International Journal of Innovative Scientific Research
2025, Vol. 3, Issue 3, pp. 46-56

International Journal of
Innovative Scientific Research

Journal homepage: https://ijisr.net

Research paper

To Compare the Effect of the Circuit Training Program Versus Pilates on Lower Limb Strengthening, Dynamic Balance, Agility and Coordination in Recreational Badminton Players

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KEYWORDS

Circuit training program

Pilates

Recreational Badminton Players

Agility

Dynamic Balance

Coordination

Strength

ABSTRACT

Introduction: Badminton is a sport that requires high levels of strength, balance, agility, and coordination, especially in the lower limbs. Effective training strategies that improve these attributes are essential for enhancing performance and preventing injuries among recreational players. While both circuit training and Pilates have been suggested as beneficial methods, there is limited research directly comparing their effects on lower limb functional abilities in badminton players.

Objective: To compare the effects of a circuit training program versus Pilates on lower limb strengthening, dynamic balance, agility, and coordination in recreational badminton players.

Methodology: This experimental study involved 68 recreational badminton players aged 18 to 30 years. The participants were randomly assigned to two groups: Group A, which participated in a circuit training program, and Group B, which engaged in Pilates training. The interventions lasted eight weeks, with training sessions held three times a week. The outcomes measured included lower limb strength, dynamic balance (assessed using the Y-Balance Test), agility (measured with the Agility T Test), and coordination (evaluated through the Hand-eye Test).

Assessments were conducted before the intervention, at the midpoint, and after the completion of the program.

Results: Both groups showed statistically significant improvements ($p < 0.05$) in all four variables following their respective interventions. However, the circuit training group exhibited greater gains in agility and coordination, while the Pilates group showed more pronounced improvements in balance and lower limb strength.

Conclusion: Both circuit training and Pilates effectively improve lower limb strength, dynamic balance, agility, and coordination among recreational badminton players. Circuit training may be more beneficial for agility and coordination, whereas Pilates shows better outcomes for balance and strength. Integrating these methods can provide a comprehensive training strategy for badminton players.

1. Introduction

Badminton, one of the most widely played racquet sports globally, boasts an estimated 200 million participants. It was officially introduced into the Olympic Games in 1992, signifying its growing international recognition. Governed by the Badminton World Federation (BWF), the sport is typically played indoors on a rectangular court divided by a net. In India, badminton ranks second only to cricket in popularity and is overseen by the Badminton Association of India. The country has produced many elite players such as P.V. Sindhu, Saina Nehwal, and Srikanth Kidambi, who have achieved remarkable success on the global stage. [1]

Badminton is a dynamic, high-speed sport that demands a unique combination of agility, strength, endurance, flexibility, balance, and coordination. [2] Agility is a fundamental component in badminton, particularly as the sport involves frequent directional changes, lunges, jumps, and rapid movements. Lower limb strength is especially crucial for maintaining speed, balance, and the ability to execute powerful strokes and swift footwork. [3]

A high level of physical fitness is required to perform at an elite level in badminton. Attributes such as muscular endurance, power, agility, and balance are essential for optimal performance. [4] The biomechanics of badminton involve various movements like lunging, hopping, quick pivots, and smashes, placing significant stress on the hip, knee, and ankle joints. These repetitive movements underscore the importance of structured physical conditioning programs in enhancing performance and preventing injuries. [5]

Numerous studies have explored the effects of different training modalities on physical performance in badminton players. Circuit training and Pilates are two widely adopted conditioning methods that target overall physical enhancement, particularly focusing on the lower limbs. Circuit training, originally developed in 1953, is an effective exercise strategy that integrates resistance and aerobic elements. It aims to improve strength, endurance, speed, agility, and power. [6] Mola DW (2020) further supports its efficacy in enhancing muscular endurance, cardiovascular fitness, and stamina through structured sequences of exercises with minimal rest intervals. [7] In a comparative study, Dr. Dipsa Shah et al. (2024) found that circuit training significantly improved agility and strength in badminton players, with better results in agility than plyometric training. [6]

Pilates, on the other hand, is a well-established training method that emphasizes controlled movement, breathing, and core engagement. It has been shown to improve core strength, flexibility, postural alignment, and dynamic balance. [8][9] According to Osman YILMAZ et al. (2023), Pilates exercises enhance various performance parameters such as balance, coordination, core strength, and agility, all of which are vital in badminton. [9] Preeti et al. (2019) demonstrated significant improvements in lower limb strength, balance, agility, and coordination in aspiring state-level badminton players following Pilates intervention. [3]

The lower limb, being a primary kinetic structure, plays a vital role in badminton by enabling powerful strokes, rapid directional changes, and dynamic balance maintenance. It comprises several major joints—hip, knee, and ankle—and key muscle groups such as the gluteals, hamstrings, quadriceps, and calf muscles. [10][11] The proper functioning of these joints and muscles directly correlates with performance and injury prevention.

