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EFFICACY OF EXERCISE PROTOCOLS ON BALANCE IN BADMINTON PLAYERS – A SYSTEMATIC REVIEW & META-ANALYSIS

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[A] Study Design; [B] Data Collection; [C] Statistical Analysis; [D] Manuscript Preparation

Abstract Objective. The goal of this "systematic review" and meta-analysis is to find out the efficacy of exercise regimes on balance in badminton players.
Study Design. Systematic review and meta-analysis.
Data Source. Pub Med, "Cochrane database (Cochrane Central Register of Controlled Trials)", Google Scholar, Springer, and DOAJ.
Eligibility criteria. Limits were applied to database searches to identify papers published in English and only human studies were included.
Results. Result of Meta – analysis was statistically significant in "anterior component of Y-balance test" (MD = 2.39, 95% CI = 1.90, 2.89; "$p \leq 0.00001$") with low heterogeneity ($I^2 = 0\%$, $p < 0.41$). There was statistically significant improvement in postero-medial component of y- balance (MD = 2.87, 95% CI = 0.55, 5.19; $p \leq 0.02$) with "moderate heterogeneity" ($I^2 = 39\%$, $p < 0.19$). Result showed statistically significant improvement in postero-lateral component of y- balance test (MD = 3.09, 95% CI = 0.64, 5.65; $p \leq 0.02$) with "moderate heterogeneity ($I^2 = 38\%$, $p < 0.20$)". There was "statistically significant "improvement in overall balance of y-balance test in "experimental group as compared to control group (MD = 8.49, 95% CI = 4.62,12.36; $p \leq 0.0001$) with low heterogeneity ($I^2 = 0\%$, $P < 0.47$)".
Conclusion. This systematic and meta-analysis concluded that various exercise protocols may result in improvement in the balance of badminton players.
PROSPERO registration number: CRD42020193620.

Key words badminton, core stability training, Pilates, Plyometric, Swiss ball, core strengthening, balance

Introduction

Exercise protocols like core stability training, Pilates, Plyometric, Swiss ball, PNF, Sensorimotor training, and core strengthening are frequently used by physiotherapists to treat trunk muscle imbalance, weakness, and lower limb injuries. "Muscular corset with abdominals in front, gluteal and erector spine at the back, diaphragms roof, hip girdle musculature and pelvic girdle as bottom describes the core." During activities where the motion of upper and lower extremities is involved such as jumping, throwing, and running, the spine and trunk are stabilized by the core muscles (Akuthota, Ferreiro, Moore, Fredericson, 2008). For improving performance, decreasing the risk of injuries in athletes (Sekendiz, Cug, Korkusuz, 2010) rehabilitation of patients with pain in lower back (Marshall, Murphy, .2006). and for enhancing physical fitness in healthy individuals (Sekendiz, 2010) core strength training has been used widely (Saeterbakken, Van den Tillaar, Seiler, 2011; Schilling, Murphy, Bonney, Thich, 2013; Stanton, Reaburn,

Humphries, 2004; Tse, McManus, Masters, 2005) and it is also believed that people with weak trunk extensor muscles have a risk of back pain (Lee, Hoshino, Nakamura, Kariya, Saita, Ito; 1999).

Pilates, which helps improve balance, posture, increase core strength, and peripheral mobility is believed to overall improve athletic performance, is a kind of exercise that incorporates in itself various series of stretching and strengthening exercises taking into account proper trunk control and breathing. It is believed to act upon trunk stability principles which are also called core stability (Akuthota, Nadler, 2004; Niehues, 2015). For improving athletic performance, Pilates may be helpful in improving posture, balance, increasing core strength and peripheral mobility (Anderson, Spector, 2000). The main objective of this exercise is supposed to be organizing the mind, body, and breath which in turn helps to build up abdominal muscles that are sleek and strong and also helps to build a strong and agile back (Tarpey, 2005).

Another type of exercise is plyometric which is believed as an effective training modality that helps in improving awareness about joint, balance, and neuromuscular properties (Arazi, Asadi, 2011). It involves stretching exercises which involve musculotendinous tissue shortening cycle that brings about maximum power production by using "the energy stored during eccentric phase and muscle spindle stimulation" which is needed for reactive neuromuscular training that is a concentric phase of movement (Asadi, de Villarreal, Arazi 2015).

Neural adaptations, that enhance proprioception, kinesthesia, and muscle performance characteristics, may be facilitated by plyometric training (Patel, 2014). "Repeated stimulation of mechanoreceptors that are near the end range of motion creates these adaptations". Plyometric training and balance relationship are attributed to neuromuscular adaptability development (Arazi, 2012).

Almost Identical to bodyweight exercises are the Swiss ball exercise, although Swiss ball exercises are slightly difficult. The strength and stability of stabilizing muscles can be improved by an unstable surface of a Swiss ball (Woodward, 2013).

