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Effectiveness of tennis specific conditioning program (TSCP) in developing selective physical and physiological proficiency among amateur tennis players

Sai Chandrakant Vispute and Saumi Sinha

Abstract

Background: Competitive tennis athletes is a mixture of aerobic and anaerobic skills such as speed, agility and power it also characterized by 300-500 explosive efforts over a match that may last up to six hour.[1] It is clear that the player must be conditioned to meet the specific aerobic, strength and explosive power demands of these matches in order to maintain the required work rate over such an extended period.[2] For better performance the player has to be trained systematically in various aspects such as physical, physiological and skill performance factors. Since the competition grows up at the advance level, training methods are being given a serious view. This study is intended to find out the effect of the tennis specific training package on the selected physical, physiological and skill performance variables of amateur level tennis players.

Methodology: After preparation of study protocol, Ethical clearance was obtained from IEC (No:63 players were screened as per eligibility criteria of the study. Total 44 participants were selected and they were randomized into Group A (n=22) and Group B (n=22) after their consent. Group A received TSCP 3 sessions per week for 12 weeks. Group B continued their regular exercise program.

Result and Data analysis: The Shapiro-Wilk test indicated that the data were normally distributed ($p<0.05$). Therefore, a one way ANOVA was conducted to analyse both within group and between group differences, Experimental group showed significant improvement on Anaerobic power ($p<0.001$), fatigue index ($p<0.05$), Aerobic Capacity ($P<0.001$) Agility ($P<0.05$), Speed ($p<0.001$), Flexibility ($p<0.001$).

Conclusion: Both the study groups showed improvement in selective fitness variables. On comparison between groups Tennis specific conditioning program (TSCP) was estimated to be more significant over the regular exercises when implemented for 12 weeks. By appropriately combining and utilizing these training methods, the physical capabilities and sports performance of adolescent tennis players can be comprehensively optimized.

Keywords: Tennis conditioning, aerobic exercises, anaerobic capacities, dynamic balance, high-intensity interval training, plyometric training

Introduction

We have witnessed an increasingly rapid development of the tennis game. Movement in tennis is characterized by explosive starting velocities, short distance sprints acceleration and decelerations, changes of directions of movement and performing strokes from various balance positions. Without an optimal physical conditioning and movement techniques tennis players are unable to use their full potentials and be competent at highest competition level. Hence tactical preparedness of these players is of high priority.

Physical conditioning has a major impact on tennis performance even among younger age categories and presents one of the factors for predicting competitive success and as a result of the aforementioned, and is taking on an increasing relevance in integral physical conditioning of young tennis players. [1, 2, 3] It is precisely well-developed motor and functional abilities in flexibility, coordination, vigour and endurance, strength, agility, and speed that enable tennis players aged to overcome different game situations on the tennis court in a strong, fast, long-lasting, precise or coordinated manner.

The systematic review and meta-analysis by Lambrich and Muchlbauer (2022) examined the impact of competition levels on physical fitness and stroke performance in tennis players, differentiating between elite and sub-elite players. The results indicated clear advantages in physical fitness and stroke performance among elite players, particularly in terms of lower extremity muscle power, endurance, and agility. These findings emphasize the need to design targeted training programs, especially at beginning level amateur tennis players, to improve these essential physical attributes.

Methodology

Design: A randomized controlled trial was conducted from January 2023 to October 2024 at the Tennis Court of MGM Aurangabad. Potential participants were assessed according to eligibility criteria. Eligible participants who are willing to participate in the study were provided with verbal information about the study and a written information sheet and were required to give informed consent before undergoing baseline assessment and being allocated to a group. Randomization was performed using simple random sampling into two groups: The experimental group and the controlled to conceal the upcoming random allocation, the randomized allocations were concealed in envelopes. The new participant was required to contact the researcher who had no other involvement in the study with the new participant's enrollment details before receiving random allocations whenever they enroll. Before the intervention period, the demographic data and baseline assessment of the study outcome measures were recorded. Participants in the experimental group had undergone 12 weeks of *Tennis Specific Conditioning Program (TSCP)* and those in the control group had undergone 12 weeks of conventional routine exercises. To limit the impact of knowing whether they were in the experimental group or controlled group, participants were advised that the study were compared two exercise regimens and they received no information about the exercise intervention to which they were not allocated. The same researchers reassessed the outcome measures after the completion of 12 weeks of the intervention period. Outcome assessors were blinded to the group to which each participant was allocated.

