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RESEARCH ARTICLE

EFFECT OF CORE MUSCLE STRENGTHENING ON BALANCE IN BADMINTON PLAYERS

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ABSTRACT

Background: Balance is a key component of a complex game like badminton. Core, is an important component of badminton players, which functions to maintain postural alignment and balance. However, it is not clear how it affects dynamic balance in sports persons. The purpose was to study the effects of core strengthening on static and dynamic balance in badminton players using SEBT, Stork test and Tandem Walk test.
Methods: It was a pre-test post-test study design, in which 30 healthy young badminton players (Mean age 13.70 ± 1.47 years) from Badminton Academy, Mumbai were selected. Measurements of their pre test parameters were recorded.
Intervention: Subjects were assessed and subjected to 8 weeks (4 days/week) of core strengthening program which consisted of four levels and lasted for 30 minutes per session. Subjects progressed to the next level at 2-week intervals. After 8 weeks post-test was conducted.
Main outcome Measures: The subjects were evaluated using the Star excursion Balance Test (SEBT), Stork test and tandem walk test.
Results: There was statistically significant improvement in SEBT scores measuring dynamic balance and Stork test measuring static balance.
(p value< 0.001) **Conclusion:** Core strengthening of eight weeks duration is effective in improving dynamic balance in healthy, young badminton players.

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INTRODUCTION

Outdoor and recreational sports participation is increasing in adolescents and an increase in the frequency or duration of recreational sports participation is leading to proportional increase in the incidence of activity induced musculoskeletal injury. (Bliss and Teeple, 2005) In this changing scenario, fitness training and injury prevention, programs incorporating spinal muscular training, including core strengthening and stability exercises have become popular because the core is considered to be the anatomic and functional centerpiece. (Haapasalo *et al*., 2007) And the power house of the body. The concepts of core stabilization, strengthening or endurance training in the sports medicine community have evolved throughout the years. Previously core stability exercises were widely used for the prevention and rehabilitation of injuries of the lower back and lower extremities. (Willardson, 2007; McGill, 1998; King, 2000; Langevin and Sherman, 2007; Hodges and Moseley, 2003) Recently core stability training has been purported to enhance athletic performance, but the literature has not supported these and, in fact, reported a small effect on performance. (Stanton *et al*., 2004; Lewarchick *et al*., 2003; Sato and Mokha, 2009; Nesser *et al*., 2008; Tse *et al*., 2005) However, the use of core stability training improved dynamic postural control. (Sato and Mokha, 2009; Kibler *et al*., 2006; Samson *et al*., 2007; Aggarwal *et al*., 2010) It appears that repeated activation of core musculature along with extremity movements helps improve postural control. (Kibler *et al*., 2006) During performance of sports skills, a stable core provides a foundation upon which the muscles of the upper and lower extremities can accelerate body segments and transfer force between distal and proximal body segments. (Samson *et al*., 2007)

The core musculature includes muscles of the trunk and pelvis that are responsible for maintaining the stability of the spine and pelvis and are critical for the transfer of energy from larger torso to smaller extremities during many sports activities. (TSE *et al*., 2005) Therefore, it is theoretically believed that if the extremities are strong and the core is weak the decrease in muscular summation through the core will result in less force production and inefficient movement patterns. The core

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stability in athletics dynamically control and transfer large forces from the upper and lower extremities through the core in order to maximize performance and promote efficient biomechanics. (Hibbs *et al*., 2008)

Balance is a complex motor skill that describes the dynamics of body posture to prevent falls. Balance is related to the inertial forces acting on the body and the inertial characteristics of body segments. (Aggarwal *et al*., 2010)

SEBT, a test for dynamic stability is a simple, reliable and valid method of lower extremity functional performance and it is a low-cost alternative to more sophisticated instrumented methods that are currently available. (Gray, 1995; Kinzey and Armstrong, 1998; Hertel *et al*., 2000)

Previous studies (Sandrey and Mitzel, 2013) have reported that balance measures like SEBT improve after 6 week core stabilization program, with few studies stating that there is significant correlation of the lower extremity balance performance with that of the core stability. (TSE *et al*., 2005) However, the effect of core strengthening on dynamic and static balance performance in badminton players has not been reported in quantitative fashion till date conclusively. Thus, the aim of the present study was to study the effect of eight week of core strengthening on dynamic and static balance in Badminton players.

