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EFFECTIVENESS OF STANDING PILATES ON DYNAMIC BALANCE AND LOWER LIMB MUSCULAR ENDURANCE IN BADMINTON PLAYERS: AN EXPERIMENTAL STUDY

Priyal Vora* BPT (Intern), PES Modern College Of Physiotherapy, Pune. *Corresponding Author

Dr Jahnvi Panwar Asst. Professor, MPT Cardiovascular And Respiratory Sciences, Pes Modern College Of Physiotherapy, Pune

ABSTRACT Badminton is a very challenging sport which demands high intensity, swift, precise and continuous movements that require a high level of dynamic balance and muscular endurance. Standing Pilates is a form of training developed to improve core strength, balance and endurance. Thirty badminton players between 18-25 years were included and divided into two groups. Experimental group (Group A) received standing Pilates and conventional training whereas control group (Group B) was given only conventional training. All players were assessed for dynamic balance and lower limb muscular endurance with Star Excursion Balance Test and Squat Test respectively. Student t-test was used in the analysis of the data collected for all variables at the beginning and at the end of 4 weeks. Comparing post SEBT and squat test values of Group A and Group B showed that standing Pilates has significant effect on dynamic balance and lower limb muscular endurance in badminton players.

KEYWORDS : Star excursion balance test, badminton, standing Pilates, dynamic balance

INTRODUCTION

Badminton, considered as one of the fastest racquet sports in the world requires excellent strength, dynamic balance, quick reflexes and co-ordination [1]. Badminton players need to conduct various explosive movement patterns during the game including lunges, jumps, quick changes in directions and rapid arm movements to strike the shuttlecock and keep the rally going. Hence, badminton is characterized by changing temporal structure with actions of short period and high or medium intensity coupled with short resting times [2].

Performance in badminton players is determined by the relationship of various variables such as strength, reaction time, foot stepping and static or dynamic balances, which are essential motor demands in this sport [2, 3]. Therefore, badminton players need enough muscular endurance and a high level of dynamic balance during the rapid postural movements around the court [2,4].

In early 1900s, Joseph Pilates began developing his exercise system known as Pilates exercises over a period of 50 years [5]. Pilates is a popular form of exercise training program which incorporates series of stretching and strengthening exercises which improve core stability with the use of proper trunk control and breathing. It is associated with numerous health benefits like improved muscle strength and endurance, tone, flexibility, coordination, lung volumes and capacities through deep breathing [6,7].

The 6 principles on which Pilates training is based on are - Centering (i.e., focusing on tightening the power house), Concentration, (i.e., mental focus and attention while performing exercise), Control (i.e., postural management while performing the exercise), Precision (i.e., accuracy of exercise techniques), Flow (i.e., smooth transition of movement within the exercise sequence), Breathing in coordination with the exercise. [8] Pilates helps to improve posture, balance, increases core strength, peripheral mobility, which can be helpful for improving athletic performance [5].

Postural control or balance is defined as an ability to maintain a base support with minimal movement actions and dynamically to perform a motor task while maintaining a stable position. Certainly, balance is the capability to maintain dynamic integration of interior and exterior forces during motor action tasks [9, 10]. Badminton is a dynamic equilibrium process which demands its players to lose balance in the air and restore it after landing. Therefore, players need body coordination and dynamic balance [11]. Dynamic balance is critical fitness component to prevent lower limb injuries that can result because of poor balance [12].

Muscular endurance is defined as the ability of a muscle group to execute repeated contractions over a period of time which results in muscular fatigue, or to maintain a specific percentage of the maximum voluntary contraction for an extended period of time [13]. Elite badminton players require muscular endurance combined with appropriate maximal and explosive muscle strength to keep the shuttle moving back and forth. The musculature of the lower extremities is particularly important in this context since quick and forceful movements with the load of the body are performed continually throughout a match [14].