Participants: 63 players were screened as per eligibility criteria of the study. Total 44 participants were selected and they were randomized into Group A (n=22) and Group B (n=22) after their consent. Group A received TSCP 3 sessions per week for 12 weeks. Group B continued their regular exercise program. Participants attended practice sessions regularly. They were aged between 18-24 years, of all genders and qualified PAR-Q. Exclusion criteria were players having any recent injury, any systemic illness and players involved in any other type of personal training methods. No Exclusion was made due to gender or Weight.

Intervention

Experimental group

Tennis Specific Conditioning Program was administered which include exercise specific Warm up, speed, strength, and endurance training along with core exercises; proprioception and agility drills for 12 weeks Exercises were progressed after every 4 weeks with alteration in frequency and intensity. The intervention was performed for 60 min/per session and 4 sessions per week for 12 weeks. (Table 1)

Control group

Control group intervention continued with the usual training program (Table 2) which include warm-up, Running, Squatting, Strengthening, stretching exercises and cool-down for 12 weeks.

Outcome measures

The physical parameters speed and flexibility were assessed with the 30m DASH test and sit and reach test and Agility was assess on Illinois agility test respectively. The physiological parameters of aerobic capacity were assessed by measuring VO2 max on Queens's college step test and Running anaerobic Sprint test each parameter was measured using the stopwatch and tape measure and scored and summed for the total score. The best of three trials was considered for better performance.

Data Analysis and Results

Statistical analysis were performed by using SPSS 23, and as the sample size is less than 2000 so Shapiro-Wilk test used to identify the normality and found that data do not follows normal distribution by ($P<0.05$). (TABLE Data set is not normally distributed as all the variables have not indicated p-value greater than 0.05 in the observation. The researcher shall use non-parametric test for data analysis purpose in the following sections. The present research work has followed repeated measures so to find out the effect, Repeated Measures of Friedman test is used. $P<0.05$ considered as statistically significant in the study (CI 95%).

Apart from 2 participants who could not complete the study due to losing their interest in participation. There was no deviation from the study protocol. The registered study questions were assessed, all participants were prescribed their randomly allocated interventions and both registered outcomes were measured at the scheduled time points.

Flow of participants throughout the study

63 players were screened as per eligibility criteria of the study. Total 44 participants were selected and they were randomized into Group A (n=22) and Group B (n=22) after their consent. Group A received TSCP 3 sessions per week for 12 weeks. Group B continued their regular exercise program. (Fig.1) the groups were comparable at baseline as presented in table-3. After 12 weeks of assessment 22 participants in the experimental group and 22 participants in the control group were available for assessment and all were measured. Compliance with the prescribed resume was not assessed.

Effect of intervention

Physical fitness variables: Both groups showed improvement in running performance and flexibility at end of the training period. Tennis-specific Conditioning program is estimated to be more effective than conventional training methods for several major physical fitness levels.

Exercise training in both groups was well tolerated and there were no adverse events. Individual participant data for all outcomes is presented in (Table-4)

Discussion

This study estimated that a Tennis Specific Conditioning Program that combines various training methods like strength, speed, agility, balance, etc was more beneficial than conventional training for several outcomes including speed, flexibility, oxygen consumption, Anaerobic Capacities in amateur Tennis players.

Sprinting bouts are regularly performed during decisive defensive and offensive game situations in Tennis. Our findings showed significant improvements in shorter (≤30m) and longer (≥30m) sprint times in Tennis players after TSCP, in comparison to the control group.