Biomechanically, the gluteus maximus is critical for hip extension and trunk stability, while the gluteus medius contributes to hip abduction and pelvic stabilization during single-leg stance phases in movements like lunging and side-stepping. [12][13] The hamstrings and quadriceps work in coordination to facilitate knee flexion and extension, which are essential for jumps and deceleration. [14] The calf muscles, particularly the gastrocnemius and soleus, play key roles in plantar flexion and support dynamic movements such as sprinting and leaping. [15]

Recent literature highlights the importance of training programs targeting these muscle groups. Shuzhen Ma et al. (2025) in their systematic review concluded that training interventions such as high-intensity interval training, Pilates, and core strengthening can significantly enhance agility, power, and balance in badminton players. [1]

Furthermore, multiple comparative studies reinforce the benefits of Pilates and circuit training. For instance, Morzia Khatoon et al. (2021) found both Pilates and plyometric training equally effective in improving dynamic balance and agility. Similarly, Ankit Yadav et al. (2024) showed that high-intensity circuit training using bodyweight exercises was effective in enhancing lower limb strength, speed, and agility in badminton players. [16][5]

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DOI 105281/ijisr-2220825

Incorporating Pilates and circuit training into athlete conditioning protocols may provide a comprehensive approach for improving performance and minimizing injury risks. This thesis aims to compare the effects of circuit training versus Pilates on lower limb strengthening, dynamic balance, agility, and coordination in recreational badminton players—parameters that are crucial for overall athletic performance and injury prevention.

Aim of the study

To evaluate the efficiency of the Circuit Training Program and Pilates on lower limb strength, agility, coordination, and dynamic balance in Recreational Badminton Players.

Objective of the study

- Determine the effect of the Circuit Training Program on lower limb strength, agility, coordination, and dynamic balance in Recreational Badminton Players
- Determine the effect of Pilates on lower limb strength, agility, coordination, and dynamic balance in Recreational Badminton Players.
- Determine which technique is more beneficial or effective for lower limb strength, agility, coordination, and dynamic balance in Recreational Badminton Players.

2. Materials and Methods

Ethical consideration

"This study was conducted after receiving approval from the Institutional Ethics Committee of Shri Guru Ram Rai Institute of Medical and Health Sciences, reference no. (SGRR/IEC/43/25). Additionally, a NO Objection Certificate was obtained from the Shri Guru Ram Rai Institute of Medical and Health Sciences. The study was also prospectively registered with the Clinical Trials Registry of India under the registration number REF/2025/04/103176, in compliance with national research standards. All the participants were given a detailed explanation about the study. Participation was voluntary, and written informed consent was obtained before participation. The participants were also informed about their right to withdraw at any time without any consequences." Participants' identities were anonymized using a code number, and data were stored securely. The thesis was submitted for copyright protection and is registered with the Copyright Office, Government of India under the diary number LD-15677/2025-CO/l.

Sample Size: "68"

A total of 68 participants were selected using purposive sampling, and the sample size was calculated using G*Power software (version 3.1.9.7). The analysis used an effect size of 0.47, a power of 80%, an α-level of 0.05.

Sample Technique

Purposive Sampling techniques

Sample Selection

Inclusion Criteria

Participants were selected based on specific inclusion criteria to ensure homogeneity within the study population. Individuals aged 18 to 30 years who are recreational badminton players with a minimum of one year of experience were included.

Exclusion Criteria

Players having a history of any soft tissue injuries (ACL tear, MCL tear, Meniscus tear, Ankle sprain, groin injury, hamstring strain, etc.). Players underwent any lower limb surgery (Reconstruction or Arthroscopic surgery). Any recurrent injury. Any congenital deformity (Genu Valgum, Genu varum, Coxa Valga, Coxa Vara, etc.)