Dynamic balance and lower limb muscular endurance are very imperative in badminton players. Poor balance and muscular fatigue have been proven to cause lower limb injuries in sports players. Hence, these components should be focused on while training to prevent such injuries. Previous studies have studied the effect of mat Pilates on healthy population, elderly population and sports players focusing on various parameters. Very few studies have been done on standing Pilates and its effect on sports that require excellent balance and muscular endurance. This work intends to develop new ways for improving performance in badminton players using a specialized training program that focuses on various muscles which would affect dynamic balance and lower limb muscular endurance.

The aim and objectives of the study was to compare the effect of standing Pilates exercises along with conventional exercises with conventional exercises alone on dynamic balance and lower limb muscular endurance in badminton players.

MATERIALS AND METHODS

The study began after receiving ethical clearance from P.E.S Modern College of Physiotherapy, Pune. Thirty badminton players were selected, according to the inclusion and exclusion criteria, from badminton centers in and around Pune. The inclusion criteria was: players between the age group of 18-25 years, players with normal BMI 18.5-24.9 [15], players with normative SEBT values [16], players with at least "good" grade Squat test values [17] and players who have been playing for at least 2 years. Players with any kind of spinal and lower limb deformities, players with recent (less than 6 months) musculoskeletal injuries, players with neurological, cardiovascular, vestibular or visual conditions and players who play other sports or do any other type of vigorous training were excluded. The whole study was explained to the players and written informed consent was taken from all the players.

Players who satisfied the inclusion and exclusion criteria were divided into two groups by odd-even method i.e., the even numbered subjects were categorized as group A which included 15 players who received standing Pilates training along with conventional exercises (Experimental group) and group B included 15 players that received conventional exercises only (Control group). Measurements were taken for age, height, weight and Body Mass Index (BMI) for all subjects. All players were then assessed for dynamic balance and lower limb muscular endurance.

1. Star excursion balance test (SEBT) for dynamic balance (r=0.85-0.96)[18]

The SEBTs were performed with the subject standing at the center of a grid laid on the floor with 8 lines extending at 45' increments from the

center of the grid. The subject maintained a single-leg stance on the stance leg while reaching with the opposite leg to touch as far as possible along the chosen line without losing equilibrium. The examiner measures the distance from the center of the grid to the touch point with a tape measure.

The 8 lines were named anterolateral (AL), anterior (A), anteromedial (AM), medial (M), posteromedial (PM), posterior (P), posterolateral (PL) and lateral (L).

The athlete's SEBT performance scores were calculated using the following equations:

- **Average distance in each direction (cm)** = Reach 1 + Reach 2 + Reach 3 / 3
- **Relative (normalized) distance in each direction (%)** = Average distance in each direction / leg length * 100

These calculations were performed for both the right and left leg in each direction, providing a total of 16 scores per athlete.

2. Squat test for lower limb muscular endurance (r = 0.95)[19]

The participant was asked to stand in front of a chair, facing away from it, with their feet shoulders width apart. They were asked to squat down and lightly touch the chair with their backside before standing back up and keep doing it until they are fatigued. The number of squats completed, were recorded.

PROTOCOL

GROUPA

The sessions were conducted on alternate days for 30 minutes, thrice a week for 4 consecutive weeks, with a total of 12 sessions.

Table 1 - Beginner level Standing Pilates training for week 1 and 2 [20]

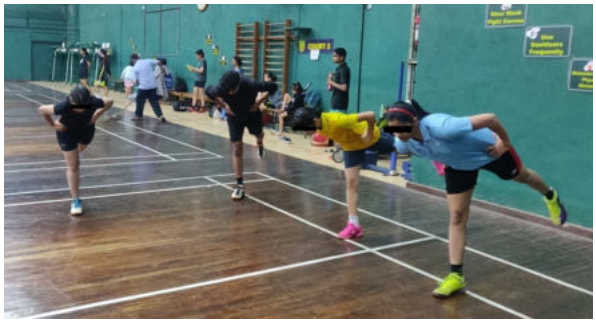
Sr. no.	Exercise
1	The teaser
2	Open leg rocker
3	Rolling like a ball
4	Leg circles
5	Leg kick back
6	Swimming
7	Spine stretch

