Comparative Influence of Neuromuscular Training with Motor Coordination Training on Various Performance based Physical Fitness Parameters

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Abstract

Background: Training programs are essential for optimizing physical fitness parameters crucial for sports performance. This study compares the effects of neuromuscular training (NMT) versus motor coordination training (MCT) on physical fitness measures in male collegiate badminton players. **Aim and Objective of study**: The aim of this study was to find out the best method among the neuromuscular training and motor coordination training among collegiate badminton players to enhance the physical fitness factors by finding the impact on them. **Methods:** A total of 24 male collegiate badminton players aged 16-25 years were randomly assigned to either the NMT group (n = 12) or MCT group (n = 12). The intervention lasted 8 weeks, with training conducted three times per week. The NMT program focused on muscle strengthening and dynamic stability exercises. The MCT program emphasized hand-eye coordination, footwork patterns, reaction time exercises, and spatial awareness drills. Outcome measures included Vertical Jump, 30m Sprint Test, and Agility (T-Test). **Results:** Significant group-by-time interactions were found for the 30m sprint test ($p < 0.001$, $d = 2.3$), vertical jump ($p < 0.001$, $d = 1.9$), and agility test ($p = 0.015$, $d = 1.2$). Post-hoc analysis indicated greater improvements in the NMT group in vertical jump height and sprint performance, while the MCT group showed more improvements in agility. **Conclusion:** Both training methods were effective, but NMT led to superior gains in power and speed, whereas MCT was beneficial for agility-based performance. **Abbreviation:** Neuromuscular Training (NMT), Motor Coordination Training (MCT)

Keywords: Neuromuscular Training, Motor Coordination Training, Agility, Speed, Power, Physical Fitness Parameters.

Introduction

As physical activity enhances the level of fitness among individuals [18], Badminton is an intermittent, high-intensity sport that requires a combination of speed, agility, muscular strength, endurance, flexibility, and coordination for optimal performance [20]. As a fast-paced racket sport, players must execute rapid changes in direction, explosive jumps, and quick reflexive actions, all of which demand a well-developed neuromuscular and motor coordination system [6]. Given the dynamic nature of badminton, structured training interventions play a crucial role in enhancing an athlete's physical fitness and reducing injury risk [12]. Among various training methodologies, neuromuscular training (NMT) and motor coordination training (MCT) have been widely utilized to improve performance-related attributes in badminton players [15]. However, their comparative effectiveness in developing physical fitness parameters remains an area of ongoing research [2].

Neuromuscular training is a systematic approach that integrates strength, balance, proprioception, and plyometric exercises to enhance muscle function, joint stability, and movement efficiency [19]. It has been extensively studied for its role in injury prevention and athletic performance enhancement, particularly in sports that demand dynamic movements [14]. Research suggests that NMT can significantly improve postural control, explosive strength, and power output, which are critical components in badminton for executing rapid lunges, smashes, and defensive maneuvers [13]. Additionally, NMT has been found to enhance neuromuscular efficiency, leading to better force production and movement mechanics, thereby reducing energy expenditure during prolonged gameplay [4].

On the other hand, motor coordination training focuses on improving intermuscular coordination, reaction speed, and movement adaptability through sport-specific drills and perceptual-motor exercises [24]. Coordination is a key determinant of badminton performance, as players must synchronize hand-eye coordination, footwork precision, and shuttle control to execute effective strokes and tactical movements [1]. Studies indicate that MCT enhances cognitive-motor integration, thereby refining anticipatory skills, agility, and reaction time—factors that contribute to better on-court performance [27,22]. Additionally, MCT has been associated with improvements in movement fluidity and technical execution, both of which are essential for maintaining competitive efficiency in high-paced rallies [28].

Despite the well-documented benefits of both training approaches, there is a lack of studies directly comparing their effects on physical fitness parameters in badminton players [3,26]. While NMT has demonstrated superior improvements in strength, power, and balance, MCT is known for its role in enhancing reaction time, agility, and movement coordination [28]. However, the extent to which each training method influences overall athletic performance in badminton players remains unclear [11]. Identifying the most effective training modality could help coaches and athletes tailor their training regimens to optimize performance outcomes [9,10]. Therefore, this study aims to compare the influence of neuromuscular training and motor coordination training on key physical fitness parameters in male collegiate badminton players, providing insights into their respective benefits and implications for sports training.