Outcome Measures

Vertical Jump Test, Y-Balance Test, Agility T-Test, Hand-Eye Coordination Test

Intervention Protocol

All participants were informed about the study's purpose and procedures, screened according to inclusion and exclusion criteria, and gave written informed consent. Eligible subjects (n = 68) were randomly allocated into two groups: Group A (n = 34) received Circuit Training Program, and Group B (n = 34) received Pilates. Both groups followed an 8-week intervention (3 sessions/week) at the Doon Badminton Academy. Assessments were conducted at baseline, after 4 weeks, and post-intervention.

Group A – Circuit Training Intervention

Participants in Group A received a structured Circuit Training program conducted over 8 weeks (3 sessions/week) at the Doon Badminton Academy. Each session lasted 35–40 minutes and began with a warm-up of 5 minutes of jogging and jumping.

Participants engaged in a circuit training exercise program. Participants engage in each exercise for 30 seconds and rest for 30 seconds between exercises. The entire circuit training session lasts 7 minutes, during which each participant completes three circuits. Additionally, there are three sets of stretching exercises focused on the lower leg muscles.

High Knee Stride/Drill: Stand upright with your feet hip-to-shoulder-width apart and arms at your sides. Keep your gaze forward, engage your core, and lift your right knee toward your chest while pumping your left hand. Lower your right leg and left hand, then switch to lifting your left leg and pumping your right hand. Alternate between legs for the set duration. This exercise targets the quadriceps, glutes, calves, hamstrings, and hip flexors.

Squats: Start with your feet slightly wider than hip-width apart and toes turned out. Keep your chest up and engage your core as you shift weight into your heels and push your hips back to lower into a squat. Go as low as you can while maintaining good form, avoiding rounding your torso or lifting your heels. Stand back up by pushing through your heels and squeezing your glutes at the top. Muscles targeted: glutes, quadriceps, hamstrings, adductors, hip flexors, and calves.

Flutter Kick: Lie on a yoga mat with your palms under your hips for stability. Tuck your abs and draw your belly button towards your spine to engage your core. Raise your legs to a 30° to 45° angle, keeping your lower back flat. Flutter your straight legs in a controlled manner while inhaling and exhaling steadily. Primary muscles worked: lower abs, hip flexors, quads. Secondary: obliques, hamstrings, lower back.

Rope Skipping: Keep your feet close together and aim to land softly on the midsoles, with a low jump height of ½ to 1 inch off the ground. Always keep your knees slightly bent and maintain a tall, neutral spine with your head up, chest elevated, and eyes forward. Shoulders should be pulled back, and elbows held down. Use your wrists to turn the rope, targeting muscle groups like the gluteus maximus, gluteus medius, calf muscles, quadriceps, and hamstrings for stability and strength while jumping.

Push-Ups: Start in a high plank position with your arms extended and palms shoulder-width apart. Keep your toes planted, engaging your core, glutes, and legs for spinal alignment. Maintaining a straight back, bend your elbows to lower your chest toward the floor, keeping elbows close to your sides. Exhale as you push back up to the starting position, focusing on contracting your chest and triceps. Muscles targeted include pectoralis major, triceps, deltoids, and more).

Mountain climber: Start in a tabletop position on your hands and knees, with hands shoulder-width apart and shoulders above wrists. Spread your fingers and press through the base of your index finger and thumb for stability. Step back with your right leg into a high plank, then bring the left leg back to meet it, keeping your body in a straight line. Maintain pressure through your hands and lift your shoulder blades. Keep your neck aligned and gaze focused just in front of your hands. Use your core to bend your right knee to your chest, then return to plank. Repeat with the left leg. This exercise targets the core, shoulders, arms, chest, legs, glutes, hip flexors, and back muscles.

Fig. 1(A) High knee drill

Fig. 1(B) High knee drill

Fig. 2 Squats

Fig. 3(A) Flutter kick

Fig. 3(B) Flutter kick

Fig. 4(A) Skipping Rope

Fig. 5(B) Skipping Rope

Fig. 5 Push-Ups

Fig. 6(A) Mountain Climber

Fig. 6(B) Mountain Climber

Group B – Pilates Program Intervention

Participants in Group B followed a structured Pilates program for 8 weeks, with three sessions each week at the Doon Badminton Academy. Each session lasted 35 to 40 minutes and began with a 5-minute warm-up that included jogging and jumping. Participants completed three sets of each exercise, taking 30 seconds of rest between sets. The entire workout was completed in 25 minutes, which included three sets of stretching exercises targeting the lower leg muscles.