"Badminton is one of the world's most popular racquet sports", attracting both recreational and competitive players. "Jumps, lunges, quick changes of direction, rapid arm movements, rapid eye-hand coordination", and a good awareness of body position are all required in badminton (Shariff, George, Ramlan; 2009; Wang, Moffit, 2009). Of all sports injury's badminton (a non-contact sport) constitutes a total of 1–5% injuries (Fahlström, Björnstig, Lorentzon, 1998; Høy, Lindblad, Terkelsen, Helleland, 1994; Krøner, Schmidt, Nielsen, Yde, Jakobsen, Møller-Madsen, Jensen 1990).

In badminton, significant physical requirements are motor and action controls, "reaction time, foot striding, and static and dynamic balance" (Phomsoupha, Laffaye, 2015; Laffaye, Phomsoupha, Dor, 2015). A high level of dynamic balance and strength are essential for badminton players when moving around the court (Phomsoupha, Laffaye, 2015). Badminton is a dynamic equilibrium sport that entails losing "balance in the air and then regaining it after landing". As a result, players require dynamic balance and body coordination (Kong, Liu, 2013). Balance interventions like Pilates, core stability training, and Swiss ball training can improve performance in badminton players. When a player forces the wrist upward to touch the "shuttlecock with the racket frame", the trunk rotates internally, emphasizing the need for core stability exercises in improving this movement pattern and maintaining balance in badminton players (Chen, Zhang, Gao, 2014). In young badminton players, eight weeks of core stability training improved their capacity to maintain optimal lower limb dynamic balance and improved their smash stroke performance (Hassan, 2017).

In overhead athletic pursuits such as badminton smashing, "core musculature serves as a connecting link between the upper and lower limbs" (Laffaye et al., 2015; Fröhlich, Felder, Reuter, 2014). Many factors contribute to producing high performance or increasing balance of badminton players such as upper limb strength, lower limb strength, and core strength.

The existing research literature regarding the effect of exercise protocols on balance in badminton players is still ambiguous. Studies corroborate (Hassan, 2017; Alikhani, Shahrjerdi, Golpaigany, Kazemi, 2019; Kalra, Yadav, Pawaria, 2019; Ozmen, Aydogmus, 2016; Amirkolaei, Balouchy, Sheikhhoseini, 2019; Sighamoney, Kad, Yeole, 2018; Srivastav, Nayak, Nair, Sherpa, Dsouza, 2016; Watson et al., 2017; Sandrey, Mitzel, 2013). as well as contradict (Arazi, 2012; Sato, Mokha, M. 2009) the effect of exercise protocols on balance in badminton players. The generalizability is limited because of various methodological loopholes like research has a limited sample size.

To our knowledge, there hasn't been any "systematic review or meta-analysis" on the impact of exercise protocols on badminton players so far. Therefore, the aim of the present "systematic review is to evaluate the efficacy of various exercise protocols on balance in badminton players".

Methods

Eligibility criteria

A randomized controlled trial performed to find out the efficacy of exercise protocols on "balance in badminton players" were included.

Limits were applied to database searches to identify papers published in English and only human studies were included.

Exclusion criteria

Reviews, case reports, editorials, letters, erratum, comments studies were excluded from the study.

Search strategy: "Preferred Reporting Items for Systematic Reviews" and "Meta-analysis were used to conduct the systematic review and meta-analysis (PRISMA guidelines 2015)". This "systematic review and Meta-analysis" are registered in the "International Prospective Register of Systemic Reviews (PROSPERO) with identification number" CRD42020193620.

To identify significant studies, five databases Pub Med, "Cochrane database (Cochrane Central Register of Controlled Trials)", Google Scholar, Springer and DOAJ were searched from inception to June 2020. The search strategy used for Pub Med is given in supplementary material 'A'.

Medical Subject Heading (Mesh) terms and associated keywords were incorporated in the search process according to the “Participant Intervention Comparison Outcome (PICO) strategy”, which was then integrated with the “Boolean operators” (“AND” & “OR”) utilizing the ‘Advance’ and “Expert search” choices. In order to conduct the search, title and abstract were used.

Selection criteria

To remove the duplicate records of the electronic database, Mendeley was used.

Two authors (NKI &MM) independently assessed the title/abstract of the identifying records. The full text of relevant papers was collected to assess them against the selection criteria.

Any disagreement among the authors was resolved by discussion and consensus. If the entire text of a relevant study was not available online, first or corresponding authors were contacted. In addition to this, the reference list of qualified publications was evaluated manually to detect the studies of interest.

