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[ORIGINAL ARTICLE]

A Sequel of Integrative Neuromuscular Training to Emphasize Sports Performance and Injury Prevention Among Tennis Players

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ABSTRACT :

The study evaluates the effectiveness of Integrative Neuromuscular Training (INT) compared to traditional tennis training in various groups of tennis players. Specifically, it aimed to assess the impact of the INT program on dynamic balance, agility, speed, single-leg function, and core strength in tennis players. Additionally, it aimed to compare the effectiveness of the INT program in high-risk groups versus low or no-risk groups among tennis players.

Fifty-six tennis players, including male and female participants who met the eligibility criteria, were recruited for the study. Functional Movement Screen (FMS) tests were conducted to assess the players, after which they were categorized into Group A (high-risk), Group B (low-risk), and Group C (no-risk), with 18 players in each group based on the FMS results. Before the intervention, assessments, including the single-leg hop test, baseline speed and agility test, and abdominal endurance test, were conducted.

The intervention consisted of a four-week training program conducted twice a week, each lasting 40 minutes. Following the intervention, a post-test evaluation was performed. The results indicated that the Integrative Neuromuscular Training program significantly improved tennis players' abdominal Endurance. However, no significant improvement was observed in dynamic balance, speed, and agility among the players.

Keywords: *Functional movement screen, Integrative neuromuscular training, Flexibility, Strength, Agility, Core strength, Single leg function, Endurance.*

Introduction:

Tennis is a game in which two players or pairs of players play on a court divided by a low net. A player scores a point by hitting the ball over the net so it bounces inside the court, and the opponent cannot hit it back.[1]

Tennis requires rapid arm movements, with the shoulder in abduction/external rotation involving jumps, lunges, multidirectional movements with changes of direction, rapid postural changes, repetitive movements of the upper limb in various strokes, prolonged gripping of racket, and high-velocity movements of racket. Tennis-related injuries can be defined as any injury, pain, or physical damage that occurs while playing tennis and leads to a player being unable to participate in training or matches playfully.[2]

Integrative neuromuscular training (INT) is a program to enhance performance, prevent injuries, and improve motor competence. INT programs have 6 essential components: dynamic stabilization, coordination, strength, plyometrics, speed/agility, and fatigue resistance. These 6 components are integrated across the long-term athlete development model, an accumulation of various seasons, practices, and training sessions.[5]

INT sessions are characterized by short bursts of physical activity interspersed with brief rest periods. Although the World Health Organization recommends that youth should engage in 60 minutes or more of physical activity daily, it has been suggested that high-intensity INT should only be performed

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2–3 times per week and on non consecutive days to allow for sufficient recovery time between training sessions.[5]

Neuromuscular control during sports actions depends on the proper functioning of the sensorimotor system. This complex system incorporates afferent and efferent nervous system signals and central integration and processing components to maintain dynamic joint stability.[7]

Improving the sensorimotor system through task-specific training leads to increased neuromuscular control, which can then improve dynamic joint stability during intense sports maneuvers. The concomitant improvements in neuromuscular control and dynamic joint stability can decrease the risk of injury.[7]

Material And Methods

- Stopwatch
- Cones
- Exercise mat
- Measuring tape
- Informed consent form
- Data collection sheet
- Evaluation pro from
- Patient information sheet

After ethical clearance (RegdNo: EC/NEW /INST/1527/ 2023/07/107), 56 tennis players were recruited from LB Stadium Hyderabad, Telangana, who fulfilled eligibility criteria. The inclusion criteria aremale and female tennis players between 20 and 35 and players with no recent injury history. Exclusion criteria are Players with Musculoskeletal disorders, Players with Deformities of upper and lower limbs, and Players with recent injuries in the past two months.

Then, the study was explained to the players, and consent was taken to participate. The subjects willing to participate were included based on the inclusion criteria. Players were tested by functional movement screen (FMS), and they were allocated into a high-risk group (HG), alow-risk group (LG), and a risk group based on the FMS test results. Groups A (HG), B (LG), and C (No risk) had 18 subjects in each group. A pretest was performed before the intervention. Group A(HG) under went INT training for 4 weeks, and Group B (LG) and Group C (no risk) were given regular tennis training programs. The post-test was performed after the intervention.

The program consisted of 8 supervised training sessions over 4weeks. Training was conducted 2 times a week, with sessions lasting 40 minutes. They included a dynamic warm-up, plyometric and jump training, strength training (lower extremity, upper extremity, and core),tennis-specific drills, and flexibility.

Inclusion Criteria

1. Both male and female tennis players.
2. Players between the ages of 20 and 35years.
3. Players with no history of recent injury.
4. Players who are willing to participate in the training program.

Exclusion Criteria

1. Players with Musculoskeletal Disorders.
2. Players with Deformities of upper and lower limbs.
3. Players with recent injuries in the past 2 months.