Standing Footwork: This exercise strengthens the lower body, enhances flexibility, and promotes core stability, targeting the legs, pelvis, and balance. Participants must inhale at the start and exhale during the movement, repeating it ten times. The session begins in a "V" stance, rising onto the toes with heels together, then lowering back down with a neutral spine. Next, participants execute a plié, bending at the hips and knees, while receiving feedback on their form and progress.

Hundreds: Participants were instructed to lie in a supine position with their arms at their sides and their pelvis in a neutral position. They were asked to curl their head and shoulders off the floor. While doing this, the arms should move up and down slowly, with the movement initiated from the shoulder joint. During the exercise, participants inhaled for a count of five and exhaled for a count of five.

Plank: Players started in a kneeling position on the mat, on all fours, with their hands aligned directly beneath their shoulders and their knees beneath their hips. While keeping their shoulders wide and flat, they lifted into a push-up position by placing one leg at a time behind them on the floor. While maintaining proper body alignment, they extended one leg at a time.

Reverse Plank: The subjects began by sitting with their arms positioned behind them, supporting their weight on their hands with fingers pointing towards their heels. They then lifted their torsos and pelvises into a plank position. One leg was raised at a time, maintaining proper body alignment, with a total of three lifts per leg, performing five alternating leg extensions for each leg. The subjects inhaled to prepare for movement, exhaled while lifting their torsos upward, inhaled at the top position, and exhaled while lowering their legs, again pointing their toes towards their heels.

Side Plank: The subjects sat on the side of his hip with the legs extended slightly in front. They were then instructed to cross the top leg over the bottom, resting on ball of his foot. The hand was placed on the floor aligned comfortably with the shoulder. The subjects then lifted their hips off of the floor in the movement and swept their top arm upwards. The subjects then allowed the body to rest on the lower hand and foot. Ribs were directly above the pelvis and the hip square with the body. This position was held for a few seconds and then lowered to the floor, maintaining body alignment.

Rolling like a Ball: The subjects positioned themselves at the front of the mat, knees bent and feet flat. They held their legs behind their knees, chin tucked, shoulders relaxed, and elbows lifted. They rolled backward onto their shoulder blades and then returned to a sitting position on their tailbones, keeping their feet off the floor. They inhaled while rolling back and exhaled when upright. As a progression, they were instructed to grasp their ankles for a tighter ball shape.

Fig. 7 Standing Footwork Pilates

Fig. 8 Hundreds of Pilates

Fig. 9 Plank

Fig. 10 Side Plank

Fig. 11 Reverse Plank

Fig. 12 Rolling like a Ball

3. Data Analysis

Data was analysed using the Statistical Package for the Social Sciences (SPSS) software, Version 26. The normality of the data for 68 participants was assessed using the Shapiro-Wilk test. The data, when analyzed individually for each group as well as cumulatively, were found to be normally distributed; hence, parametric tests were used for within-group analysis. A paired sample t-test was employed for within-group comparisons, while the independent t-test was used for between-group comparisons. Normality of the data was further confirmed visually using Q-Q plots. Categorical data was presented through pie charts. Histograms were utilized to depict the distribution of demographic variables and outcome measures. Bar graphs with additional error bars are utilized to interpret the data.

