Journal of Advances and Scholarly Researches in Allied Education
Vol. 19, Issue No. 6, December-2022, ISSN 2230-7540

Core strength training's impact on badminton players' performance skills is compared before and after

Dr. Gunjan Shukla[1]*, Dr. Kalpana Jain[2], Dr. Namrata Srivastava[3], Dr. Kartik Chhonker[4], Dr. Neeraj Singh[5]

Abstract -

TITLE: Core strength training's impact on badminton players' performance skills is compared before and after.

BACKGROUND: Reduced core muscle strength is an independent risk factor for sports injury and injury in badminton players. Core stability depends on core strength, which also lowers injury risk and improves performance.

PURPOSE OF STUDY: The goal is to evaluate how a core-strengthening exercise programme affects players' performance abilities and core stability.

METHODOLOGY: In this study 30 badminton players were included for the study, pre and post intervention assessment was done for strength using outcome measure (Lockhart-Mcpherson badminton test and Miller Wall-Volley test) followed by core strengthening exercises programme to perform 45 mins for 5 days per week for 6 weeks

RESULT: According to table 1, Graph 1, Graph 2 training in core strength has shown that Lockhart-Mcpherson badminton test score increases in mean value from 116.03 to 124 between pre and post-test and Miller Wall-volley in meanvalue from 102.82 to 111.56.

The table infers a significant increase in Lockhart-Mcpherson badminton test and Miller Wall-volley test scoreby core strength training at P < 0.05.

CONCLUSION: The result indicates that core strength training programme are significantly effective in improvement of corestability performance skills in badminton players

Keywords - Core strength training, Lockhart-Mcpherson badminton test, Miller Wall-Volley test, trunk stability

----------X----------

INTRODUCTION

After reviewing the relationship between core strength and sports in the 1990s, when sports received a lot of public attention, researchers finally applied core strength to competitive sports, which significantly improved athletes' athletic achievements. Since then, developing one's core strength has become essential for training in competitive sports[1]. Badminton is an extremely competitive dynamic sport requiring such a demand on the muscular system. Core strength exercises are frequently employed in the health and fitness, rehabilitation, and strength and conditioning fields, with claims of improving performance and lowering the risk of injury [2,3].

The core strength is a strength generated by core components supporting the body during movement. Core segments of the body are the places where main strengths of the body are gathered, which will effectively control the lower and upper extremities and the direction of COG during movement[1]. Those muscle in the core are layers of muscles which perform an analogous function that is providing stability and help the limb perform fluently over a stable Base of Support [4-6]. Throughout the motion, the core strength can perceive the needs of the body in advance so as to make the player ready for movement in advance[7]. A a steady core offers a basis throughout the development of sporting skills on which the lower and upper extremity muscles will

accelerate body parts and transmit the force between proximal and distal body segments[8].

Characteristics of the badminton throughout movement mainly include, aiming at attack during movement: Unlike the basketball or soccer, the badminton is especially aiming at attack, once receiving the shuttle from the opponent; the player will increase the intensity of the attack and attack quickly. Fast in attack: Through power generation, the badminton player can regulate the speed of the shuttle, but during a match, it must be kept quick. The quick attack can reduce the opponent's time for observation and thinking, which will cause psychological tension and fear of the opponent in order to diffuse his or her own focus during the game and achieve the victory of attack. Flexible and diverse during movement: In order to provoke the opponent's counterattack and score points, players should employ adaptable attack strategies throughout movement based on the opponent's tendencies and in-game analyses[1]. steadily moving: The badminton sport is to activate the movement of all parts, therefore, throughout the movement,it focuses on the steadiness whether in the body or the way of attack [9], Specifically, throughout the movement, it is necessary to balance the body and no imbalance because of receiving it, of which the attacker should have a stable technique and take the shuttle distance, time to receive, and attach orientation into consideration during the attack so that the opponent cannot exploit it[1].

As a result of Core Strength Training, significant improvements in core strength have been reported, but the same study has not shown any changes concerning the Performance that need further research[10-12]. Several studies have shown significant improvement in performance such as running kinetics, lower extremitystability, 5000-M performance, running economy, core stability, balance, swimming performance with core muscle training[13-17]. Also, there are studies shown in order to avert harm to various sports such as football,volleyball, badminton & athletics[18-23] and studies that show improvement in pain[24, 25].