Data extraction and quality assessment

The data was retrieved by two investigators working independently (NKI and MM). Data extracted from the study were investigator and year, study design, the number of participants, sample size, trial duration, study location, trial type, intervention, outcome measures, and results. The primary outcome was a mean change in balance to evaluate the efficacy of the treatment. Missing data of standard deviation for change from baseline was imputed using a correlation coefficient. On other hand, to record any adverse effect safety outcome was measured. The “Chi (X^2) and I^2 –statistics (degree of heterogeneity)” were employed to assess study heterogeneity”. The “heterogeneity of the studies was assessed using the I^2 scale, with 0–25” percent indicating “low heterogeneity”, 26–75 percent suggesting “moderate heterogeneity,” and 76–100 percent indicating “severe heterogeneity.” The meta-analysis was carried out using Review Manager Software (Rev Man, version 5.4). Every study’s methodological quality was appraised using the Pedro rating system. The “internal quality and validity of the randomized control trials” were assessed using the Pedro rating scale. It is an 11-point scale, “a score of 6–10 indicates excellent quality, a score of 4–5 indicates acceptable quality, and a score of 3 indicates poor quality”. Cochrane collaboration risk of bias tool evaluated the risk of bias. The tool consisted of 7 “primary sources for bias: Random Sequence Generation, Allocation Concealment, Selective Reporting, blinding of participants and personnel, Blinding of outcome assessment, incomplete outcome data and other sources of bias”. Authors used independent sources to categorize bias risk as high, low, or unclear.

Mean differences including standard deviation (SDs) for change in anterior, posteromedial, Posterolateral, and overall balance (MSEBS) scores were used to analyze the “efficacy of exercise protocols on balance”. Confidence interval (CI) was used to assess continuous variables with 95% (CI) along with weighted mean differences (WMD). At p0.05, the Results of the “meta-analysis” were deemed statistically significant a $p \geq 0$. The “Review Manager (Rev Man, version 5.4) software” was used to generate forest plots and funnel plots.

Results

Study selection

"A total of 105 articles were retrieved from the database searches, of which 5 met the selection criteria. 3 out of 5 studies comprising 40 players in the experimental group and 40 players in the control group were included for the Meta-analysis of the anterior component of the Y-balance test. 3 out of 5 studies comprising 40 players in the experimental group and 40 players in the control group were included in the Meta-analysis of the posteromedial component of the Y-balance test. 3 out of 5 studies comprising 40 players in the experimental group and 40 players in the control group were included for the Meta-analysis of the Posterolateral component of Y the balance test. 2 out of 5 studies comprising of 28 players in the experimental group and 23 players in the control group were included in the Meta-analysis" of overall components of Y-balance test.

Study characteristics

The characteristics of the included studies are represented in Table 1. Most studies were conducted in Iran (2) (Alikhani et.al., 2019; Amirkolaei et.al., 2019). Egypt (1) Hassan (2017), India (1) Kalra et al. (2019), and Turkey (1) Ozmen, Aydogmus (2016). Only Randomized control trials were included.

All included studies provided dynamic balance training to the badminton players by core stability training, core strengthening exercise, Pilates, Plyometric, and Swiss ball training methods.

Only one study took a stroke to smash velocity and accuracy in badminton players along with dynamic balance as outcome measures.

Table 1. Studies were included having major characteristics

Sr. No.	Author (year)	Sample size	Age, group, and Intervention	Outcome measures	Conclusion
1.	Hamed et al., 2017	20	Under 19 ages 1. Experimental group (n = 10) = = CST 8 × 2 (25 min.) weeks 2. Control group (n = 10) = badminton traditional training	Smash velocity, Accuracy, Balance	After "eight week of core stability training, lower limb dynamic balance and smash stroke performance increased"
2.	Preeti et al., 2019	40	Age group 17–28 years 1. Experimental group (n = 20) Pilates + Conventional Training 5 × 2 (60 min.) weeks 2. Control group (n = 20) = Conventional training	Agility, Lower Limb Strength, Dynamic Balance, Co-ordination	Pilates exercise training improves balance, agility, lower limb strength, and coordination in badminton players
3.	Alikhani et al., 2019	22	Age group 15–25 years 1. Experimental group (n = 12) = Plyometric Training 6 × 3 (20 min.) weeks 2. Control group (n = 10) = Routine Exercise	Dynamic balance, Knee proprioception	According to a study, novice female badminton players improved their dynamic balance and knee proprioception after a six-week plyometric training programme
4.	Ozmen et al., 2016	20	Age group 10–12 years 1. Training group (n = 10) = Core stability training Regular scheduled training 6 × 2 weeks 2. Control group (n = 10) = Regular scheduled training	Core Endurance, Dynamic balance, Agility	Core dynamic & dynamic balance is improved by 6 weeks of CST but agility in adolescent badminton players is not improved
5.	Amirkolaei et al., 2019	29	Age group 11–16 years 1. Experimental group (n = 16) = Swiss ball training 8 × 3 weeks 2. Control group (n = 13) = Conventional training	FMS Test, Balance test (upper & lower limbs)	Eight weeks of Swiss ball exercise enhance the consistency of functional motions and the balance of the upper and lower limbs in teenage badminton players

Assessment of quality

The quality of the studies included is represented in Table 2.