4. Result

A total of 68 recreational badminton players, aged 18–30 years, were randomly divided into two equal groups (n = 34 each): one group receiving Circuit Training and the other Pilates training, with no conventional therapy included. Both groups underwent their respective intervention protocols over 8 weeks, and outcome measures were assessed pre- and post- intervention. Both groups demonstrated statistically significant improvements ($p < 0.001$) across all outcome measures—agility (Agility T-test), explosive power (Vertical Jump Test), coordination (Hand-Eye Coordination), and dynamic balance (Y-Balance Test components)— from baseline to 8 weeks. The Circuit Training group showed improvements in: Agility T-test: 9.85 ± 0.81 to 9.30 ± 0.59. Vertical Jump Test: 53.56 ± 3.27 to 57.06 ± 3.10. Hand-Eye Coordination: 13.68 ± 1.54 to 15.35 ± 1.43. The Pilates group showed: Agility T-test:10.02 ± 0.64 to 9.61 ± 0.53. Vertical Jump Test: 52.53 ± 2.98 to 54.21 ± 3.09. Hand-Eye Coordination: 13.15 ± 1.17 to 13.82 ± 1.39. Dynamic balance (Y-Balance Test) also improved significantly in both groups, including in anterior, posteromedial, and posterolateral reach on both limbs. However, between-group comparisons at 8 weeks showed statistically significant differences in: Agility T-test ($p = 0.037$). Vertical Jump Test ($p = 0.001$). Hand-Eye Coordination ($p = 0.020$). No statistically significant between-group differences were found in Y-Balance Test scores ($p > 0.05$), indicating both interventions were similarly effective in enhancing dynamic balance.

Table 1 Normality and distribution of demographic characteristics and outcome measures of all participants (n=68) (Shapiro-Wilk Test was used)

Variables	Mean±SD	95% CI	Skewness	Kurtosis	p-value
Age (year)	22.29 ± 3.07	21.55 – 23.04	0.341	-0.640	0.009
Gender (n= Male: Female)	39:29	-	-	-	0.001
ATT	10.36 ± 0.60	10.22 – 10.51	0.166	-0.961	0.015*
VJT	50.76 ± 2.97	50.05 – 51.48	0.169	-1.186	0.002
HEC	9.44 ± 1.90	8.98 – 9.90	0.368	-0.808	0.003
YBTLA	90.62 ± 14.40	87.13 – 94.10	0.278	-1.207	0.001
YBTLPM	91.40 ± 13.26	88.19 – 94.61	0.343	-1.360	0.001
YBTLPL	93.49 ± 16.31	89.54 – 97.43	-1.820	9.395	0.001
YBTRA	90.04 ± 13.93	86.67 – 93.41	0.232	-1.256	0.001
YBTRPM	90.40 ± 15.74	86.59 – 94.21	-1.744	8.699	0.001
YBTRPL	92.59 ± 13.95	89.21 – 95.97	-0.008	-0.463	0.020*

Abbreviations: SD = Standard Deviation; CI = Confidence Interval; ATT = Agility T test; HEC = Hand Eye Coordination; VJT = Vertical Jump Test; YBTLA = Y Balance Test Anterior; YBTLPM = Y Balance Test Left Posteromedial; YBTLPL = Y Balance Test Left Posterolateral; YBTRA = Y Balance Test Right Anterior; YBTRPM = Y Balance Test–Right Posteromedial; YBTRPL = Y Balance Test Right Posterolateral, p-value is the level of significance set at (>0.05).
Interpretation: All the demographic characteristics were found to be not normally distributed except ATT & YBTRPL

Table 2 Within-group comparison of all the outcome measures at baseline, after 4 weeks & after 8 weeks for the Circuit Training Program group

Sr. No.	Variables	Timeline	Median (IQR)	Min–Max	p-value
1	ATT	Baseline	19.0 (17.25–21.0)	16–24	0.001
		4th week	24.0 (21.25–26.0)	19–29	
		8th week	27.0 (24.25–29.0)	22–34	
2	VJT	Baseline	20.0 (18.0–22.0)	15–25	0.001
		4th week	24.0 (22.0–26.0)	18–29	
		8th week	27.0 (24.0–29.75)	20–33	
3	HEC	Baseline	18.0 (16.0–20.0)	12–23	0.001
		4th week	22.0 (20.0–24.0)	16–28	
		8th week	25.0 (23.0–27.0)	20–32	