Core strength training has important roles in badminton.

Sport research on the key functions of core strength in sport would help raise people's understanding of the significance of core strength and support badminton-specific core strength training. Accordingly, the sport of badminton's core strength, energy, and players' safety are analyzed. Among its core strength's functions are:

1) **Assist in body balance control for players:** The shuttle mass is relatively light and requires less activities, so it moves very slightly. However, because the player must maintain consistency at the foot to improve shuttle movement in badminton, physical balance is prioritized. Furthermore, the player has to manage the body equilibrium throughout the assault smash. All of these are only accomplished with core strength management. But in the case of badminton, perhaps a lot of people believe that the sport only calls for arm motion. The use of weapons is done for technological purposes. According to science, the different components of the body must work together in harmony if badminton is to be successful. This implies that each move made in badminton must be controlled by its main strength.

2) **Maintain the equilibrium of energy and improve players' skills:** The majority thinks badminton is just a game where players move their lower limbs to locate a shuttle for the assault due to optical phenomena. Actually, Every player's movement and energy conversion during the game of badminton is controlled by their core strength, which guarantees the orderly flow of their body's energies, reduces joint tension, and improves their body's ability to work together while they move.

3) **Protect the safety of players and avoid injuries during movement**: In recent years fitness has progressively become a trendy issue, and badminton activities have grown popular with a large number of sport fans as a national sport. However, Overtraining exercises invariably result in injuries to the body, including joint damage and spinal injury. But US expert investigation has demonstrated that players who have better power not only can fully maintain body balance in motion thanks to their strong skills, but can also quickly restore muscles to a short relaxation period which reduces the consumption of energy and the stresses to ensure players' safety during their movement and reduces the potential for harm. Additionally, athletes with stronger core muscles can maintain ideal postures when moving in the heat, which reduces energy loss and injuries brought on by improper motions. Despite the fact that core strength has received widespread attention, little research has been done on it in various sports, especially badminton, which is a popular sport with the public. This lack of research is what inspired this study.

OBJECTIVE OF THE STUDY

The goal is to determine how badminton players' performance skills are affected by core strength training.

NEED OF THE STUDY

Several studies analyzed how Core Strength Training impacts injury prevention and pain reduction in badminton players and improved performance in other players, However, no study has been published that explains how badminton

players' performance skills are impacted by their core muscular strength. This study is to focus on improving the performance skills among badminton players by the core muscles strengthening.

HYPOTHESES

Null Hypothesis

Training for core strength has no discernible impact on badminton players' performance abilities.

Alternate Hypothesis

Core strength training has a substantial impact on badminton players' performance abilities.

REVIEW OF LITERATURE

Anusha R et al., (2017) concluded that in non-athletes with low back pain, there is a significant positive connection between core muscle strength and hand-eye coordination. This study makes it very evident that, while not being a direct cause and effect, core muscle strength is an essential part of upper extremity skill output.

Mengyao Xie et al. (2016) came to the conclusion that core strength training is crucial to the sport of badminton because it can improve stability, the movement of the spine and pelvis, as well as the ability of athletes to work more effectively and efficiently, connect their upper and lower limbs, and prevent injuries.

Mohamed Faisal et al. (2016) came to the conclusion that strengthening the core muscles helps female Patellofemoral Pain Syndrome patients with pain and dynamic balance.

Akhtar Pooja et al., (2015) concluded that core strengthening of eight weeks duration is successful at enhancing dynamic equilibrium in healthy, young badminton players.

James W.Youdas et al., (2014) concluded that Muscle recruitment was greater within ipsilateral skeletal muscles weight-bearing trunk and thigh for all examined muscles except RA during RSB and LT during TESS. For strengthening, activation at or above 50% MVIC is required. The GM and EO being activated satisfies these conditions.

Huxel et al., (2013) stated that musculoskeletal injury prevention programmes frequently involve strengthening core stability through exercise. But it appears that a comprehensive preventative strategy that incorporates core stability exercises can minimise the incidence of lower extremity injuries.