All of the included studies' research scored highly on the "Pedro scale". Three out of five studies scored (six) (Hassan, 2017; Alikhani et.al., 2019; Kalra et.al., 2019). Two studies scored (five) (Ozmen, Aydogmus, 2016; Amirkolaei et.al., 2019). All the studies were of good quality.

Table 2. Pedro Scoring scale was used for quality assessment

Art	1	2	3	4	5	6	7	8	9	10	11
Article	Specified eligibility Criteria	Random allocation	Concealed allocation	Similar baseline	Subjects blinding	Therapist's blinding	Assessors blinding	Measures of key outcomes from greater than 85% of the subject	Intention to treat analysis of one key outcome	Statistical comparisons between-group of at least one key outcome	Variability for at least one key outcome
Hamed et al., 2017	Y	Y	N	Y	N	N	N	Y	N	Y	Y"
Preeti et al., 2019	Y	Y	N	Y	N	N	N	Y	N	Y	Y"
Alikhani et al., 2019	Y	Y	N	Y	N	N	N	Y	N	Y	Y"
Ozmen et al., 2016	Y	Y	N	N	N	N	N	Y	N	Y	Y"
Amirkolaei et.al., 2019	Y	Y	N	N	N	N	N	N	N	Y	Y

Note: Y = YES, N = No.

Table 3. Cochrane Collaboration Risk of Bias Assessment

Study	Random sequence generation	Allocation concealment	Selective reporting	Other sources of bias	Participants and personnel	Outcome Assessment	Incomplete outcome data
Hamed et al., 2017	Low	Unclear	Low	Unclear	Unclear	Unclear	Low
Preeti et al., 2019	Low	Unclear	Low	Unclear	Unclear	Unclear	Unclear
Alikhani et al., 2019	High	Unclear	Low	Unclear	Unclear	Unclear	Unclear
Ozmen et al., 2016	Low	Unclear	Low	Unclear	Unclear	Unclear	Low
Amirkolaei et.al., 2019	Low	Unclear	Low	Unclear	Unclear	Unclear	Low"

"Risk of bias": The included studies' risk of bias is represented in Figure 2. "Random sequence generation was described adequately in 4 studies. (Hassan, 2017; Kalra et al., 2019; Ozmen, Aydogmus, 2016; Amirkolaei et al., 2019). Selecting reporting" was done in most of the studies (Hassan, 2017; Fröhlich et al., 2014; Kimura et al., 2014; Nesser et al., 2008; Richardson, Jull, Hides, Hodges, 1999; Alikhani et al., 2019 Kalra et.al., 2019; Ozmen, Aydogmus, 2016; Amirkolaei et al., 2019). Incomplete outcome data" were described in three studies. Hassan (2017), Ozmen, Aydogmus (2016), Amirkolaei et al., 2019). All of the studies included had a low overall risk of bias.

Meta-analysis: The anterior component of the Y-balance test was assessed by three studies included in the Meta-analysis. Exercise protocols improved balance in badminton players with statistically significant differences "($p \leq 0.00001$) and low heterogeneity ($I^2 = 0\%$, $p < 0.41$) (Figure 1)".