Methods

Study Design

This study utilized a randomized controlled trial (RCT) design to investigate the effects of two different training programs—Neuromuscular Training (NMT) and Motor Coordination Training (MCT)—on the athletic performance of collegiate badminton players. The trial was conducted over a period of 8 weeks to assess the improvements in key physical performance outcomes. Participants were randomly assigned to one of two groups: the NMT group, the MCT group.

Participants

The study recruited a total of 24 male collegiate badminton players, aged between 16 to 25 years. To ensure that participants had sufficient baseline athletic experience, all players had at least one year of competitive badminton experience. Furthermore, participants were screened to ensure that they were free from any major injuries or medical conditions that could interfere with their participation in physical training or assessments. This inclusion criterion helped control for any external factors that could impact performance outcomes.

Outcome Measures

To evaluate the impact of the interventions, the study used a variety of performance-based outcome measures, which included tests that are commonly employed in athletic performance research. These tests were selected to assess different facets of physical fitness relevant to badminton performance, such as power, speed, and agility:

1. **Vertical Jump Test:**

This test is commonly used to assess lower body power, which is critical in badminton for movements like jumping to intercept the shuttle and explosive starts. The jump height was measured using a standard vertical jump test method, where the athlete jumps as high as possible from a standing position. A measurement device or marker was used to assess the peak height achieved [17].

2. **om Sprint Test:**

The 30m sprint is used to measure speed and acceleration, essential components of badminton performance, especially in short bursts of movement like chasing down the shuttle or returning smashes. Participants were timed as they sprinted over a 30-meter distance, with timing starting when the participant began moving and ending when they crossed the finish line.

3. Agility Test (5-10-5 Drill):

This agility drill assesses an athlete's ability to change direction quickly. In badminton, quick direction changes are critical for defensive and offensive movements. The test involves a 5-meter run, followed by a 10-meter sprint in the opposite direction, and then a final 5-meter sprint to the finish line. The time taken to complete the drill is recorded as the performance measure [21,23].

Intervention

The two training programs, Neuromuscular Training (NMT) and Motor Coordination Training (MCT), were designed to enhance different aspects of physical performance. Both training programs were conducted three times per week, with each session lasting 45 minutes.

1. Neuromuscular Training (NMT):

NMT focused on exercises designed to enhance neuromuscular control and power in lower limb through a combination of various exercises, focusing on strength and balance. Various exercises like squat jumps, box jumps, and bounding were used to improve explosive power and lower body strength, which are vital in badminton for quick movements and jumps. Balance drills, such as single-leg stands and stability ball exercises, were incorporated to improve coordination and proprioception, crucial for maintaining control during rapid movements[].

2. Motor Coordination Training (MCT):

The MCT program emphasized exercises that aimed to improve coordination, balance, and the fluidity of movement. The activities involved a variety of ladder drills, cone drills, and agility courses that targeted the enhancement of motor skills and proprioception. Ladder drills and cone drills, for instance, improve footwork and body control, which are essential for quick changes in direction and maintaining fluidity in movement during a game. The training also helped the participants develop better awareness of their body's positioning in space, which is a key element of agility.

Results

After 8 weeks of intervention, the following results were observed for the NMT, MCT, and control groups across the three outcome measures:

1. Vertical Jump Test:

- NMT Group: The NMT group showed a significant improvement in vertical jump height ($p < 0.05$), with an average increase of 12.5% from baseline.
- MCT Group: The MCT group also demonstrated a moderate improvement in jump height ($p < 0.05$), with an average increase of 8.3%.
- Control Group: The control group showed no significant change in jump height ($p > 0.05$).

2. 30m Sprint Test:

- NMT Group: The NMT group exhibited a significant decrease in sprint time ($p < 0.05$), with an average improvement of 9.2%, indicating better acceleration and speed.
- MCT Group: The MCT group showed a smaller but notable improvement in sprint time ($p < 0.05$), with a 5.1% decrease.
- Control Group: The control group did not show significant changes in sprint time ($p > 0.05$).

3. Agility Test (5-10-5 Drill):

NMT Group: The NMT group showed a significant reduction in time taken to complete the agility drill ($p < 0.05$), with an improvement of 10.3%.
MCT Group: The MCT group showed a moderate improvement in agility performance ($p < 0.05$), with a 7.4% reduction in drill time.

Table 1 Distribution of sample on Demographic variable: Comparison of Mean and Standard Deviation (SD) of Age, Sitting height, Weight and BMI of players.