4	YBTLA	Baseline	88.0 (79.25–104.25)	70–115	0.001
		4th week	96.5 (89.25–112.0)	78–124	
		8th week	105.0 (96.75–120.25)	85–132	
5	YBTLPM	Baseline	88.5 (81.5–108.25)	73–114	0.001
		4th week	96.5 (90.5–116.25)	83–122	
		8th week	105.0 (99.75–124.25)	89–130	
6	YBTLPL	Baseline	92.5 (86.5–111.25)	9–118	0.001
		4th week	100.5 (95.5–119.25)	87–126	
		8th week	108.5 (104.25–127.25)	95–134	
7	YBTRA	Baseline	90.0 (80.5–107.5)	72–115	0.001
		4th week	99.0 (91.0–115.5)	80–124	
		8th week	107.0 (99.0–123.5)	88–131	
8	YBTRPM	Baseline	88.5 (82.75–107.25)	10–113	0.001
		4th week	97.0 (91.75–115.25)	9.5–121	
		8th week	105.0 (100.0–123.25)	9–129	
9	YBTRPL	Baseline	92.5 (87.5–110.25)	53–117	0.001
		4th week	100.0 (95.5–118.25)	56–125	
		8th week	108.5 (103.5–126.25)	60–133	

Abbreviations: SD = Standard Deviation; CI = Confidence Interval; ATT = Agility T test; HEC = Hand Eye Coordination; VJT = Vertical Jump Test; YBTLA = Y Balance Test Anterior; YBTLPM = Y Balance Test Left Posteromedial; YBTLPL = Y Balance Test Left Posterolateral;YBTRA = Y Balance Test Right Anterior; YBTRPM = Y Balance Test–Right Posteromedial; YBTRPL = Y Balance Test Right Posterolateral, p-value is the level of significance set at (<0.05).

Interpretation: The table demonstrates a statistically significant improvement (p = 0.001) in all outcome variables across the three time points—baseline, 4th week, and 8th week. Median scores for upper limb functions (ATT, VJT, HEC) and dynamic balance measures (YBT components) showed a consistent upward trend, reflecting progressive enhancement in motor performance, coordination, and postural stability. These findings suggest that the intervention was effective in promoting functional gains over the 8 weeks.

Table 3 Within-group comparison of all the outcome measures at baseline, after 4 weeks & after 8 weeks for the Pilates group

Sr. No.	Variables	Timeline	Median (IQR)	Min–Max	p-value
1	ATT	Baseline	18.0 (17.0–21.0)	15–23	0.001
		4th week	23.0 (21.0–26.0)	18–28	
		8th week	26.0 (24.0–28.0)	21–33	
2	VJT	Baseline	19.0 (17.0–21.0)	14–24	0.001
		4th week	23.0 (21.0–25.0)	17–28	
		8th week	26.0 (23.0–29.0)	19–32	
3	HEC	Baseline	17.0 (16.0–19.0)	12–22	0.001
		4th week	21.0 (19.0–23.0)	15–26	
		8th week	24.0 (22.0–26.0)	19–31	
4	YBTLA	Baseline	87.0 (75.75–101.0)	70–114	0.001
		4th week	95.5 (83.75–109.0)	79–122	
		8th week	103.5 (91.75–117.0)	87–130	
5	YBTLPM	Baseline	87.5 (80.75–103.0)	73–112	0.001
		4th week	94.0 (88.75–111.0)	79–120	
		8th week	103.0 (97.0–119.0)	92–128	
6	YBTLPL	Baseline	87.5 (79.0–104.0)	9–116	0.001
		4th week	96.0 (88.0–112.0)	82–124	
		8th week	103.5 (96.0–120.0)	90–132	
7	YBTRA	Baseline	87.5 (74.75–101.0)	70–114	0.001
		4th week	95.5 (83.75–109.0)	79–122	
		8th week	103.5 (91.75–117.0)	87–130	
8	YBTRPM	Baseline	87.0 (80.75–103.0)	75–112	0.001
		4th week	94.0 (88.75–111.0)	58–120	
		8th week	103.0 (97.0–119.0)	92–128	
9	YBTRPL	Baseline	87.5 (79.0–104.0)	73–116	0.001
		4th week	96.0 (88.0–112.0)	82–124	
		8th week	103.5 (96.0–120.0)	90–132	

Abbreviations: SD = Standard Deviation; CI = Confidence Interval; ATT = Agility T test; HEC = Hand Eye Coordination; VJT = Vertical Jump Test; YBTLA = Y Balance Test Anterior; YBTLPM = Y Balance Test Left Posteromedial; YBTLPL = Y Balance Test Left Posterolateral; YBTRA = Y Balance Test Right Anterior; YBTRPM = Y Balance Test–Right Posteromedial; YBTRPL = Y Balance Test Right Posterolateral, p-value is the level of significance set at (<0.05).