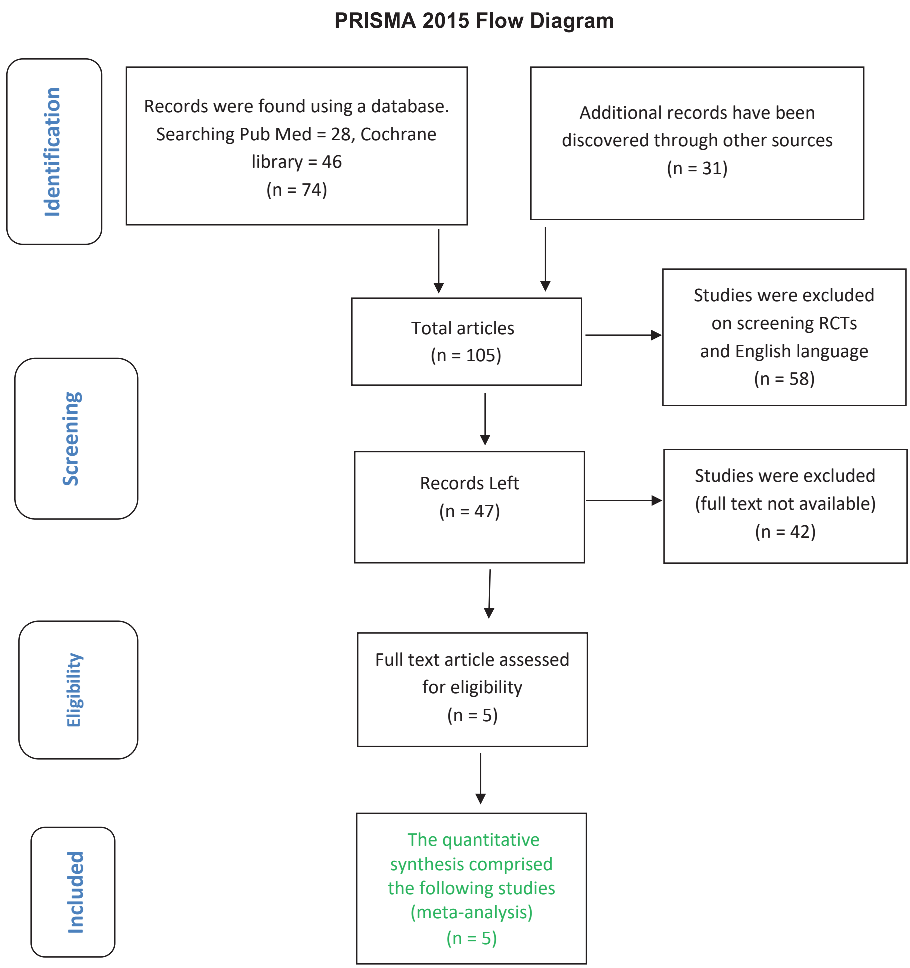
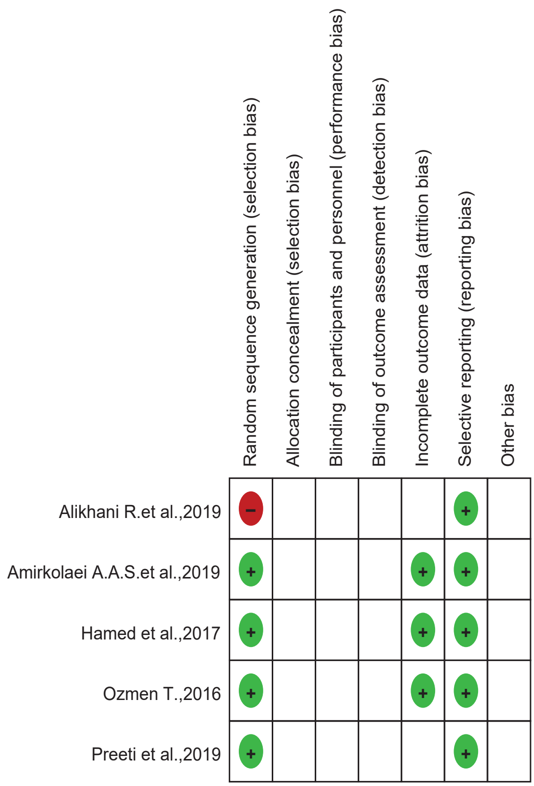


Figure 1. A flow diagram depicting a number of studies

A “meta-analysis of the posteromedial component of the Y-balance” test included three studies. The result of “meta-analysis was statistically significant ($p \leq 0.02$) with “moderate heterogeneity ($I^2 = 39\%$, $p < 0.19$)” (Figure 3)”.

Three “studies were included in the “Meta-analysis of the posterolateral component of the Y-balance test”. The result showed statistically significant improvement ($p \leq 0.02$) of balance in badminton players who underwent exercise protocols with “moderate heterogeneity ($I^2 = 36\%$, $p < 0.20$)” (Figure 5).

Two studies were included in the Meta-analysis of the overall balance of the Y-balance test. Results were “statistically significant ($p \leq 0.0001$)” with “low heterogeneity ($I^2 = 0\%$, $p < 0.47$)” (Figure 7).



Studies in green or positive are at low risk of bias. Studies in red or negative are at high risk of bias. Studies in blank are at unclear risk of bias.

Figure 2. Risk of bias summary

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
Ozmen T.,2016 (Anterior Component)	7.47	5.63	10	1.78	7.42	10	0.7%	5.69 [-0.08, 11.46]	2016
Hamed I.et al.,2017(Anterior Component)	5.4	5.58	10	1.3	5.43	10	1.0%	4.10 [-0.73, 8.93]	2017
Preeti et al.,2019(Anterior Component)	2.5	0.8	20	0.15	0.81	20	98.2%	2.35 [1.85, 2.85]	2019
Total (95% CI)			**40**			**40**	**100.0%**	**2.39 [1.90, 2.89]**	

Heterogeneity: Tau² = 0.00; Chi² = 1.76, df = 2 (P = 0.41); I² = 0%
Test for overall effect: Z = 9.48 (P < 0.00001)