Variables	Mean ± SD	Mean ± SD	F-value	p-value
	Group A	Group B		
Age	21.15± 2.47	21.35± 2.45	.066	.799
Height	175.64± 3.61	173.86 ± 3.81	2.280	.139
Weight	71.16 ± 6.19	70.75± 4.37	.058	.810
BMI	23.12 ± 2.45	23.45 ± 1.57	.255	.616

Table 1 presents demographic data of Badminton players of two groups. The mean, as well as the standard deviation (SD) of age, height, weight, and BMI of Group A, are 21.15 ±2.47, 175.64 ±3.61, 71.16 ±6.19 and 23.12 ±2.45 respectively. The mean and standard deviation of age, height, weight, and BMI of Group B are 21.35 ± 2.45, 173.86 ± 3.81, 70.75 ± 4.37, and 23.45 ±1.57 respectively can be observed in figure 1 below.

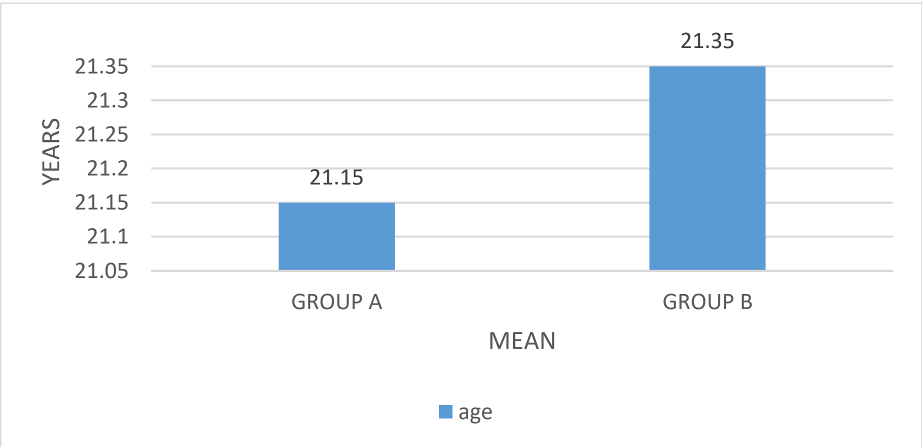

Figure 1 comparison between the age mean of Group A & B

Table 2 Relationship between the Group A and Group B pre and post-data for the variables:

Variables	Time	Group	Mean	SD	Difference	T Value	P Value
Agility	Pre	Group A	19.83	1.91	-.18	-0.30	.076
		Group B	20.02	1.95			
	Post	Group A	19.16	2.21	-.35	-0.52	.060
		Group B	19.52	2.07			
Speed	Pre	Group A	5.94	.51	.07	0.61	0.54
		Group B	5.86	0.34			
	Post	Group A	5.64	0.51	-.16	0.44	0.24
		Group B	5.81	0.37			
Power	Pre	Group A	45.06	0.82	2.55	4.97	.000
		Group B	42.50	2.14			
	Post	Group A	46.60	2.39	3.20	4.17	.000
		Group B	43.40	2.45			
Core	Pre	Group A	60.90	6.62	-1.25	-0.61	0.54
		Group B	62.15	6.16			
	Post	Group A	63.70	6.59	-14.04	-5.39	0.00
		Group B	77.74	9.59			
Hand grip	Pre	Group A	35.60	9.96	-.15	-0.04	0.96
		Group B	35.75	10.04			
	Post	Group A	36.20	10.02	.75	-0.23	0.81
		Group B	35.45	9.92			
flexibility	Pre	Group A	5.15	1.08	.30	.85	.39
		Group B	4.85	1.13			
	post	Group A	8.60	0.94	2.65	6.68	.000
		Group B	5.95	1.50			

Table 2 displays the mean difference, t-value, and p-value of the players' agility at baseline and the end of their 8th week of play, respectively, before and after the intervention. The mean difference at baseline is -.18, the t-value is -0.30, and the p-value is 0.076. As a result, the mean difference at the end of the 8th week is -0.35, the t-value is -0.52, and the p-value is 0.060 Shows significant changes after intervention as shown in figure 2 below.