Table 2 – Intermediate level Standing Pilates training for week 3 and 4 [20]

Sr. no.	Exercise
1	The teaser with a high leg lift to the side
2	Open leg rocker with arms out to the side
3	Rolling like a ball with single leg balance and a full lunge
4	Leg circles with leg lifts and active arms
5	Leg kick back with a knee bend and greater range of spinal extension
6	Swimming with arm movements
7	Spine stretch with arms wide and lumbar flexion

Along with these exercises they also received conventional training.

Image 1 – Players performing standing Pilates exercises



Group B

They continued with their conventional training which included warm up, badminton specific exercises and cool down.

STATISTICALANALYSIS

The data was analyzed using Graph Pad Instats software for windows version. Mean and standard deviation of all the variables were calculated. The data was then subjected to statistical analysis using unpaired-t test.

Table 3 - Mean comparison of age, height, weight and BMI was done for players in both the groups

Variables	Group A	Group B	t-value	p-value
Age (years)	20.357 ± 2.134	19.786 ±1.672	0.7886	0.4375
Height (cm)	166.21 ± 6.963	167.57 ± 5.801	0.5603	0.5801
Weight (kg)	58.143 ± 6.443	62.393 ± 8.058	1.541	0.1353
BMI (kg/m^2)	20.978 ± 1.858	22.129 ± 2.053	1.555	0.1321

Between group analysis shows that there was no significant difference in means of age, height, weight and BMI of the players in both groups.

RESULTS

The data was collected for group A and group B using the star excursion balance test and squat test. As there was not a significant within subject difference (paired-t test) in any direction between right and left lower limb relative distance, the average across both limbs was calculated for each direction. The pre and post values of SEBT and squat tests of Group A and Group B were compared using paired t-test. The average relative distances in 8 directions, recorded at the end of 4 weeks, of group A was compared with group B and analyzed using unpaired-t test. Similarly, the squat test values, recorded at the end of 4 weeks, of group A was compared to group B and analyzed using the unpaired-t test. The difference between the pre and post SEBT and squat test values were compared in both the groups and analyzed using paired –t test.

The SEBT values in Group A, who participated in standing Pilates training showed a p value of <0.0001 in all 8 directions and the squat test values also showed a p value of <0.0001 which is statistically significant and thus standing Pilates training is effective in improving dynamic balance and lower limb muscular endurance.

The SEBT values in Group B, who continued with their conventional training showed a p value of <0.0001 in all 8 directions and the squat test values also showed a p value of <0.0001 which is statistically significant and thus conventional training is effective in improving dynamic balance and lower limb muscular endurance.

Comparing the post SEBT values of Group A and Group B showed a p value <0.0001 in anterior, posterior, anterolateral and anteromedial, 0.0115 in medial, 0.0002 in lateral, 0.0226 in posterolateral and 0.0046 in posteromedial direction which is statistically significant and thus standing Pilates has more effect on dynamic balance in badminton players.

Table 4 - Mean comparison of dynamic balance between the groups.

Direction	Group	Mean	SD	t-value	p-value	Significance
Anterior	A	89.385	3.309	5.586	<0.0001	Extremely significant
	B	82.371	3.336			
Posterior	A	100.896	1.699	5.557	<0.0001	Extremely significant
	B	94.85	3.7			
Medial	A	100.01	3.769	2.718	0.0115	Significant
	B	95.567	4.815			
Lateral	A	83.267	3.019	4.3	0.0002	Extremely significant
	B	77.825	3.648			
Anterolateral	A	88.546	4.212	5.112	<0.0001	Extremely significant
	B	80.928	3.654			
Anteromedial	A	97.721	3.615	6.348	<0.0001	Extremely significant
	B	89.978	2.786			
Posterolateral	A	97.289	4.496	2.424	0.0226	Significant
	B	92.567	5.735			
Posteromedial	A	100.703	3.119	3.104	0.0046	Significant
	B	96.671	3.727			

Comparing the post squat test values of Group A and Group B showed a p value <0.0001 which is standing Pilates has more effect on lower limb muscular endurance in badminton players.