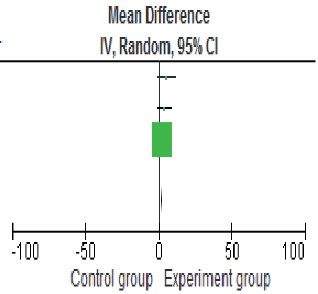


Figure 3. Mean difference and standard deviation change of anterior component of Y-balance test

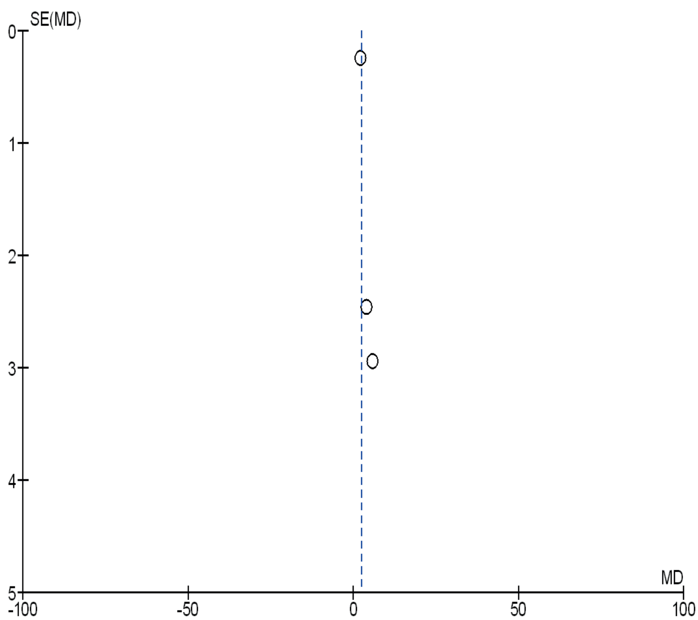


Figure 4. Funnel plot showing no publication bias in the anterior component of the Y-balance test

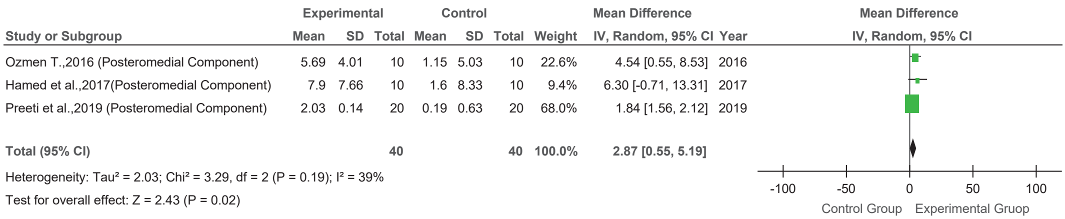


Figure 5. Mean difference and standard deviation change of Posteromedial component of Y-balance test

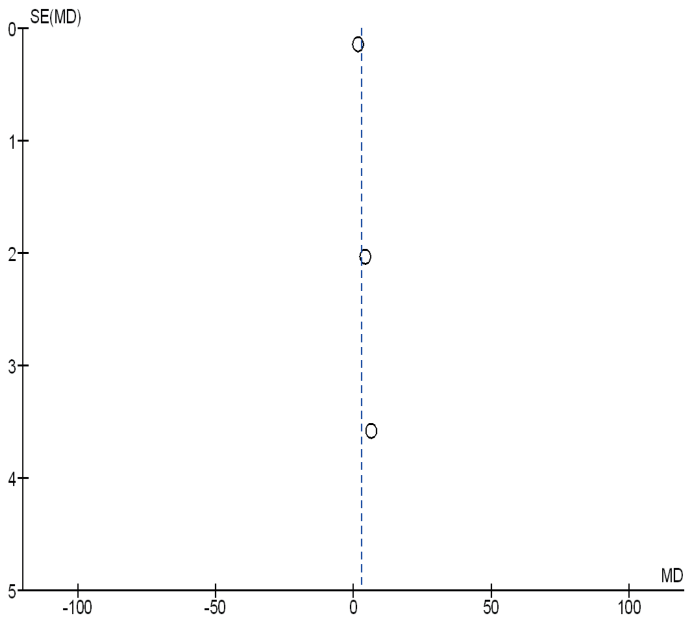


Figure 6. Funnel plot showing no publication bias" in the posteromedial component of Y-balance test