Aims and objectives

The study was aimed at evaluating the effects of core muscle strengthening on balance in badminton players using sports specific tests such as Star-excursion balance (SEBT), Tandem walk test and Stork test.

Methodology

Study design

Before and after effect evaluation study

Study population

The study population was drawn from Badminton players who were attending Badminton Academy of Dadoji Kondev stadium, Thane, Mumbai and Dr. D. Y. Patil Sports Academy, Nerul, Navi Mumbai, either practicing or playing badminton.

Subjects

Inclusion criteria

Either gender, subjects between the age group of 8 to 18 years, playing badminton for more than two years, atleast 30 minutes a day for 4 days per week, and not involved in any formal abdominal or core training program.

Exclusion criteria

1. Had low back pain during last six months
2. Participation in any formal core training and balance training program.
3. Having Ankle fracture/Injuries in the last four months, chronic ligament sprain, Trauma to lower limb and Neurological disorders having balance impairment
4. Not willing to join the study

Sample size

Thirty subjects were enrolled in the study and no formal sample size calculation was carried out.

Study factors

At the time of recruitment, the subject's basic demographic data, injury and treatment details if any, were recorded. Subjects were explained about the study, its importance and the need for his/her cooperation in attending the exercises regularly. After he/she agreed to participate, the patient was asked to fill the consent form. Pretesting was carried out for the three tests SEBT, stork test and Tandem walk test, following the protocol to the exact specifications as described in the literature. Participants were instructed not to change their training schedule or activity level acutely during the period of whole study.

Outcome measures

In the present study, static balance was measured using the stork Balance test; dynamic balance using Star Excursion Balance Test (SEBT) and Tandem walk test. Stork balance test and SEBT were measured on the dominant lower leg. Using the recommendation and method by Gribble and Hertel (2003), we considered only three reach directions (Anteror, Posteromedial and Posterolateral) The reach distance in all the three directions were normalized to the reaching limb length and the average distance was considered.

INTERVENTION: CORE STABILITY TRAINING

After the initial testing, the subjects performed core strengthening exercises for a period of 8 weeks. The subjects performed the exercises with the researcher, 4 times a week for a maximum of 30 min/ session. The 8-week protocol for the core strengthening program was a 4 progressive levels of exercises focusing on strengthening the abdominals, low back and pelvic muscles while maintaining neuro-muscular control. (Table 1)

Statistical analysis

The basic demographic data is presented as Descriptive statistic in tables. The Analytical statistics included the pre and post intervention values which are analyzed using parametric Student's t-test for statistical change in the outcome after ascertaining the normality of data using Graph Pad.

RESULTS

A total of 30 subjects were enrolled in the study, of which 23 were males and 7 were females. The mean age of the subjects in the study was 13.7 years with S.D. of 1.47.

Table 1. Protocol for core stability training

During following functional tasks the participants were instructed to maintain the isometric contraction of the transversus abdominus (TrA) and multifidus (MF) muscles.