Outcome Measures:

Singleleg hoptest -The subjects begin by standing on the designated leg, and they were instructed to hop as far as possible forward and land on instructed to hop as far as possible forward and land on the same leg, holding that position for at least 2 seconds. The subjects were allowed to use their arms for balance as required. The distance hopped was recorded.

Baseline speed and agility test- A cone was placed in the center of the baseline and on the singles sideline. Upon command, the subject began on the starting position. It ran to the cone on the sideline, completed a swing with the racquet, ran back to the starting position, and continued back and forth for30seconds, timed with a digital stop watch. The number of repetitions completed in the 30 seconds was recorded and converted to the total distance covered.

Abdominal endurance test: The subjects were positioned on a mat on their backs with their arms crossed over their chests upon command. Both legs were lifted together approximately 15cm off the ground. The player was instructed to maintain this position for as long as possible. The time the subjects maintained this position was recorded with a digital stopwatch.

Integrative and neuromuscular training program

Component	Exercise	Duration
Dynamic warm	1 lap around 2 courts/side step/ arm circles	2 courts
	Straight leg march	Baseline-net-baseline
	Forward lunge	Baseline-net-baseline
	Lateral lunge	Baseline-net-baseline

Component	Exercise	Duration
Jump training	Wall jump	20-25 s
	Tuck jump	20-25 s
	Squat jump	10-20s
	Barrier jump side to side	20 s
	Barrier jump forward-backward	20 s
	180 degree jump	20-25 s
	Single-leg triple hop	3 reps on each leg

Component	Exercise	Duration
Agility/speed	Cross shadow, singles sideline-sideline	2 sets of 10 reps
	Net zig-zag	2 sets
	Forehand with resistance belt	2 sets, 20 sec
	Backhand with resistance belt	2 sets, 20 sec
	Short/deep ball reaction: forward	2 sets of 8 reps
	Short/deep ball reaction: backward	2 sets od 8 reps
	sprints	10 reps
	Ladder	2 reps
	1 court suicide	4 reps
	2 court suicide	1 rep

Component	Exercise	Duration
Strength training	Medicine ball forehand, backward, overhead	2 sets of 6-16 reps
	Medicine ball backwards, between legs	2 sets of 6-16 reps
	Backward lunge, add hand weight day 7	1-2 reps
	Wall push-ups (girls) Regular push ups (boys)	3 sets of 10-20 reps
	Wall sits, ball pressed between legs	3 sets, 45-60 s
	Abdominals crunches, bicycle	3 sets,45-60s
	Abdominals crunches, twisting	30-60 s
	Abdominals plank, alternate leg raise	60-90 s
	Abdominals superman, alternating	2 sets of 10 reps

Component	Exercise	Duration
flexibility	hamstrings	20-30 sec, repeat 2 times each side
	Quadriceps	
	Iliotibial band	
	Gastrocnemius/soleus	
	Deltoid	
	Triceps	
	Pecs/biceps	

Backward Lunge

Wall sits with ball pressed between legs

Side Lunge

Single leg triple hop

Results

Table: Mean Compar is on among high, low, and no-risk groups.

MeanComparison		Pretest	Post-test	Cohen's d	Effect Size
High-riskgroup	Singleleghop test	99.2±5.63	102.33±3.92	0.65	0.31
	Baselinespeed andagilitytest	16.56±6.35	18.39±6.48	0.29	0.14
	Abdominal endurancetest	29.61±7.41	36.78±6.85	1.01	0.45
Low-riskgroup	Single-leg hoptest	100.14 ±4.67	101.71±3	0.4	0.2
	Baseline speedandagilitytest	16.53±6.25	17.83±5.62	0.22	0.11
	Abdominal endurancetest	29.83±8.99	31.94±8.03	0.25	0.12
No riskgroup	Singleleghop test	100.8±5.92	100.22 ±5.06	0.11	0.05
	Baseline speed And agility test	15.69±6.79	14.94±7.07	0.11	0.05
	Abdominal endurancetest	27.11±7.19	28.83±6.35	0.25	0.13

Table 2 : Association between high-risk group pre and post-test.

High-riskgroup		Mean difference	t-test	95% Confidence Interval		P-value
				Lower	Upper	
Single-leghoptest	**pre-post**	3.13±5.19	-2.56	-5.72	-0.55	0.02*
Baseline speed and agilitytest	**pre-post**	1.83±2	-3.87	-2.83	-0.84	0.001**
Abdominal endurance test	**pre-post**	7.16±2.72	-11.14	-8.52	-5.81	0.000***

Note: p-value is given by paired t-test and *, **, *** refer to <0.05, <0.01 and <0.001 level of significance

Table 3: Association between low-risk group pre and post-test.

Low-riskgroup		Meandifference	t-test	95% ConfidenceInterval		P-value
				Lower	Upper	
Single-leghoptest	**pre-post**	1.57±4.68	-1.42	-3.91	0.75	0.172
Baseline speed and agilitytest	**pre-post**	1.31±1.82	-3.04	-2.22	-0.39	0.007*
Abdominal Endurance test	**pre-post**	2.11 ±4.14	-2.16	-4.17	-0.05	0.045*

Note: p-value is given by paired t-test and *, **, *** refer to <0.05, <0.01 and <0.001levelof significance

Table 4 : Association between no-risk group pre and post-test.