Sheri P.Silfies et al., (2013) It was determined that there is just a little amount of data to support the use of core stability training in athletic injury prevention or performance enhancement programmes.

Bien DP et al., (2011) According to the study's findings, stretching, hip and hamstring strengthening, core stability, plyometrics, agility, balance, and neuromuscular training with video and verbal feedback to correct technique are all crucial parts of warm-up programmes for preventing ACL injuries in women.

Liemohn WP et al., (2010) reported that the total or mean of trials 2 to 6 for days 2 to 4 was used as the criterion score, and the internal consistency intraclass reliability coefficients based on a one-way analysis of variance model were 0.89, 0.95, and 0.92, respectively. For day 2 compared to day 3 and day 3 compared to day 4, the stability reliabilities were 0.76 and 0.92, respectively.

McGill SM et al., (2009) We came to the conclusion that the information offered in this study might be utilised to inform clinical decision-making when selecting a particular exercise style, as well as when determining the right starting point, a logical progression, an appropriate dosage, and potential corrective techniques to improve patient tolerance.

Sato K et al., (2009) concluded that: After 6 weeks, the core strength training group had faster times in the 5000-meter run, indicating a significant interaction. CST did not have a substantial impact on lower leg stability or GRF characteristics, either. Running performance may be improved by using a core strength training programme.

Steffen K et al., (2008) oncluded that the injury prevention programme (a set of exercises known as the "11") had no impact on the injury rate, perhaps as a result of the program's low compliance.

Carpes FP et al., (2008) determined that pelvic discomfort, low back pain, and bodily balance are all influenced by the strength and stability of the trunk.

Smith CE et al., (2008) It is suggested that a conceptual, 3-phase, progressive volleyball-specific training programme be developed to increase dynamic trunk stability and possibly lower the rate of back injuries among volleyball players.

Peate WF et al., (2007) The findings imply that core strength and functional mobility development programmes are necessary to prevent accidents in people whose jobs require them to be in uncomfortable positions.

Stevens VK et al., (2007) concluded that a training regimen that emphasises neuromuscular control can affect muscle recruitment patterns in healthy participants.

Gribble PA et al., (2003) concluded that prolonged ankle instability and fatigue altered regulation of sagittal-plane joint angles proximal to the ankle, which in turn impaired dynamic postural control.

McGill et al., (2001) Note that the goal is to push muscular systems to reach a level of functional stability while sparing the spine from an excessively aggravating load.

METHODOLOGY

- Study design: Experimental study
- Study type: Pre and Post-test
- Sampling method: Convenient sampling
- Study duration: 6 weeks
- Sample size: 30
- Study setting: Career College Bhopal. Indore's Raja Ram Mohan Roy Badminton Academy.

Inclusion Criteria

- Age group 16-25 years
- Both men and women
- Professional badminton players of experience > 2 year
- Off-season players

Exclusion Criteria

- Participation in another study
- History of disc pathology
- Neurological condition
- Cardio-respiratory condition
- History of spinal surgery in the past 2 years
- History of any fracture in the past 2 years

Variables

- **Independent Variable:** Core strength training exercises
- **Dependent Variable:** Lockhart Mcpherson badminton test and Mill wall volley test

PROCEDURE

The participants were taken based on following; both sexes with age between 18-28 years with more than 2 years of experience are included with players off the season. While the players with Participation in another study, history of disc pathology, neurological conditions, cardio-respiratory conditions, history of spinal surgery in past 2 years, history of any fractures in past 2 years are excluded. The informed consent was taken from the players after explaining the test procedures in their language. The participants were evaluated through Badminton performance tests (Lockhart- McPherson Badminton test and The Badminton wall volley test) as a pre-test and followed by core strengthening exercise regimen administered to perform 45 min/day for 5 Days per week, for 6 Weeks.

Core strengthening exercises

The above mentioned pre-test scores were measured as post-test scores after 6 Weeks programme for core strength training.

Supine Bridge

The player is told to go into the supine position, bend their knees to 90 degrees with their feet lying flat on the ground, and then rise their hips to align their shoulders and knees in a straight line. This exercise required a holding period of 15 seconds, which was repeated for 4 reps in a set and 3 sets in a session.