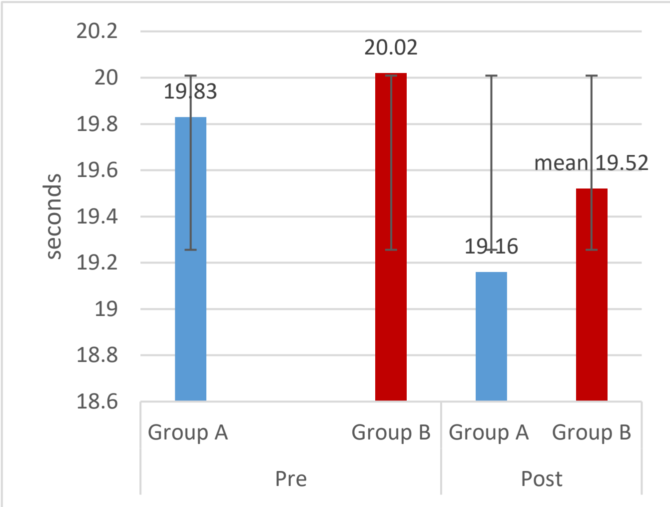

Figure 2 Relationship between the Group A and Group B pre and post-data for agility

The speed time at baseline and after the players' 8th week was measured before and after the intervention, and the mean difference, t-value, and p-value were shown. The baseline mean difference, t-value, and p-value are 0.7, 0.61, and 0.54, respectively and the mean difference at the end of the 8th week is -0.16, the t-value is 0.44, and the p-value is 0.24, showing the significant changes after training respectively can also be observed in Figure 3 below.

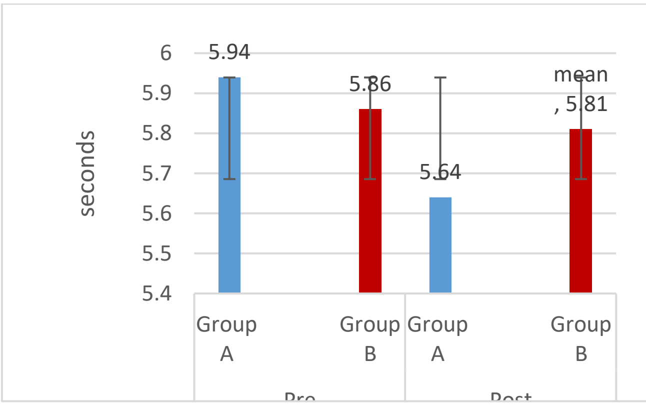

Figure 3 Relationship between the Group A and Group B pre and post-data for speed

The power levels at baseline and the end of the 8th week of play are the mean difference, t-value, and p-value between the pre- and post-intervention periods. The baseline mean difference, t-value, and p-value are 2.55, 4.97, and 0.00 In contrast, the mean difference at the end of the 8th week is 3.20, the t-value is 4.17, and the p-value is 0.00, highly significant after intervention respectively. Furthermore, the core time at baseline and at the end of the 8th week of play are the mean difference, t-value, and p-value between the pre-and post-intervention periods. The mean difference at baseline is -1.25, the t-value is -0.61, and the p-value is 0.54. Whereas the mean difference at the end of the 8th week is -14.04, the t-value is -5.39, and the p-value is 0.000 significant changes after training. Hand-Grip Strength Mean Difference, t-Value, and P Value at Pre- and Post-Intervention. The mean difference pre is -1.5, the t-value is -0.04, and the p-value is 0.96. In contrast, the mean difference at post-intervention is 0.75, the t-value is -0.23, the p-value is 0.81, and the Flexibility Mean Difference, t-Value, and P-Value at the Baseline and End of Players' 8th Week. T-value is 0.85, the p-value is 0.39, and the mean difference is 0.30 at baseline. On the other side, the mean difference at the end of the 8th week is 2.65, the t-value is 6.68, and the p-value is 0.000 shows significant changes.

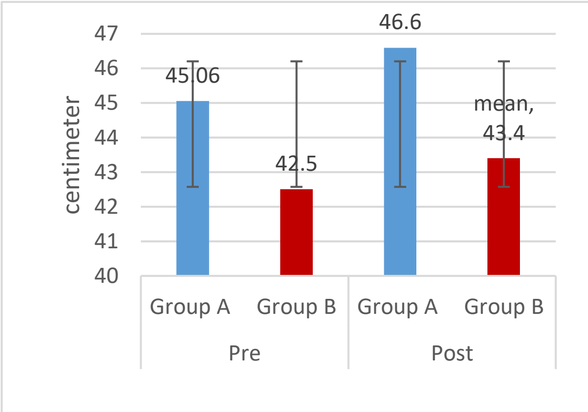

Figure 4: Relationship between the Group A & B pre and post-data for power

Discussion

The results of this study support the hypothesis that both Neuromuscular Training (NMT) and Motor Coordination Training (MCT) are effective in improving the physical performance of collegiate badminton players, specifically in lower body power, speed, and agility.