	Experimental			Control				Mean Difference	
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI	Year
Ozmen T.,2016 (Posterolateral Component)	4.78	5.17	10	1.42	5.86	10	19.9%	3.36 [-1.48, 8.20]	2016
Hamed I.et al.,2017(Posterolateral Component)	9.2	7.43	10	1.3	7.47	10	12.5%	7.90 [1.37, 14.43]	2017
Preeti et al.,2019 (Posterolateral Component)	2.23	0.82	20	0.11	0.83	20	67.6%	2.12 [1.61, 2.63]	2019
Total (95% CI)			**40**			**40**	**100.0%**	**3.09 [0.54, 5.65]**	

Heterogeneity: Tau² = 2.45; Chi² = 3.23, df = 2 (P = 0.20); I² = 38%

Test for overall effect: Z = 2.37 (P = 0.02)

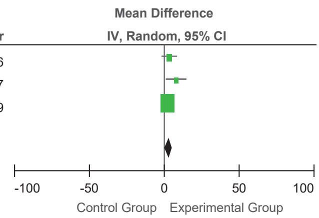


Figure 7. Mean difference and standard deviation change of posterolateral component of Y-balance test

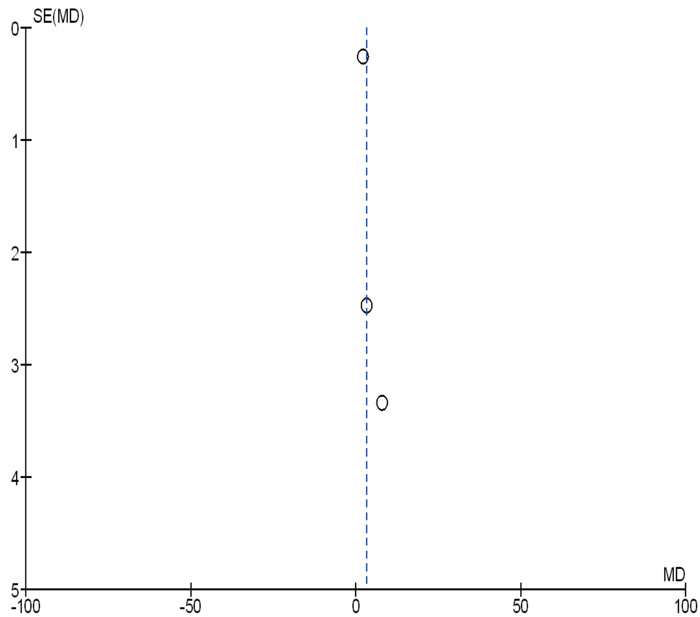


Figure 8. Funnel plot showing no publication bias in the posterolateral component of the Y-balance test

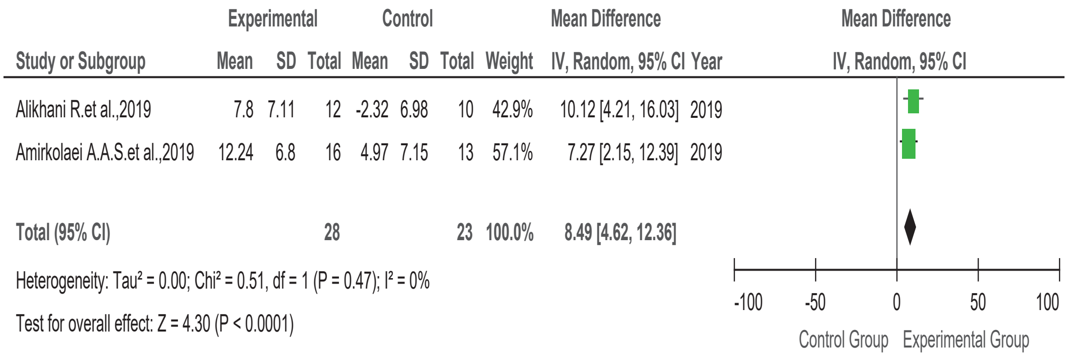


Figure 9. "Mean difference" and standard deviation change of overall Y-balance test

