined with close monitoring of individual performance changes, transforms the limited sample size from a potential limitation into an opportunity for in-depth analysis. This study conducted independent group analyses with a total of 20 participants, divided equally into two groups. Post-hoc power analysis indicated that the statistical power of 19%, which reflects the limitations of the sample size. Although the sample size was restricted to 10 participants per group, the observed effect size (d=1.39, d=1.78) suggests that the combination training methods could have a meaningful practical impact on young players. Replicating the study with a larger sample size is essential to further validate these findings.

Conclusions

We recommend the combined training program as an effective method for enhancing tennis-specific performance using portable and lightweight equipment near to the training area. This model is both safe and effective for improving tennis skills in young players, particularly in serving, forehand and backhand accuracy. However, further research is required to determine whether core training significantly influences the depth of strokes and volley shots.

Authors' Contribution

Study Design: GŞ, OK; Data Collection: OK, GŞ; Statistical Analysis: GŞ, OK; Manuscript Preparation: GŞ, OK.

Ethical Approval

The study was approved by Çanakkale Onsekiz Mart University Clinical Researches Ethics Committee (Date: 07.05.2020, Issue No: 18920478-050.01.04-E. 20000641673, Decision No: 2020-07) and it was carried out in accordance with the Code of Ethics of the World Medical Association also known as a declaration of Helsinki.

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Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

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