1. Vertical Jump Test:

The NMT group showed the greatest improvement in vertical jump height, suggesting that various exercises and strength training for lower limb were effective in enhancing lower body power. These exercises likely contributed to increased explosive strength, which is essential for actions like jumping and lunging in badminton whereas Bhosale N et. al, [5] demonstrated same effects in plyometric training. The MCT group, while showing an improvement, did not achieve the same magnitude of gain, which may be attributed to the focus of MCT on coordination and fluidity rather than on direct power training.

2. 30m Sprint Test:

Both training groups showed significant improvements in sprint times, with the NMT group showing the greatest reduction. The NMT exercises, which included various exercises focusing on power & strength, likely helped improve acceleration and quickness. The MCT group also demonstrated improvement, possibly due to enhanced proprioception and coordination, which may help players accelerate more efficiently in short sprints as like in study of Churi AB et al (2020) [7] which shows indirect improvement in the sprint power of athletes with makeable enhancement in neuromuscular power.

3. **Agility Test:**

The agility test results were similar to the sprint and jump test outcomes, with both the NMT and MCT groups showing significant improvements. The NMT group showed a larger improvement, possibly because of the dynamic nature of the training, which involved rapid changes in direction and balance drills. The MCT group showed moderate improvements, indicating that motor coordination exercises also enhanced the participants' ability to change directions quickly.

Overall, the NMT group demonstrated the greatest improvements across all three outcome measures, suggesting that a combination of strength training, and balance exercises are particularly effective for enhancing athletic performance in badminton players.

Conclusion

In conclusion, both Neuromuscular Training (NMT) and Motor Coordination Training (MCT) have been shown to significantly improve key performance aspects such as lower body power, sprint speed, and agility in collegiate badminton players. NMT, however, demonstrated a greater overall impact on these performance measures, suggesting its superiority for improving athletic outcomes in this population. These findings support the implementation of neuromuscular and motor coordination exercises as part of training regimens for competitive badminton players. Further studies with larger sample sizes and longer intervention periods are recommended to generalize the findings.

Limitations

1. **Sample Size:**

The sample size of 24 participants may have limited the statistical power of the study. A larger sample size could provide more robust results and allow for subgroup analyses.

2. **Duration of Intervention:**

The study duration of 8 weeks may not have been long enough to observe more significant long-term adaptations in performance. Future studies could extend the intervention period to evaluate sustained effects of the training programs.

3. **Generalizability:**
The study only included male collegiate badminton players, which limits the ability to generalize the results to other populations, such as female players or individuals from different sports.

4. **Assessment Method Limitations:**
Although the outcome measures used in this study (vertical jump, sprint test, and agility drill) are common in athletic performance research, they may not capture all aspects of performance relevant to badminton. Incorporating sport-specific tests, such as those evaluating shuttlecock speed, reaction time, or match performance, could provide a more comprehensive assessment of the effects of the interventions.

Declaration

Ethical approval and Clinical Trial Registration: CTRI/2025/07/091355 was registered before starting the study with REF/2025/07/109909. The ethical approval was taken from the concerned authority (Teerthanker Mahaveer University, Moradabad, Uttar Pradesh India, with reference number TMDCRC/IEC/PHD/24-25/PHYSIOTHERAPY/01 accordance with the Declaration of Helsinki. The research was adhered to National Ethical Guidelines for Biomedical and Health research involving human participants (ICMR, India).

Consent to participate: The detailed information taking the demographic details and values was taken from the participants before the data collection with right to withdraw policy.

Consent for publication:' All the authors agreed to publish this research and the consent from participants in study has been taken already without identifying their individual data.

Availability of data and materials: The dataset which was analysed by the corresponding author is available with the corresponding author.

Competing Interest: There was no conflict of interest in this study.

Funding: There was no source of funding received from any funding agency or organization.

Author contribution: The authors have contributed as follows - Dr Amit Saraf - Supervision, methodological analysis and guidance and revision of manuscript. Dr Pooja Anand - Assistance and guidance for data interpretation, critical review and final approval of manuscript. Himanshu [corresponding author] - All over writing and drafting of manuscript, data collection, analysis and interpretation and preparation of results.

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