Supine Unilateral Bridge

The player is told to lie in the supine position, bend both knees to 90 degrees with the feet lying flat on the ground, lift the hips to form a straight line with the shoulder and knees, and lift one leg into full knee extension. This exercise was held for 15 seconds for each repetition, with four repetitions in a set and three sets in a session.

Side Plank

The participant was told to lie on side with the trunk supported over the forearm with the elbows bent to 90 degree; the hip is then raised to align it with trunk; this exercise was held for 15 Seconds for the repetition of 4 in a Set and 3 Sets for a session.

Plank

The participant was directed to Prone on elbows and lifts the body to make a line with shoulder and feet with the elbows placed directly below the shoulders and feet shoulder-width apart; this exercise was held for 15 Seconds for the Repetition of 4 in a Set and 3 Sets for a Session.

Bird Dog

The individual was routed to make quadruped position; then the contralateral arm and leg are lifted alternatively; this exercise was repeated for 8 Repetitions each side in a Set and 3 Sets for a Session.

Dead Bug

Began lying supine with the arms extended perpendicular to the floor and body in line with the shoulder; Knees flexed to 90 degree angle; Then the contralateral arm and leg is lowered down parallel to the floor; Returned back to the beginning point, then repeated on alternate sides. This exercise was repeated for 8 Repetitions each side in a Set and 3 Sets for a Session.

MATERIALS REQUIRED

1. Badminton Racquet
2. Shuttlecock
3. Inch tape
4. Marking tape/chalk
5. Stop watch

OUTCOME MEASURES

Lockhart- McPherson Badminton test

The Miller Wall Volley Test

Markings:

Wall marking line - 5 ft. from the floor (net height) Starting line - 6.5 ft. from wall

Restraining line – 3 ft. from wall

Procedure:

Serves the shuttle from behind the starting line against the wall to begin. The student continues returning the shuttle against the wall from wherever they are behind the restraint line after it hits the wall and bounces back. The goal is to strike the shuttle as many times as possible in 30 seconds. They may pick up the shuttle if it touches the ground and return it to play from behind the starting line, starting the count over again. If a student steps outside of the net line or restraining line, they are still allowed to take the test, but any hits that occur during that infraction are not allowed to be counted. Each student takes the exam three times, and the results are combined.

Miller wall volley testProcedure:

The player could use any stroke to keep the Shuttlecock in play. If the hit eventually goes on or overthe 7 ½ Foot Wall-line, a carried shuttlecock or a double hit are counted as a score.

Scoring:

The score for each trial is an Accumulative number of hits made within 30 seconds. It offers three, 30 second trials. The score is a total of 3 trials.

DATA ANALYSIS

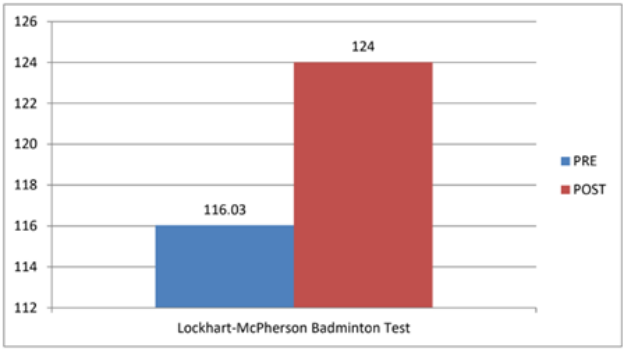
Data were analyzed by using IBM SPSS version 16.0 software. A paired t- test was applied to assess the Lockhart-McPherson Badminton Test and Miller wall-volley test.