Compared to conventional tennis training, plyometric, neuromuscular, and functional training significantly enhanced speed, strength, power, agility, and dynamic balance in adolescents. A high level of technical skill is essential in tennis, yet without a robust physical demands base, consistent and sustainable peak physical demands is unattainable [4]

Moreover, neuro-mechanical adaptations induced by lower power TSCP, such as enhanced neural drive to agonists muscles and optimization of muscle-tendon stiffness [6] may improve Stretch shortening cycle efficacy. As a result of improvements in the Stretch shortening cycle in lower body musculature, greater force production likely occurs in the concentric movement phase after rapid eccentric muscle action [6, 7, 8] which is a key requirement for enhanced sprint performance [5],

Neuromuscular training stimulates peripheral receptors to enhance muscle reaction integration and unconscious movement responses via optimized input signals and cortical integration. This training improves dynamic posture control [6] and boosts athletes physical demands Functional training targets specific segments and connections in the human movement chain to execute precise actions. It includes activities like accelerating, decelerating, and stabilizing multi-dimensional motions that align with targeted actions [7]. Functional training emphasizes overall human movement training and can adjust joint angles, improve muscle function, and enhance movement efficiency to improve athletic physical demands [8] and has a positive impact on the physical demands of both untrained children and experienced [9].

Different training sequences and surfaces can significantly impact the development of physical demands in adolescent tennis players. The timing of neuromuscular training can greatly affect its efficacy. Conducting neuromuscular training before regular tennis practice, rather than after, more effectively enhances speed, agility, and power [11] this enhancement is likely due to optimal neural and muscular preparation provided by pre-training sessions, facilitating better muscle fiber activation and recruitment during subsequent exercises. In contrast, neuromuscular training performed after routine practices may induce fatigue, reducing potential benefits in speed, agility, and power [12]. The choice of training surface also significantly impacts an athlete's physical demands. Training on hard surfaces is better suited for improving explosive power [13]as it provides stable support and minimizes energy loss [14] Conversely, sand training, with its inherent instability, increases muscle loading [15] making it more effective for enhancing strength, speed, and balance demands [13].

The TSCP inclusive of change of direction exercises with varying speeds will facilitate and contribute to the development of neuromuscular and metabolic adaptations. The improvement in the power performance is one of the important variables along with neural adaptations and enhancement of motor unit recruitment for an increase in agility [16].

The portable reason for an increase in flexibility is an increase in stretch force on muscle has increased tension on the series elastic component and parallel elastic component of the muscle. The muscle cells which store the energy in eccentric contraction are released once the stretch is released [11] dynamic stretching and ballistic stretching are the common stretching methods used in a Tennis Specific Conditioning Program which are characterized by quick bouncing movements that create momentum to carry the body segment to the range of motion to stretch the shorten structures. Repetitive loading on the tissues at a sub-maximal level for successive days increases the deformation of collagen tissues. The collagen tissue deformation occurs to different degrees at different intensities of force and different forces of application and it further requires the breaking of collagen bonds and realignment of fibers for permanent elongation or increase flexibility [17].

Aerobic capacity is an integral indicator of the functional capacities of all systems involved in the supply, transportation and energic oxygen transformation [18]. The probable reason for the increased aerobic capacity in Tennis players are:

Increase in cardiovascular adaptations like increased cardiac output, stroke volume and increased arteriovenous oxygen difference. Regular physical training increases the VO2 max by 50% and rests by 50% is increased because of the extraction of oxygen by working muscles which is reflected as an increase in arteriovenous oxygen difference [19].

The experimental group has effective increase in aerobic capacity could be because of the interval training method and adding the sport-specific sprinting drills with appropriate recovery intervals and also taking into consideration, the morphological and functional changes as the consequences of the training process.

Apart from the strength of shoulder girdle muscles when trained with high intensity inter spread with intervals the oxidative capacity of the skeletal muscles was found to be improved Also, there is an increase in VO2peak following endurance training of high intensity for short duration. Improvements in VO2max could be due to an increased oxygen delivery (increase in stroke volume) and/ oxygen utilization by active muscles. As maximum heart rate remains unchanged in response to training, improvements in oxygen delivery to exercising muscles during high intensity exercising can be attributed to an increase in stroke volume. Stroke volume can increase through a higher left ventricular contractile force and/ or through an increase in cardiac filling pressure, which raises end diastolic volume and resultant stroke volume. In addition sprint training protocol evokes changes in the capacity to produce energy via oxidative metabolism. It is also known that the aerobic contribution to sprint exercise increases, depending on the recovery between bouts, as a function of successive sprint. The relatively short recovery periods used would have imposed a considerable demand on the aerobic metabolism in meeting ATP synthesis in the latter sprint bouts; all of these factors may explain the observed increase in VO2max. Hence, time saving strategies for enhancing performance limiting factors such as endurance and strength performance are desirable.