Table 5 - Mean comparison of lower limb muscular endurance between the groups.

Group	Mean	SD	t-value	p-value	Significance
A	69.78	7.87	4.6	<0.0001	Extremely significant
B	56.57	7.31			

DISCUSSION

Group Mean SD t-value p-value Significance A 69.787.874.6<0.0001 Extremely significant B 56.577.31The objective of this study was to determine the effectiveness of standing Pilates on dynamic balance and lower limb muscular endurance in badminton players.

Different badminton centers were visited where subjects were selected on the basis of inclusion and exclusion criteria, divided into 2 groups and their values for SEBT and squat tests were taken. Standing Pilates sessions were taken for group A for 4 weeks and values for both groups were taken again at the end of 4 weeks and analyzed.

Both groups showed significant improvement in both, SEBT and squat test values, but Pilates group brought better results.

Johnson EG et al., found the effects of Pilates-based exercise on dynamic balance in healthy adults. The 5-week Pilates-based exercise session improved core stability and subjects became more kinesthetically conscious of how to reduce flawed movement patterns, leading to improved motor control. He concluded that ten sessions of a Pilates based exercise improved dynamic balance as measured by the Functional Reach Test in healthy adults[21].

Standing Pilates exercises may lead to task-specific neural adaptations at the spinal and supraspinal levels by suppressing spinal reflex excitability such as the muscle stretch reflex during postural tasks which leads to less destabilizing movements and improved balance[22].

The statistical findings of study by Yeole UL et al., on the effect of core strengthening on dynamic balance and agility in badminton players showed that compared to group that performed conventional exercises, Pilates training group had significant improvements in agility, core strength, neuromuscular coordination and dynamic balance at the end of 4 week of training [12].

Preeti et al., found that both, Pilates and control group, improved significantly at the end of 5th week but experimental group showed highly significant difference for lower limb strength, dynamic balance, agility and coordination as compared to Control group. There was considerable increase in SEBT readings of Pilates group in all directions as compared to the control group after 10 sessions [1].

The results of this study are also consistent with a study done by Rasika et al., which concluded that there was a significant difference in balance in basketball players who received standing Pilates training for 4 weeks [23].

In all athletic activities, the players tend to hold their breath, which could affect their performance by reducing the air entry and therefore reducing the oxygen uptake and energy. One of the principles of Pilates is breathing control which makes awareness of one's own breathing during dynamic activities, which enhances the performance by increasing air entry and therefore increases the oxygen uptake and energy. Pilates enhance biological capacity as there is increased oxygen supply to lungs and muscles by enhancing passage of oxygen through them and thereby increasing muscular endurance [24].

The standing Pilates group had much significant improvement than control group because the regular use of standing Pilates exercise led to strengthening of abdominal and core muscles, flexibility of trunk muscles and increased the biological capacity efficiency by breathing control [25].

LIMITATION

- Small sample size
- Limited age group

FUTURE SCOPE

- Larger sample size
- Long term effects of standing Pilates
- Effect of standing Pilates on incidence of injuries
- Effect of standing Pilates on other physical fitness variables like strength, agility, co-ordination and cardiopulmonary fitness.
- Effects of standing Pilates can be compared to other exercise protocols

CONCLUSION

The results of the study showed that physical fitness components i.e. dynamic balance and lower limb muscular endurance showed significant improvement in the experimental group that performed standing Pilates training along with conventional exercises as compared to the control group that performed only conventional exercises. So it is concluded that standing Pilates exercises should be incorporated in the training programme of badminton players in addition to the conventional training to improve balance and muscular endurance.

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