Noriskgroup		Mean difference	t-test	95% Confidence Interval		P-value
				Lower	Upper	
Single-leghoptest	**pre-post**	0.58±6.85	0.36	-2.82	3.99	0.724
Base line speed and agilitytest	**pre-post**	0.75±4.78	0.66	-1.63	3.13	0.515
Abdominal Endurance Test	**pre-post**	1.72±3.25	-2.25	-3.33	-0.11	0.038*

Table 5 : ANOVA of high, low, and no-risk groups

ANOVA			Some of Squares	df	Mean Square	F-test	p-value
Single-leg hoptest	**pre-test**	**Between Groups**	23.27	2	11.635	0.394	0.676
		Within Groups	1504.641	51	29.503		
		Total	1527.91	53			
	post-test	**Between Groups**	42.527	2	21.263	1.275	0.288
		Within Groups	850.572	51	16.678		
		Total	893.099	53			

Baselinespeed andagilitytest	**pre-test**	**Between Groups**	8.62	2	4.31	0.103	0.902
		Within Groups	2133.75	51	41.838		
		Total	2142.37	53			
	post-test	**Between Groups**	123.111	2	61.556	1.496	0.234
		Within Groups	2098.722	51	41.151		
		Total	2221.833	53			
Abdominale ndurancetest	**pre-test**	**Between Groups**	82.259	2	41.13	0.659	0.522
		Within Groups	3184.556	51	62.442		
		Total	3266.815	53			
	post-test	**Between Groups**	576.926	2	288.463	5.705	0.006**
		Within Groups	2578.556	51	50.56		
		Total	3155.481	53			

Note:*,**,***referto<0.05,<0.01and<0.001levelofsignificance

Discussion

In this study, we investigated the effect of integrative neuromuscular training on dynamic balance, agility, speed, single-leg function, and core strength in tennis players. The neuromuscular training principles and exercises chosen for this study were derived from a previously published training program that effectively improved neuromuscular indices.

The subjects were divided into 3 groups, with 18 subjects in each group, with a mean age of 24.3 and 12 males and 6 females in the high-risk group, low-risk group with a mean age of 2.7 and11 males and 7 females, no risk with a mean age of 23.7 and 13 mean and 5 female.

The average age of study participants in group A (HG) was 24.39+-3.29, group B (LG) was 24.78+-3.63, and group C (no risk) was 23.78+-2.55.

The present study states that the pre & post-test of the High-risk group for the Single leg hop test, Baseline speed and agility test, and Abdominal endurance test were 3.13 ± 5.19, 1.83 ± 2, and 7.16 ± 2.72, respectively. Pre & post-tests of the High-risk group were highly statistically significant, with a 95% significance level (p-value < 0.05). This study's findings are similar to the study conducted by Barber Westin et al. on 15 junior tennis players in 2017, which concluded that the INT program is efficacious in improving most neuromuscular indices tested($p<0.05$).

In this study, we took 3 groups (high, low, and no-risk groups); we measured dynamic balance, speed and agility, and abdominal Endurance for all the groups.

The statistical analysis showed only a significant value of the Abdominal endurance test with a p-value of 0.006 below 0.05 (p-value < 0.05), which means it is statistically significant.

The present study showed a significant effect size for the abdominal endurance test except for the single leg hop test and baseline speed and agility test.

It has shown highly significant improvement in the player's abdominal Endurance. Core stability and strength are required for trunk rotation during the serve; these elements play an integral role in tennis performance and are required in tennis conditioning programs. This program incorporated numerous drills and exercises to improve core strength and stability in both directions, such as twisting lunges with a medicine ball and exaggerated forehand and backhand medicine ball throws. Joanna Majewska (2022) conducted a study on the effects of 6 weeks of core stability training on fundamental movement patterns in tennis players and concluded that the study showed that specific core strengthening exercises improve the FMS test scores in adult tennis players and this may have an influence on reducing injury risk.

There was no significant improvement in the single-leg hop test because the training program did not include single-hop training, and the only single-leg exercise was the triple hop.

Agility in tennis represents the ability of the player to produce a rapid, reactive change of direction in response to the motion or pathway of the tennis ball. This program included tasks in forward, backward, sideways, and diagonal patterns to improve

agility.The study showed no significance; it could be because the comparative group was low and at no risk, which influenced the results.

Supervision of training of competitive tennis players is essential for continued improvement in both the physical and mental aspects of the game. Kovacs et al. 2009 found that 5-week of unsupervised tennis training significantly reduced speed, power, and aerobic capacity in collegiate-ranked players.

Conclusion

The research concludes that an integrative neuromuscular trainingprogramsignificantly improved the abdominalEndurance of tennis players. However, no significant improvement was seen in the players' dynamicbalance, speed, or agility.

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