In this study, the running anaerobic sprint test (RAST) was used to evaluate the anaerobic power and the fatigue index.

Anaerobic Power

The Anaerobic Power and fatigue index is considered an important indicator of anaerobic capacity. The lower the fatigue index, the greater the body's ability to maintain its power output through anaerobic performance. Running the anaerobic sprint test is widely used by coaches, athletes and researchers to measure lower body anaerobic strength load capacity and fatigue index. According to high-intensity exercise significantly increases the amount of lactate in muscles and blood, as well as the fatigue index value, while the increased accumulation of lactate causes an increased concentration of hydrogen ions and corresponding acidosis as its primary factors. The study sought to assess the anaerobic capabilities of physical education and sports students by employing the Running Anaerobic Sprint Test (RAST) and determining the Fatigue Index (FI).

The explanation underlying three possibilities related to the central and peripheral adaptations to training- 1. Decrease the rate of lactate formation during exercise 2. Increase rate of lactate clearance during exercise 3. The combined effect of both. Players who engaged in various anaerobic activities tolerate higher blood lactate levels and lower pH values than their untrained counterparts. This raises speculation that anaerobic training proves the body's capacity for acid-base regulation perhaps, enhancing chemical buffers or alkaline reserve [14].

Conclusion: The training program designed was a calculated approach which involved specific exercise plans, individual instructions and systematic monitoring. Exercises used in the preparation differed in the type, their intensity, duration and repetitions.

From the results of present study we conclude that both groups showed improvement in variables related to physical performance, agility, speed, and flexibility, along with improvement in physiological variable, aerobic and anaerobic capacity. With built in training programs for longer periods on this information, we think it would be useful in terms of gaining success and to reach the standards the performances of amateur tennis players.

Table 1: Content and progression of the experimental group intervention

Warm-up(5-7min)	**General mobilization, Single hop jumps, High Knees, Buttock Kicks, Tennis, Stretching**		
Level - I			
Exercise category	**Exercises**	**Level I Week 1-4**	
		Reps.	**Sets**
Running Exercises	Straight running 100m	2	1
	Alternate leg bounds	2	1
	Side Stepping Running including side stepping	2	1
	Running Back and Front	2	1
	Suicide Run	2	1
Agility Drills	Agility - Cone Calls	8-10	2
	Ladder Drill -Split steps	8-10	2
Strength, Endurance	Push ups	8-10	2
	Squats	8-10	2
	Plank	3	2
	Shoulder Tap Plank	3	2
	Side Plank.	3	2
Proprioception (Balance Drills)	Drop feed ball and hold	10sec hold	3
Plyometrics & Motor Control (Involving Trunk Twister)	Skipping	100	2
	HOP Jumping	8-10	2
	Crook lying with pelvic & trunk rotations:	8-10	2
Speed Drills	Speed	8	2
Level - II			
Agility Drills	Acceleration / Deceleration Drill	6-8	2-3
	Ladder Drill - 2 in forward	3	1
Strength, Endurance	Push up	15-20	2
	Squats on toes	10-12	
	Plank	15-20 sec hold x 5 reps	
	Shoulder Tap Plank	10-12 times each. 5 reps	
	Side Plank	Hold for 20 sec. 5 reps	
Proprioception (Balance Drills)	Balancing with soft tennis ball	8 -10/sessions	2
Plyometrics & Motor Control (Involving Trunk Twister)	Mountain climber exercise	10 to 12 reps	2
	Lateral Jumping	2 reps for 30 seconds	
	Whole body coordination while trunk twisting	8-10/session	
Speed Drills	Speed	6 -8/session	2
Level - III			
Agility Drills	*M Drill*	5 times	2-3
	Ladder Drill - Lateral in and out	2 /session	1
Strength, Endurance	Push up	25-30 reps	2
	One leg Squats	8 to 10 reps	
	Plank	30 sec hold x 5 reps	
	Shoulder Tap Plank	10 -12 times each. 5 reps	
	Side Plank	Hold for 30 sec. 5 reps	
Proprioception (Balance Drills)	Ball Hits balancing on BOSU Ball	10 -15 sec hold 8 to 10 hits / session	2
Plyometric & Motor Control (Involving Trunk Twister)	Single leg over 10 cones	2 reps	2
	One leg box jump	8 to 10 times	
	Trunk Twist	8-10 / session	
Speed Drills	Speed	6 -8/session	2
Cool down (5-7 min)	Spot Jogging, Stretching of major Group of muscles		