TABLE-1: COMPARISON OF PRE AND POST TEST VALUES OF LOCKHART-MCPHERSON BADMINTON TEST AND MILLER WALL VOLLEY TEST

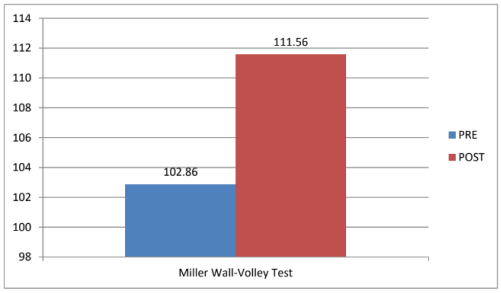
	N	PRE		POST		T-TEST	SIG
		MEAN	S.D	MEAN	S.D		
Lockhart-McPherson Badminton Test	30	116.03	19.31	124	18.69	-7.46	.000
Miller Wall-Volley Test		102.86	19.82	111.56	19.59	-8.25	.000

The above table shows the mean, standard deviation, t-test and p-value of Lockhart-McPherson Badminton Test and Miller Wall-volley Test. This shows an increase in Lockhart-McPherson Badminton Test score mean value from 116.03 to 124 and Miller Wall-volley Test score mean value from 102.82 to 111.56 between pre and post-tests. The table infers a significant increase in both Lockhart- McPherson Badminton Test score And Miller Wall- volley Test score between pre and post-test at $p<0.05$ level.

GRAPH-1: PRE AND POST TEST VALUES OF LOCKHART-MCPHERSON BADMINTON TEST



GRAPH-2: PRE AND POST TEST VALUES OF MILLER WALL-VOLLEY TEST RESULTS



According to Table 1, Graph-1 and Graph-2 CORE STRENGTH TRAINING has shown a Lockhart-McPherson Badminton Test score increase in mean value from 116.03 to 124 between pre and post-test and Miller wall-volley test score increase in mean value from 102.82 to 111.56.

The table infers a significant increase in a Lockhart-McPherson Badminton Test score and Miller wall-volley test score by core strength training at $p<0.05$ level.

DISCUSSION

This study aims to ascertain how core strength training affects performance skills among badminton players spanning over a period of 6 weeks duration. The study involves 30 subjects given core strength training. The statistical result has shown that the core strength training showed statistically significant improvement in Lockhart-McPherson Badminton Test and Miller Wall-volley Test scores. Anusha Reddy et.al (2017) suggested that hand eye coordination have been improved using core muscle strength and endurance training[26]. Aminaka N et al. (2008) suggested that the ability to control posture is impacted by core strengthening due to the altered sensory/motor pathways or both[27]. Investigating exercise could greatly improve dynamic balance, according to research on the performance effects of core stability exercises.[28-31]. Sandrey et al. (2013) suggested that the dynamic balance have been augmented in the Track& Field Athletes by a 6week Core Stability training regimen[28]. Ibrahim Hassan (2017) also shown that a core stability training programme lasting eight weeks considerably enhanced players' smash stroke and dynamic balance[30]. Additionally, Rajiv Sighamoney et al. (2018) found that performing core stability exercises significantly improved (P=0.02) badminton players' dynamic balance and agility[31].

There are many outcome measures to assess the effectiveness of the badminton players such as serve tests, clear tests and smash tests but they lack in simulating the real game situation. So the Lockhart McPherson Badminton Test and Miller Wall Volley test which are both reliable and simulating a game situation[32, 33].

Though the badminton pertains to a lightweight movement, the player during attack needs to control the body balance, which can be only completed by the well-controlled core. Usually the badminton is perceived as the movement of arm is the only essential requirement as most of the technical actions are done by arm. Yet it is a mutual coordination of different bodily parts especially of controlled core strength[1].

Usually the badminton seems to be the lower limb's movement which helps locating the shuttle and the mobility of the upper limb which helps in controlling attack direction and intensity, yet the movement and energy conversion are controlled by the core strength which helps reducing the joint load and enhance cooperation between body parts during movement[1].

For instance, in badminton, the players mostly score points through attacks, hence in order to properly score points; they have to gather the power to the arm, then through swing the bat with the power transferred to the shuttle. This transfer of the power requires that the core strength should control the whole body for movement and concentration. Thus, the core strength has a good effect in maintaining the harmony between energy and improving the skills of the players[1].

Ensure the players' safety when moving, and prevent injuries: In recent years, the badminton sport, as a nationwide sport, are popular in many sports fans. However the overload exercises are inevitably causing some body injuries such as joint damages and spinal injury and so on [34]. In addition, the players with better core strength can keep correct exercise postures during movement and lower the energy loss and injuries due to wrong actions[1]. Thus, it seems that by improving core muscles, badminton players canimprove their performance.

