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RESEARCH ARTICLE

Effect of multidirectional plyometric training along with core strengthening among tennis players on dynamic balance, vertical jump performance and agility

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Abstract

Dynamic balance and agility are crucial in tennis, players move quickly around the court to reach the ball and maintain positioning, explosive power, and reaction time. Core strength is vital for maintaining stability and transferring power from the lower to the upper body, contributing strength and control on the court. Targeting these tennis skills through multidirectional plyometric training and core strengthening. Objectives: Determine the impact of multidirectional plyometric training and core strengthening on dynamic balance, vertical jump performance, and agility. Methods:50players were selected based on inclusion and exclusion criteria. Recreational tennis players aged 24.48 ± 3.92 years; height 166.58 ± 5.425 cm, weight 68.62 ± 9.72 kg were selected. Subjects were evaluated with the star excursion balance test, illinois agility test, and vertical jump tests. Intervention received 60 minutes, twice a week, for 6 weeks. Post-assessment was taken and the data were analyzed with SPSS. Result: comparing the pre-post intervention, the study's outcomes showed significant improvement in the following end measures, dynamic balance of right leg pre-test (81.80 ± 4.70) and post-test (91.02 ± 4.67), $p = 0.0001 \leq 0.05$, for left leg pre-test (82.22 ± 4.88) and post-test (90.83 ± 4.68), $p = 0.0001 \leq 0.05$, of vertical jump pre-test (43.44 ± 6.01) and Post-test (53.74 ± 7.02), $p = 0.0001 \leq 0.05$, agility pre-test (19.60 ± 1.34) and Post-test (17.64 ± 1.16), $p = 0.0001 \leq 0.05$. Paired test analyses showed statistically significant improvement ($p < 0.001$) in dynamic balance, jump performance, and agility. Conclusion: The intervention has a positive impact on vertical jump performance, balance-related measures, and agility, as evidenced by the significant improvements in all the outcome measures.

Keywords: Recreational tennis player, Kinetic chain, Dynamic balance, Agility, Plyometric, strength.

Introduction

Tennis is a noncontact sport although It's a racquet sport with high levels of activity in competitive matches that may be played with two teams of two players each, or it can be played alone against one opponent (Reilly et al., 1990). It is a fast-paced, agile, dynamic sport that requires explosive power, anaerobic and aerobic conditioning, as well as rapid reactions and anticipation (Bashir *et al*., 2019).

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Tennis needs multidirectional movement at rapid intervals, which makes it crucial to maintain balance using proprioceptive input from the lower extremities. As a result, proprioception is vital in tennis for better-balancing activities (Ferragut *et al*., 2021). Also solid core is essential, if the core and lower limb muscles are weak player is at risk (Majewska *et al*., 2022) The trunk (38.9%) and muscular strain (61.1%) were the most frequent injury types and locations (Abadi *et al*., 2021).

Different interventions are given for better performance, such as plyometric and core strengthening. Plyometric exercise is more dynamic and includes training for explosive power. Exercises that are either vertical or horizontal or a combination of the two are included in plyometric training (Pluim *et al*., 2007).

Exercises involving jumping that use the stretch-shortening cycle of muscular activity are known as plyometric training. This enhances physical capacity by increasing power (Ramirez-Campillo *et al*., 2023). Athletes who are swift on the court are frequently able to change directions quicker than their opponents; in a comparable

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way, athletes who can rapidly decelerate and then accelerate again typically exhibit the quickest multidirectional speed (Jlid *et al*., 2020).

The lower back muscle, abdominal muscle, pelvic muscles, and hip musculature are combined and called the core. The core is an important structure for transmitting motion between the upper and lower bodies. It acts as a segmental link between the upper and lower bodies. As a result, core stability is vital in enhancing physical activity, balance, and hence performance (Kibler *et al*., 2006; Bashir *et al*., 2019). The capacity to maintain optimal force transmission and control over the pelvis through trunk posture and motion is known as core stability. The dynamic chain activates through the core (Nuhmani *et al*., 2022).

During a spike player jumps as much as possible to hit the ball and the trunk movement is more at mid-air. The player twisted the trunk horizontally across a nearly vertical axis. It's possible due to the function of pelvic rotation and lower limb force in forehand and backhand strokes. It was determined that the significance of internal extensor moments at the back hip. The trunk and leg transmit 55% of the body force during the spike. Lower extremity and core strength are imbalanced, which affects tennis performance. Vertical jump height is improved by improving lower limb power (Elliott *et al*., 2003).

During a match, tennis players have to change direction many times; for that, athletes need agility and dynamic balance skills. Being agile means having the capacity to swiftly change direction and maintain body posture when responding to the ball and opponent on the court (Miller *et al*., 2006).