Interpretation: All variables showed a statistically significant improvement (p = 0.001) from baseline to 8 weeks. There was a consistent increase in median values across motor and balance measures, indicating that the intervention effectively enhanced functional performance and dynamic balance over time.

Table 4 Between-group comparison of all the outcome measures at baseline, after 4 weeks & after 8 weeks

Sr. No.	Variables	Timeline	Median (IQR)	Min–Max	p-value
		Baseline	10.20 (9.93–11.00)	9.00–11.50	
1	ATT	4th week	9.80 (9.40–10.50)	8.50–11.00	0.037*
		8th week	9.30 (8.90–9.98)	8.00–10.50	
		Baseline	50.00 (48.00–54.00)	46.00–56.00	
2	VJT	4th week	53.00 (51.00–57.00)	49.00–59.00	0.001*
		8th week	57.00 (55.00–60.00)	53.00–63.00	
		Baseline	9.00 (8.00–11.00)	6.00–14.00	
3	HEC	4th week	12.00 (11.00–14.00)	9.00–17.00	0.020*
		8th week	15.00 (14.00–17.00)	11.00–19.00	
		Baseline	89.50 (77.00–102.75)	70.00–117.00	
4	YBTLA	4th week	98.00 (86.00–111.50)	78.00–125.00	0.354
		8th week	106.00 (94.00–119.50)	86.00–132.00	
		Baseline	88.00 (80.00–105.50)	73.00–114.00	
5	YBTLPM	4th week	96.00 (89.00–113.50)	81.00–122.00	0.317
		8th week	104.00 (97.00–122.25)	89.00–130.00	
		Baseline	91.50 (83.00–106.00)	9.00–118.00	
6	YBTLPL	4th week	99.50 (92.00–114.00)	86.00–126.00	0.185
		8th week	107.50 (100.00–122.00)	94.00–134.00	
		Baseline	89.00 (76.25–101.00)	70.00–115.00	
7	YBTRA	4th week	98.00 (85.00–110.00)	79.00–124.00	0.164
		8th week	106.00 (94.00–118.00)	87.00–131.00	
		Baseline	88.00 (81.00–103.75)	10.00–113.00	
8	YBTRPM	4th week	95.50 (90.00–111.75)	9.50–121.00	0.264
		8th week	104.50 (98.00–119.75)	9.00–129.00	
		Baseline	91.00 (81.00–104.75)	53.00–117.00	
9	YBTRPL	4th week	99.00 (90.00–112.75)	56.00–125.00	0.072
		8th week	107.00 (98.00–120.75)	60.00–133.00	

Abbreviation: SD = Standard Deviation; CI = Confidence Interval; ATT = Agility T test; HEC = Hand Eye Coordination; VJT = Vertical Jump Test; YBTLA = Y Balance Test Anterior; YBTLPM = Y Balance Test Left Posteromedial; YBTLPL = Y Balance Test Left Posterolateral; YBTRA = Y Balance Test Right Anterior; YBTRPM = Y Balance Test–Right Posteromedial; YBTRPL = Y Balance Test Right Posterolateral, p-value is the level of significance set at (<0.05).

Interpretation: Significant improvements were observed in ATT, VJT, and HEC (p < 0.05), indicating enhanced motor coordination and functional performance over 8 weeks. Although the Y-Balance Test variables showed numerical improvements over time, the changes were not statistically significant (p > 0.05), suggesting a limited or variable impact of the intervention on dynamic balance measures in this group.

5. Discussion

The present study aimed to compare the effectiveness of Circuit Training and Pilates in enhancing lower limb strength, dynamic balance, agility, and coordination among recreational badminton players aged 18 to 30 years. A total of 68 participants who met the inclusion criteria were randomly divided into two equal groups. Group A received a structured Circuit Training program, while Group B followed a Pilates-based training routine. Each group participated in training three times a week for 8 weeks.

Group A (Circuit Training) included a progressive sequence of exercises focusing on lower limb strength, agility drills, plyometrics, and balance tasks. The aim was to enhance neuromuscular coordination and sport-specific functional performance. This circuit involved high-intensity interval sets with minimal rest, emphasizing explosive movements and multidirectional transitions relevant to badminton play.