CONCLUSION

The study was concluded that the core strength training showed a statistically significant increase in Lockhart-McPherson Badminton Test score And Miller Wall-volley Test score.

LIMITATIONS AND RECOMMENDATIONS

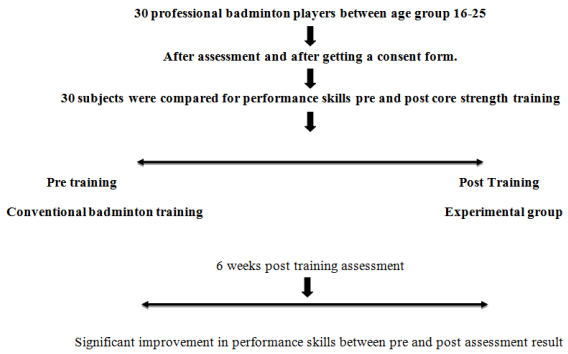
Limitations

- The study duration was very less.
- Subjects more than 28 years of age were not included.
- The sample size was small

Recommendations

- The long duration of the study can be done.
- Further studies can be executed with a broader dimension and long follow up.
- Other outcome measures which can assess the performance more similar to a game situation can beused.

SUMMARY



REFERENCES

1. Wang J, Cheng J. Application of Core Strength Training in Badminton Sport. In2016 2nd International Conference on Economy, Management, Law and Education (EMLE 2016) 2016 Dec. Atlantis Press.
2. McGill SM. Low back stability: from formal description to issues for performance and rehabilitation. Exercise and sport sciences reviews. 2001 Jan 1;29(1):26-31.
3. Olmsted LC, Carcia CR, Hertel J, Shultz SJ. Efficacy of the star excursion balance tests in detecting reachdeficits in subjects with chronic ankle instability. Journal of athletic training. 2002 Oct;37(4):501.
4. Panjabi MM. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. Journal of spinal disorders. 1992 Dec 1;5:390-.
5. Akuthota V, Nadler SF. Core strengthening. Archives of physical medicine and rehabilitation. 2004 Mar1;85:86-92.
6. Bergmark A. Stability of the lumbar spine: a study in mechanical engineering. Acta Orthopaedica Scandinavica. 1989 Jan 1;60(sup230):1-54.
7. Wang J, Cheng J. Application of Core Strength Training in Badminton Sport. In2016 2nd International Conference on Economy, Management, Law and Education (EMLE 2016) 2016 Dec. Atlantis Press.
8. Samson KM, Sandrey MA, Hetrick A. A core stabilization training program for tennis athletes. Athletic Therapy Today. 2007 May 1;12(3):41.
9. Wang J, Cheng J. Application of Core Strength Training in Badminton Sport. In2016 2nd International Conference on Economy, Management, Law and Education (EMLE 2016) 2016 Dec. Atlantis Press.
10. Hsu SL, Oda H, Shirahata S, Watanabe M, Sasaki M. Effects of core strength training on core stability. Journal of physical therapy science. 2018;30(8):1014-8.
11. Ekstrom RA, Donatelli RA, Carp KC. Electromyographic analysis of core trunk, hip, and thigh muscles during 9 rehabilitation exercises. Journal of orthopaedic & sports physical therapy. 2007 Dec;37(12):754-62.
12. Hung KC, Chung HW, Yu CC, Lai HC, Sun FH. Effects of 8-week core training on core endurance and running economy. PloS one. 2019;14(3).
13. Sato K, Mokha M. Does core strength training influence running kinetics, lower-extremity stability, and 5000-M performance in runners?. The Journal of Strength & Conditioning Research. 2009 Jan 1;23(1):133- 40.
14. Stanton R, Reaburn PR, Humphries B. The effect of short-term Swiss ball training on core stability and running economy. The Journal of Strength & Conditioning Research. 2004 Aug 1;18(3):522-8.
15. Cosio-Lima LM, Reynolds KL, Winter C, Paolone V, Jones MT. Effects of physioball and conventional floor exercises on early phase adaptations in back and abdominal core stability and balance in women. The Journal of Strength & Conditioning Research. 2003 Nov 1;17(4):721-5.
16. Scibek JS. The effect of core stabilization training on functional performance in swimming (Doctoral dissertation, University of North Carolina at Chapel Hill).
17. McGill SM, Karpowicz A. Exercises for spine stabilization: motion/motor patterns, stability progressions, and clinical technique. Archives of physical medicine and rehabilitation. 2009 Jan 1;90(1):118-26.
18. Huxel Bliven KC, Anderson BE. Core stability training for injury prevention. Sports