The athlete's agility is primarily challenged when he or she holds sports equipment, such as tennis rackets, squash rackets, and badminton frames. The equipment directly increases the athlete's movement technique, producing highly specific agility movement patterns (Bloomfield *et al*., 2007). The validity and reliability of multiple prearranged agility tests, both racquet-free and with (Fernandez-Fernandez *et al*.,2016). The Illinois agility test measures agility. It's a reliable and valid tool to measure agility.

Poor or moderate balance suggests a risk of injury and weak performance. While moving in court and landing after a jump, players need good balance. SEBT is a gold standard tool to measure dynamic balance (Pardos-Mainer *et al*., 2021). A player who has received training in agility, balance, and jump performance may move more quickly on the court and change their direction quickly while still keeping control of their body (Plisky *et al*.,2006).

Competitors often train with core strengthening and plyometrics to increase their strength. Core strengthening involves stabilizing the spine and trunk of the body to increase the strength of the extremities and plyometric training incorporates explosive strength training and is more dynamic (Sekulic *et al*., 2017). Combined use of open and closed kinetic chains is a general trend toward supporting plyometric and core strengthening exercises combined use as training to prevent injury and improve performance in athletes (Hill *et al*., 2011).

Methodology

A Single group pre-test-post-test experimental design was conducted in the region of South Bangalore. The ethical clearance was obtained from the Institutional Ethical Committee. Tennis players aged 18 to 35 who had played tennis competitively for at least 1 year and participated in tennis-related activities were eligible to participate. All subjects endorsed informed consent. Exclusionary factors included any upper limb and lower limb injury, pathology, or surgery within 6 months prior to the initial testing, Disease, or illness that may hamper the performance. Before the intervention, the participants' skills were assessed using the vertical jump performance test, the Illinois agility test, also measured star excursion balance test for both legs. Took 50 participants, who met the inclusion criteria, Illinois agility test: 16.8–22.4, pre vertical jump test score 12–20, dynamic balance (fair) average. All participants underwent a progressive and tailored intervention consisting of multidirectional plyometric training along with core strengthening (Figure 1).

Intervention

The intervention targeted vertical jump performance, agility, and dynamic balance (Figures 2-4). The frequency of training sessions adhered to the FITT principle, with 2 sessions/week, with a moderate intensity of 15 repetitions per set for six weeks. The sessions lasted approximately 60 minutes, including appropriate rest intervals of 2-3 minutes between sets. The chosen training type was plyometric training and strength training (Jlid *et al*., 2020; Ozmen *et al*., 2016). After 6 weeks of intervention, a post-test was conducted and compared with the pre-test value.

The data was analysed using SPSS (version 29.0) for Windows. Descriptive statistics were done to find out the mean and standard deviation (SD) of the baseline characteristics and outcome measures. A paired T-test was used to find the statistically significant difference within the group of recreational Tennis players. The significance level was set at a two-tailed *p-value* < 0.05.

Outcome measures

Star excursion balance test

Vertical jump test

Illinois Agility test

Results

The sample of 50 participants (Table 1) mean and SD of age is 24.48 ± 3.924, participants a mean and SD of height is 166.08 ± 5.671. Participants' mean and SD of weight is 68.62 ± 9.72. Participants' mean and SD of limb length are 77.04 ± 3.77.