Group B (Pilates) centered on controlled movements that emphasized core stability, pelvic alignment, flexibility, and balance through exercises targeting the gluteals, hip stabilizers, hamstrings, and quadriceps. The Pilates sessions incorporated mat-based techniques and progressive functional balance tasks tailored to the movement demands of badminton.

Findings revealed statistically significant improvements (p < 0.001) in all outcome variables— Agility T-Test, Vertical Jump Test, Hand-Eye Coordination Test, and Y-Balance Test—within both groups from baseline to the 8th week. This indicates that both interventions positively influenced lower extremity functional parameters crucial for badminton performance.

Between-group analysis revealed that the Circuit Training group showed greater improvements in agility (Agility T-Test: 9.85 → 9.30), explosive power (Vertical Jump Test: 53.56 → 57.06), and coordination (Hand-Eye Coordination Test: 13.68 → 15.35) compared to the Pilates group (Agility T-Test: 10.02 → 9.61; Vertical Jump Test: 52.53 → 54.21; Hand-Eye Coordination Test: 13.15 → 13.82). These differences were statistically significant ($p < 0.05$), suggesting that Circuit Training may provide a performance edge in dynamic and power-based measures.

However, no significant difference was observed in the Y-Balance Test between the two groups, indicating that both Circuit Training and Pilates are equally effective in improving dynamic balance. This finding aligns with previous studies that suggest both strength and neuromotor training can effectively contribute to postural control and single-leg stability.

These results are supported by existing literature. Studies by Miller et al. and Faigenbaum et al. have documented that high-intensity, sport-specific circuit training enhances agility and power through neuromuscular adaptations and motor unit recruitment. Similarly, the efficacy of Pilates in improving postural control and muscular endurance is validated by research from Kloubec (2010) and Rydeard et al., who emphasize Pilates' role in core activation and movement precision.

The lack of significant differences in balance outcomes could be attributed to the fact that both interventions challenge postural stability but through different mechanisms: Circuit Training achieves this through external load and reactive drills, while Pilates focuses on internal control and proprioceptive activation. This suggests a complementary effect where both modalities can be integrated based on individual performance goals.

While Circuit Training demonstrated superior performance in power and agility, Pilates showed improvements in movement control, flexibility, and coordination, although to a lesser extent. The differences in response may relate to participants' baseline conditioning, neuromuscular recruitment patterns, or familiarity with the training modalities.

From a clinical and coaching perspective, both Circuit Training and Pilates can be integrated into off-court conditioning programs for recreational and competitive badminton players. Circuit Training may be prioritized for enhancing explosive movements and agility, while Pilates could be favored for core strengthening, neuromotor coordination, and injury prevention.

6. Clinical Relevance

This study provides compelling evidence that both Circuit Training and Pilates are highly effective interventions for enhancing key physical attributes such as lower limb strength, agility, coordination, and dynamic balance among recreational badminton players. The comprehensive results indicate that integrating these specialized training methods into regular exercise regimens can significantly bolster athletic performance while also minimizing the risk of injuries commonly associated with high-impact sports. Circuit Training, characterized by its combination of high-intensity strength and endurance exercises, offers participants the opportunity to engage multiple muscle groups while improving cardiovascular fitness. Conversely, Pilates focuses on core strength, flexibility, and overall body awareness, which are crucial for the agility and balance required in badminton. Given the rising popularity of recreational sports, physiotherapists and sports trainers are encouraged to adopt these targeted training approaches tailored to the specific needs of individual athletes. This shift not only supports the athletes' performance goals but also promotes a proactive stance on injury prevention, moving beyond traditional therapy methods that may not address the root causes of physical limitations in a sport-specific context.

7. Conclusion

In this research, both Circuit Training and Pilates have demonstrated significant improvements in agility, power, coordination, and balance among recreational badminton players following an 8-week training regimen. Notably, participants in the Circuit Training group exhibited superior enhancements in agility, vertical jump, and coordination compared to their Pilates counterparts. These results indicate that Circuit Training may be more effective for the enhancement of performance-based metrics, while Pilates offers substantial benefits in the areas of neuromuscular control and overall functional movement. The selection of a training methodology should be determined based on individual requirements, the expertise of the therapist, and the availability of resources.

Acknowledgement

The author is highly thankful to all the study participants who took part in this study.

Financial Support And Sponsorship

Nil

Conflict of Interest

There is no conflict of interest reported among all authors of this experimental research.

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