	Level 1 Core strengthening exercises	
S. No	Week 1 & 2	Sets x Repetitions
1.	TrA and MF muscle contraction in crook supine lying position	3×15 reps
2.	TrA and MF muscle contraction in prone lying position	3×15 reps
3.	TrA and MF muscle contraction in quadruped position	3×15 reps
4.	TrA and MF muscle contraction in standing on single limb	1×10 reps
5.	TrA and MF muscle contraction in crook lying with leg movements(Foot Lift)	2×10 reps
6.	Bridging	3×15 reps
7.	Quadruped exercise with foot and hand lifts	3×15 reps
8.	Wall squats	3×15 reps
9.	Seated medicine ball rotation	3×15 reps
	Level 2 Week 3 & 4	
1.	TrA and MF muscle contraction with cycling	3×15 reps
2.	Single leg bridging	3×15 reps
3.	TrA and MF muscle contraction seated on swiss ball	3×15 reps
4.	TrA and MF muscle contraction-multidirection lunges(Akuhota and Nadler, 2004; Herrington and Davies, 2005) (Each Extremity)	2×10 reps
5.	TrA and MF muscle contractions Seated on swiss ball (Behm *et al*, 2005)	3 x 15 reps
6.	Squat with swiss ball (Liebenson, 1997)	3 x 15 reps
7.	Superman	2 x 10 reps
	Level 3 Week 5 & 6	
1.	Modified planks	3 x 10 reps
2.	Front planks	3 x 10 reps
3.	Side planks	3 x 10 reps
4.	TrA and MF muscle contractions- Diagonal curls on swiss ball	3 x 15 reps
5.	TrA and MF muscle contractions- Twist on swiss ball	3 x 15 reps
	Level 4 Week 7-8	
1.	Front plank- Stability ball (Behm *et al*, 2005)	2 x 10 reps
2.	Back bridge on stability ball (Akuhota and Nadler, 2004; Behm *et al*, 2005, Fredericson and Moore, 2005; Carter *et al*-2006)	2x10 reps
3.	Twists on swiss ball with 1 kg medicine ball (Fredericson and Moore, 2005)	10 reps each side
4.	Theraband resisted shoulder movements seated on swiss ball	3 x 15 reps
5.	Prone Hip-Knee flex-Ext on swiss ball (Marshall PW, Murphy BA. 2005)	2x10 reps
6.	Stability trainer standing twists with 1 kg medicine ball	3 x 15 reps

Star Excursion Balance Test

Definite improvement in star excursion balance test was observed with the mean pre intervention score of 4.847±0.289 which increased to 5.270±0.404 post intervention. This improvement was statistically significant. (p value<0.0001) **(Table 2)**

Stork Test

The mean pre intervention value was 6.030±2.256 which increased to7.740±3.026 after intervention. This was statistically significant. (p value<0.016) (Table 3)

Table 2. Change in post intervention SEBT score

Parameter	N	Mean	Std. Dev	95% CI
SEBT Pre	30	4.847	0.289	-0.605 to -0.242
SEBT Post	30	5.27	0.404	

The two-tailed P value is < 0.0001, considered extremely significant.

Table 3. Changes in post interventional Stork test

Parameter	N	Mean	Std. Dev	95% CI
Stork Pre	30	6.03	2.256	-3.089to -0.331
Stork Post	30	7.74	3.03	

The two-tailed P value is < 0.016, considered statistical significant.

Table 4. Changes in post interventional Tandem walking test

Parameter	N	Mean	Std. Dev	95% CI
Tandem Pre	30	10.34	0.9046	-0.303 to 0.6414
Tandem Post	30	10.17	0.9219	

The two-tailed P value is < 0.0476, considered not statistical significant.

Tandem walking

The pre intervention mean value improved from 10.340±0.90 sec to10.171±0.921 sec in post test. This was statistically not significant. (p value is < 0.0476) (Table 4)

DISCUSSION

The purpose of the current study was to examine the effects of 8-weeks of core strengthening program on balance in badminton players. To observe the effects of the same, dynamic balance was measured with SEBT and tandem walk test and static balance was measured with stork test. We hypothesized that balance would improve in badminton players after 8 weeks of core strengthening program.

Badminton is an extremely demanding sport. At an elite level, players are often required to perform at their limits of speed, agility, flexibility, endurance and strength. It is a complex game which involves strength, stamina, co-ordination and timely execution of the movement. Analysis of badminton biomechanics has revealed that loading on the spinal structures and the transfer of the torque forces to the spinal segments can be very high during various badminton shots. These dynamic activities cause the centre of gravity to move in response to muscular activity which requires integration of appropriate levels of proprioception, range of motion and strength. This dynamic balance is important for injury prevention. A useful measure of dynamic balance is star excursion balance test.

The SEBT is a measure of dynamic balance and postural control. The core becomes activated before gross body movements as part of the postural control system. Since the core is responsible for postural control, assessments of dynamic balance are alternatives to assess core strength. The three reach directions of the SEBT used in this study were thought to best simulate multiplanar human movement (Sandrey and Mitzel, 2013) noted in badminton sport and would be able to evaluate balance and stability.