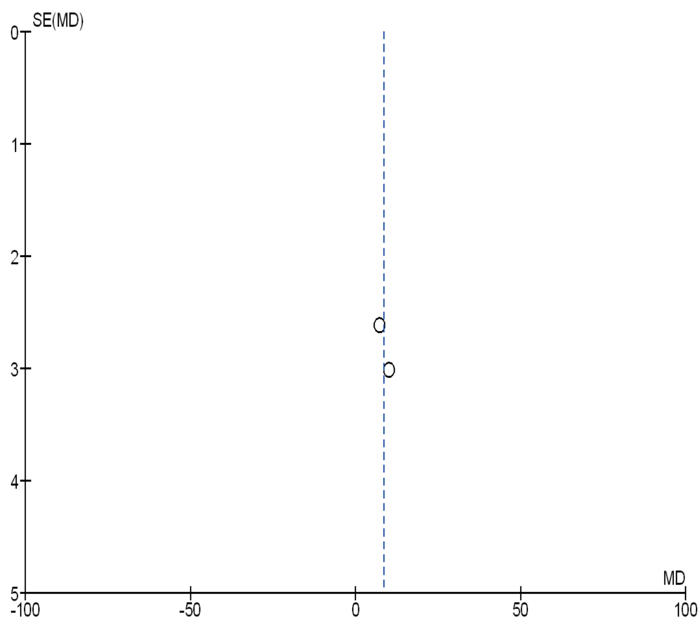


Figure 10. Funnel plot showing no publication bias in overall Y-balance test

Discussion

Low back pain, knee valgus, lower limb injuries, interruption of energy transmission, and decreased performance may occur due to trunk imbalance, weak or poor core muscles strength, which ultimately predisposes the individuals to injury (Kimura et al., 2014; Lee et al., 1999; Nesser et al., 2008; Richardson et al., 1999).

In this meta-analysis, exercise protocols resulted in statistically significant improvement in balance. So, these exercise protocols can play an important role in strength training protocols in badminton players to improve their performance. Many previously published studies support these results (Hassan, 2017; Alikhani et al. 2019; Kalra et.al., 2019; Ozmen, Aydogmus, 2016; Amirkolaei et al., 2019; Sighamoney et al., 2018; Srivastav et al., 2016; Watson et al., 2017; Sandrey, Mitzel, 2013) whereas some of the previous studies are antithetical to our results (Arazi, 2012; Sato, Mokha, 2009).

Core stability can increase muscle strength, endurance, balance, intersegment spinal control, global muscular control of trunk movement, and intra-abdominal pressure (Sedaghati, Sarlak, Saki, 2018; Harati, Daneshmandi, Shahabi Kaseb, 2018; Nesser et al., 2008; Hassan, 2017; Ozmen, Aydogmus, 2016; Sighamoney et al., 2018; Srivastav et al., 2016; Watson et al., 2017; Sandrey, Mitzel, 2013) . Core stability training causes muscle hypertrophy by increasing the number and size of myofibrils, the density of capillaries, the density of tendon nerves and ligaments, and the total contractile proteins, particularly myosin contractile proteins. Because of the alterations in muscle fibers, the pace of muscular contraction did not increase (Modi, Bhatt, 2017).

Plyometric training aids in the development of proper landing techniques and the improvement of dynamic control of the center of mass (COM), resulting in improved neuromuscular adaptation (Popa, Oravițan, 2017). Pilate's training can increase the body's deep sensory approach, which leads to greater balance (Johnson, Larsen, Ozawa, Wilson, Kennedy, 2007). Core muscles provide a firm biomechanical systematic platform for muscles" of the peripheral to act. Proximal to the distal pattern is indicated by assessment of throwing, striking & hitting with segmental sequencing (Marshall, Elliott, 2000) "Pelvic and abdominal muscles are the segmental links of the kinetic chain that connect the lower and upper bodies" "They work as a fulcrum, with the upper and lower bodies serving as movable levers" (Faries, Greenwood, 2007).

Although many studies are proved the effectiveness of core strengthening in improving balance & other exercise parameters which are in sink with the current study but some studies are contradictory to the present meta-analysis. These discrepancies could be attributed to variances in training intensity, plyometric drills, dynamic balance measurement methodologies, gender, and sample population years of experience, the age of subjects and different training programs and as subjects in the growing phase can better improve their motor skills (Arazi, 2012; Sato, Mokha, 2009).

This "meta-analysis and systematic review corroborate that exercise protocols are effective in increasing balance". Exercise Protocols like core stability training, Pilates, plyometrics, and Swiss ball training help improve balance in badminton players, reduce the risk of injuries, and increase the performance of badminton players.

There are several noteworthy aspects to this "meta-analysis and systematic review". This is the first review study as per our knowledge that evaluates the impact of exercise protocols on badminton players' balance. Second, all of the studies that were included had a lower risk of bias and were of greater quality. Finally, because RCTs are the gold standard in experimental research, we only included them in our study. Furthermore, there is no publication (Figures 2, 4, 6, 8).

Despite these advantages, there were several drawbacks to this research. Although we contacted the authors of numerous researches to get missing data, we were forced to omit studies due to a lack of information. We have a smaller number of studies for Meta-analysis.

The clinical implications of this systematic review and Meta-analysis are significant. A weak core disrupts energy flow, resulting in decreased athletic performance and a greater risk of injury to a muscle group that is weak and undeveloped. The primary goal of the training programmer should be trunk strength to develop an athlete's full strength and power potential. The meta-analysis' findings give early evidence that workout programmers that include core strengthening can improve badminton players' balance.

Conclusion

Results of "meta-analysis suggest that exercise protocols result in significant improvement in balance" in Badminton players. Further, comparisons and optimization of these exercise protocols are warranted in future studies.

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