*Three sessions per week were prescribed, Min=Minutes, Reps=Repetitions

Table 2: Content and progression of the control group intervention

Exercise Category	Exercise	Volume	
Warm Up	ROM, Jumping Jacks, Skipping, Jogging 5 to 7 mins (1- 12 weeks)		
		Reps	Sets
Strength Endurance Training	Pull Ups	10	3
	Squats	10	2
Aerobic group exercise Session	Running 200 mts	2	1
	Curl Ups	10	3
	Free Hits	10	3
Cool Down	Stretching of Major group of muscles, gentle walk for 5 minutes.(1- 12 weeks)		

*Three sessions per week were prescribed, Min=Minutes, Reps=Repetitions

Table 3: Characteristics of participants at baseline (n=44)

Variable	Group	Mean	SD	z-value	p-value
Age	Exp.	21.87	1.67	0.287	0.774
	Con	21.91	1.86		
Weight	Exp.	58.56	4.87	1.299	0.194
	Con	59.67	4.93		
Height	Exp.	167.80	6.76	NA	NA
	Con	167.80	6.76		

*Con= control group, Exp = experimental group,

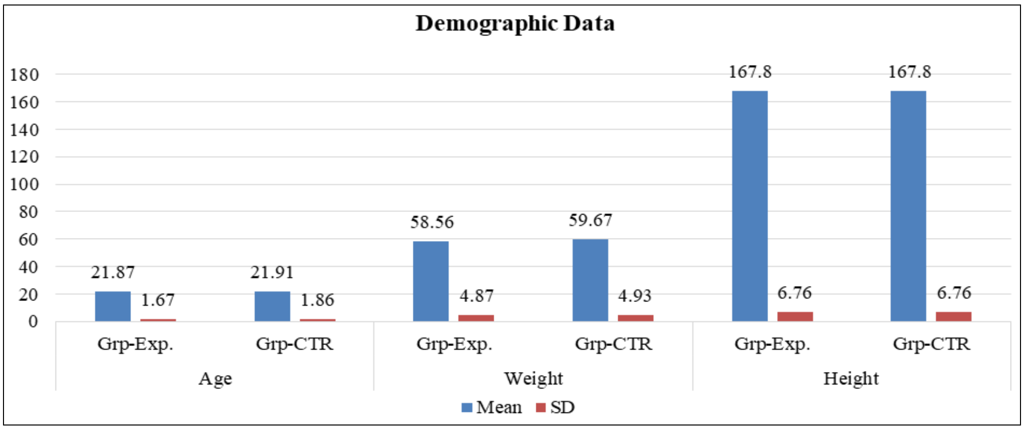

Fig 1: Demographic Data of all Participants (n=44)

Table 4: Mean (SD) of Groups, Mean (SD) Difference within groups and mean (95% CI) difference between groups