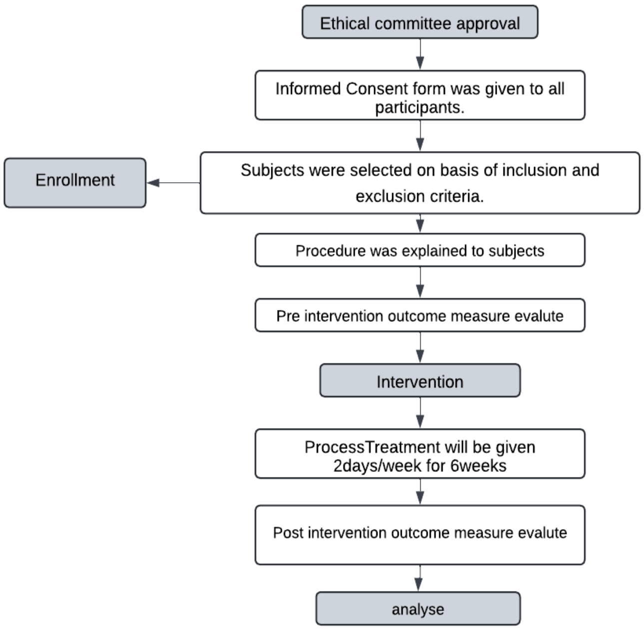

Figure 1: Procedure of the study

Figure 2: Evaluation of SEBT

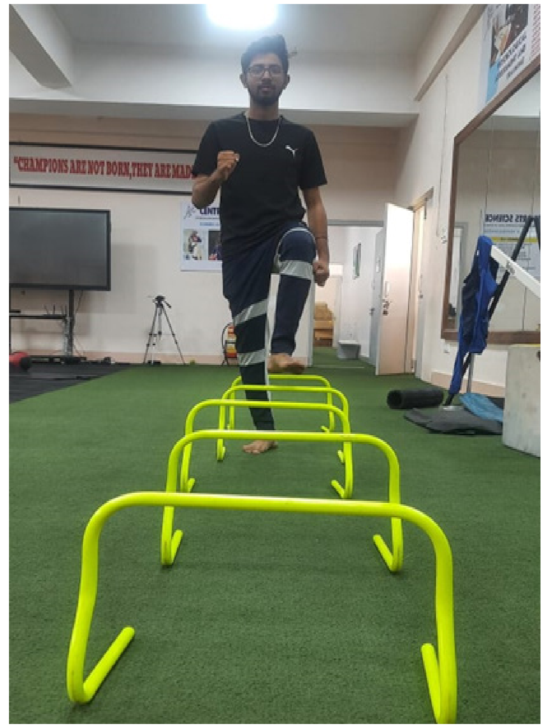

Figure 3: Subject performing Plyometric training (forward jump)

Table 2 indicates that there are highly significant changes in the outcome measures.

A paired t-test was implemented on 50 participants who were assessed to compare outcome measures before and after the intervention. Vertical jump performance improved from 43.44 to 53.74 (mean difference -32.605, *p-value* <0.001**). Illinois Agility test time reduced from 19.602 to 17.644 (mean difference 21.912, *p-value* <0.001**) which means agility of the player improves, value for SEBT (right leg) improved from 81.802 to 91.029 (mean difference -30.293, *p-value* <0.001**), value for SEBT (left leg) improved from 82.222 to 90.838 (mean difference -34.569, *p-value* < 0.001**), it suggests that dynamic balance improve significantly.

Discussion

Research design has the potential to investigate whether a combined plyometric and core strengthening training leads to increased power output and vertical jump performance in tennis players. Plyometrics are exercises that involve rapid muscle lengthening followed by forceful contraction, which is a key component of power generation (Novak *et al*., 2023). By incorporating exercises like squat jumps, depth jumps, and lateral jumps, the program can target the fast-twitch muscle fibres responsible for explosive movements. A strong core is crucial for transferring power from the lower to the upper body during strokes. Core exercises like planks, anti-rotational presses, and medicine ball throws can improve core stability and allow for more efficient force transfer, potentially leading to increased power output. Lower limb

Figure 4: Subject performing core strengthening exercise (Prone bridge on physio ball)

Table 1: Distribution of study participants

	N	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Age	50	18	33	24.48	3.924
Height	50	156	178	166.08	5.425
Weight	50	55	89	68.62	9.727
Limblength	50	72	86	77.04	3.774
VJT pre	50	33	56	43.44	6.014
VJT post	50	42	67	53.74	7.027
IAT pre	50	17.3	22.5	19.602	1.3458
IAT post	50	15.8	20.3	17.644	1.1688
SEBT RT pre	50	67.79	90.20	81.8020	4.70104
SEBT RT post	50	76.62	97.80	91.0382	4.61553
SEBT LT pre	50	70.11	90.20	82.2222	4.88261
SEBT LT post	50	79.96	97.70	90.8388	4.67960

Table 2: Paired t-test within the group

	N	*Mean*	*Std. Deviation*	*Std. Error Mean*	*Paired t test*		
					t	*df*	*Sig. (2-tailed) P value*
VJT pre	50	43.44	6.014	.851	-32.605	49	<0.001 **
VJT post	50	53.74	7.027	.994			
IAT pre	50	19.602	1.3458	.1903	21.912	49	<0.001 **
IAT post	50	17.644	1.1688	.1653			
SEBT RT pre	50	81.8020	4.70104	.67158	-30.293	48	<0.001 **
SEBT RT post	50	91.0290	4.66289	.66613			
SEBT LT pre	50	82.2222	4.88261	.69051	-34.569	49	<0.001 **
SEBT LT post	50	90.8388	4.67960	.66180			

Highly Significant **

power is frequently determined by measuring vertical leap height (Panda *et al*., 2022). If the program effectively strengthens the leg muscles (mainly leg extensor muscles) and improves core stability, it's reasonable to expect an increase in vertical jump height. Chamari *et al*., (2004) suggest that there may have been a considerable gain in lower limb strength in the EG, as seen by the notable improvement in vertical jump height.