SEBT is a reliable functional test with 80-88% reliability hence used as the main outcome factor. SEBT was used as an indirect measurement tool which assesses the dynamic balance and functional capacity of lower extremity where the concept of neuromuscular control is integrated in an optimal performance enhancement program. This test uses the biomechanical principle that the subjects center of gravity must be adequately located over the base of support of the stance leg, as well as it involves an efficient eccentric and isometric neuromuscular control of the joints of the stance leg. In addition, the present study has used SEBT as it mimics the excursions that are used in badminton to prepare for certain shots. After the interventions, significant improvements in the mean SEBT scores were observed in present study. This may be attributed to the abdominal bracing incorporated in the core strengthening program that stabilized the core for the lower-limb movement (Kahle and Gribble, 2009) or to the fact that the subjects possessed neuromuscular control systems that were better suited to their respective movements in sports field. Similar results were also observed by Blackburn and Guskiewicz, Piegaro (Blackburn *et al*., 2000).

It was found that maximal reach distances improved for the SEBT at posttest using healthy subjects compared with a control group after a 6- week core-stability-training program. They summarized that the improvements were related to contraction of the transverse abdominis, internal and external obliques, and the rectus abdominis to provide stabilization to the spine and provide a stronger base of support for lower extremity movement. (Kahle and Gribble, 2009) This stabilization occurs because of initiation of the limb movement. (Kibler *et al*., 2006) Furthermore, the core strengthening program improved the strength and recruitment of the trunk musculature to such an extent that standing on one limb during the SEBT while using the opposite limb to reach may have activated the core muscles and perhaps led to greater reach distances posttest.

The present study also analyzed the effect of core on two other tests i.e. the stork test and tandem walking which are routinely utilized as balance measures. The unilateral balancing stance that is required in stork test is again a measure of trunk balance and stability which is known to be improved with core trunk muscle stability program. In a study by Anoop Agrawal *et al*. they concluded that there was a significant correlation between Stork test i.e. single limb balance performance and core stability. (Gladwell and Samantha, 2006; Hatzitaki *et al*., 2002) Thus stork test was used as one of the outcome measures tests to assess the effect of core strengthening program. During stork balance test there is need to stabilize the whole body weight, in balanced fashion, on the ball of toes.

It is well known that position of the spine significantly determines the position of the body's COG and the compensatory muscle synergy/strategy to counteract the perturbations, to maintain the body's equilibrium state and to regulate body's postural control. Higher core stability performance allows optimal and long sustained contraction of deeper spinal stabilizer muscles. These stabilizer muscles due to their close proximity with the spine are responsible for better control of the intersegment motion of the spine and thus a better control of the body's COG. (TSE *et al*., 2005)

The core muscles after eight weeks of strengthening will respond like any other skeletal muscle, to training, thereby improving the ability of the neuromuscular system to perform dynamic concentric, eccentric, isometric stabilization contractions in response to gravity and momentum. Higher core stability performance might lead to more efficient neural recruitment patterns, increased nervous system activation, improved synchronization of motor units and a lowering of neural inhibitory reflexes (Ludmila *et al*., 2003; Staron *et al*., 1994)

Tandem gait is a high demand activity requiring careful control of both centre of mass movement (head, trunk, pelvis) and the successive reestablishment of a stable, narrow BOS. Compared to normal gait, the tandom walk test tends to be more specific to impairments affecting balance. We hypothesized that this simple tool to assess balance would stress the core muscles, since the torso is important for any movement, involving a more efficient control of upper and lower body muscles thus having a better body balance. It was presumed that better core would offer a better tandem walking score but values of this test were not statistically significant in present study.

The current study used a variety of core strengthening methods that included using unstable surfaces, using limb movement to challenge the postural-control system, and performing some exercises in the weight-bearing position thereby contributing to improved balance scores.

Methodologically this was an exploratory study as there were no similar studies in literature on badminton players. Sample size calculations were not done and best implication of this study is to carry out an RCT in Badminton players comparing core strengthening with other standard training programs and assessing balance as well as performance and long time injury prevention.

Conclusion

The core strengthening program of 8 week duration was effective in improving both dynamic and static balance in badminton players thus leading to the conclusion that core muscle strengthening could become part of standard training program for Badminton players and other sports activities.

Implications

Sports medicine practitioners must incorporate core strengthening techniques as a part of training protocol to improve performance and prevent injury. Core strengthening program can be used in patients with balance deficits, so as to improve balance and reduce the risk of falls and injuries.

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