	Group	Time Frame	Mean	SD	P-value
Anaerobic Power	EXP	Week 0	477.19	60.12	0.001
		Week 6	493.5	60.27	
		Week 12	512.5	60.27	
	CTR	Week 0	474.81	59.96	0.001
		Week 6	486.7	60	
		Week 12	493.5	60.04	
Fatigue Index	EXP	Week 0	53.79	4.37	0.001
		Week 6	46.06	4.73	
		Week 12	36.77	5.26	
	CTR	Week 0	52.87	4.4	0.001
		Week 6	48.02	6.08	
		Week 12	42.69	5.85	
VO2 MAX	EXP	Week 0	41.2	3.51	0.001
		Week 6	45.51	3.65	
		Week 12	50.17	3.76	
	CTR	Week 0	38.82	3.45	0.001
		Week 6	40.93	3.08	
		Week 12	44.25	3.05	
Flexibility	EXP	Week 0	26.47	2.38	0.001
		Week 6	33.31	4.54	
		Week 12	37.98	4.41	
	CTR	Week 0	27.47	4.4	0.001
		Week 6	30.33	4.12	
		Week 12	33.3	4.17	
Speed	EXP	Week 0	4.88	0.86	0.001
		Week 6	4.37	0.47	

		Week 12	3.73	0.49	
	CTR	Week 0	4.91	0.45	0.001
		Week 6	4.53	0.39	
		Week 12	4.32	0.42	
Agility	EXP	Week 0	26.47	2.38	0.001
		Week 6	23.13	2.7	
		Week 12	18.73	3	
	CTR	Week 0	25.42	4.03	0.001
		Week 6	23.41	2.76	
		Week 12	20.62	2.86	

*Con= control group, Exp = experimental group,

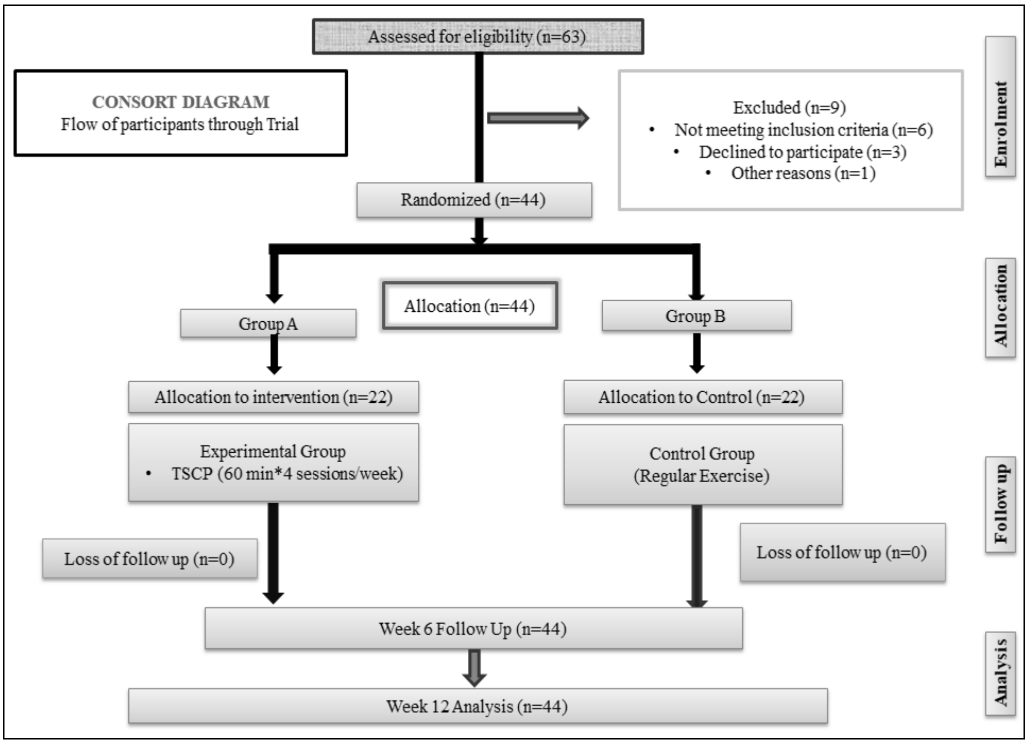

Fig 2: Design and flow of participants through the trail

Footnotes: IBM SPSS23 Software Windows V.28.0.10 version (Statistical package for social science), SPSS

- **Ethics approval:** The Institutional Ethics Committee(s) approved this study. (PIMS/DR/PhD/COPT/2022/142) All participants gave written informed consent before data collection began.
- **Competing interests**: NIL
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