This can translate to greater power during serves; it also aids in reaching high balls, executing smashes, and transitioning from defence to offense quickly (Stojanovic *et al*., 2017; Saez de Villarreal *et al*., 2012). The training program design is crucial. It should include exercises that target both power development and core strengthening in a progressive manner. Specificity to tennis movements can be beneficial. Consider incorporating plyometric drills that mimic the multidirectional nature of tennis movements for a better transfer to on-court performance (Gherghel *et al*., 2021). Pardos-Mainer (2021) suggests that muscle strength and jump ability significantly improved when endurance training and plyometric exercises/strength training regimens were combined (Pardos-Mainer *et al*., 2021)

A lack of agility can result in slower movement, decreased court coverage, and difficulty in adjusting to fast-paced exchanges, ultimately affecting a player's ability to compete at a high performance (Ahmed *et al*., 2022). Core strengthening exercises can enhance stability and control, while multidirectional plyometrics can improve footwork and coordination, resulting in enhanced agility on the court. Nuhmani (2018) says that improved neuronal adaptability, greater neural recruitment, or improved motor recruitment are the outcomes of core training and can lead to improved agility in sports like football, basketball, and tennis. This is a result of the fast motions and abrupt positional and direction shifts that these sports demand. Plyometric training challenges the body to react quickly and change direction explosively, which are crucial aspects of agility in tennis (Raya *et al*., 2013). Miller (2006) has proven a link between improvements in agility tests and plyometric training, which benefits player who requires fast movement by increase in agility. Nesser (2008) also found that there was a moderate correlation between core stability and agility. Ergin (2020) says that tennis is a technical sport that requires practice in multiple directions. To succeed in tennis, it would not be enough to work on just one quality. Jones and Nimphius 2019 say that agility allows players to reach difficult shots and respond (Hernández-Davó *et al*., 2021) It also helps in recovering from wide shots, moving laterally along the baseline, and positioning oneself optimally for each shot. Agility training can enhance a player's footwork, reaction time, and overall court coverage (Maciejczyk *et al*., 2021)

Dynamic balance, which refers to the ability to maintain stability while moving, is crucial for tennis players to execute quick changes in direction and recover from wide shots (Ferragut *et al*., 2021) Plyometric exercises, such as jumps and hops in multiple directions, can challenge the neuromuscular system and improve dynamic balance by enhancing proprioception and coordination (Sole *et al*., 2021) This improvement can be attributed to neuromuscular adaptation and biomechanical efficiency, which are essential for tennis (Radnor *et al*., 2018) Core strength also plays a vital role in maintaining proper posture, balance, and stability during dynamic movements on the court (Ahmed *et al*., 2022). Also improves a player's ability to maintain balance during lunges, quick changes of direction, and landings after jumps. Traditional training methods might not always address the specific demands of tennis. By incorporating exercises that mimic the multidirectional movements and quick stops and starts required on the court, the combined program could be more effective in improving agility and balance relevant to tennis performance (Chun *et al*., 2021). Ensure the traditional program is still effective for overall fitness, but doesn't directly target plyometric and core strength as intensely. Bashir (2018) reported that athletes who participated in a core training program demonstrated enhanced dynamic balance and agility. As a result, integrating core strength training into other training regimes could potentially boost the agility and dynamic balance of tennis players, leading to improved performance.

Overall, the findings of this research suggest that a combined training program incorporating multidirectional plyometric and core strengthening can positively impact dynamic balance, vertical jump performance, and agility in professional tennis players. Players' power production, mobility efficiency, and on-court performance may all improve by focusing on these physical characteristics.

Limitation

Elite tennis players are not considered. A higher sample size can improve the credibility and generalizability. The long-term effects of the program on player health and performance could be valuable.

Recommendation

A more thorough examination and interpretation of these results will shed light on how well the intervention worked on various physical performance metrics, identify the precise mechanisms by which it affected dynamic balance, and help to better design interventions in the future to produce results along these lines. Finds a study gap on the efficacy of multidirectional plyometric and core strengthening training coupled for tennis players, especially when assessed with reputable agility and balance tests. This implies that more research into this particular training methodology is necessary.

CONCLUSION

In conclusion, the combination of multidirectional plyometric training and core strengthening among professional tennis players can have a significant positive impact on dynamic balance, vertical jump performance, and agility. These training methods can enhance power, speed, and agility on the court, allowing players to change direction rapidly, respond to shots, and cover the court efficiently. Additionally, core strengthening plays a crucial role in stabilizing the body and transmitting force between the lower and upper body during shots, ultimately improving performance and reducing the risk of injury. By incorporating these training methods into their regimen, tennis players can optimize their game and reach their full potential on the court.

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