health. 2013 Nov;5(6):514-22.

19. Bien DP. Rationale and implementation of anterior cruciate ligament injury prevention warm-up programs in female athletes. The Journal of Strength & Conditioning Research. 2011 Jan 1;25(1):271-85.

20. Peate WF, Bates G, Lunda K, Francis S, Bellamy K. Core strength: a new model for injury prediction and prevention. Journal of Occupational Medicine and Toxicology. 2007 Dec 1;2(1):3.

21. Lockhart A, McPherson FA. The development of a test of badminton playing ability. Research Quarterly. American Association for Health, Physical Education and Recreation. 1949 Dec 1;20(4):402-5

22. Steffen K, Myklebust G, Olsen OE, Holme I, Bahr R. Preventing injuries in female youth football–a cluster-randomized controlled trial. Scandinavian journal of medicine & science in sports. 2008 Oct;18(5):605-14.

23. Kang AL, Ramalingam V. Risk factors for lower extremity injuries in young badminton players. Scientia Medica. 2018;28(2):5.

24. Carpes FP, Reinehr FB, Mota CB. Effects of a program for trunk strength and stability on pain, low back and pelvis kinematics, and body balance: a pilot study. Journal of bodywork and movement therapies. 2008 Jan 1;12(1):22-30.

25. Chevidikunnan MF, Al Saif A, Gaowgzeh RA, Mamdouh KA. Effectiveness of core muscle strengthening for improving pain and dynamic balance among female patients with patellofemoral pain syndrome. Journal of physical therapy science. 2016;28(5):1518-23.

26. Reddy A, Arunachalam R, Anitha A. CORRELATION BETWEEN CORE MUSCLE STRENGTH AND HAND-EYE COORDINATION IN NON ATHLETES. INTERNATIONAL JOURNAL OF PHYSIOTHERAPY. 2017 Oct 1;4(5):291-5.

27. Aminaka N, Gribble PA. Patellar taping, patellofemoral pain syndrome, lower extremity kinematics, and dynamic postural control. Journal of athletic training. 2008 Jan;43(1):21-8.

28. Sandrey MA, Mitzel JG. Improvement in dynamic balance and core endurance after a 6-week core- stability-training program in high school track and field athletes. Journal of sport rehabilitation. 2013 Nov 1;22(4):264-71.

29. Granacher U, Schellbach J, Klein K, Prieske O, Baeyens JP, Muehlbauer T. Effects of core strength training using stable versus unstable surfaces on physical fitness in adolescents: a randomized controlled trial. BMC sports science, medicine and rehabilitation. 2014 Dec; 6(1):40.

30. Hassan IH. The effect of core stability training on dynamic balance and smash stroke performance in badminton players. International Journal of Sports Science and Physical Education. 2017 Aug 10;2(3):44-52.

31. Sighamoney R, Kad R, Yeole UL. Effect of core strengthening on dynamic balance and agility in badminton players. International Journal of Physical Education, Sports and Health. 2018;5(1):86-.

32. Lockhart A, McPherson FA. The development of a test of badminton playing ability. Research Quarterly. American Association for Health, Physical Education and Recreation. 1949 Dec 1;20(4):402-5.

33. Miller FA. A badminton wall volley test. Research Quarterly. American Association for Health, Physical Education and Recreation. 1951 May 1;22(2):208- 13.

34. Xing Zhinan, Important Role of Core Strength Training in Badminton Exercise [J]. Heilongjiang Science and Technology Information, 2014(10)

Corresponding Author

Dr. Gunjan Shukla*