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Effects of Lower Limb Concentric versus Eccentric Dynamic Resistance Training on Agility and Speed in Badminton Players

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ABSTRACT

Background: The performance of footwork is analyzed by the ability of an athlete to move forward and backward on the court. Plyometric training is the simplest and most effective method for increasing agility. **Objective:** To determine the effects of lower limb concentric training versus eccentric dynamic resistance training on speed and agility in badminton players. **Methodology:** A clinical trial (ClinicalTrials.gov identifier: NCT06509607) was conducted for 10 months using purposive sampling to recruit participants from badminton clubs and sports centres in Faisalabad. About 64 participants were recruited and randomly allocated into two groups of 34 each using the lottery method. It included male and female badminton players aged 18 to 35 years, having one year of experience in badminton. All participants who were pregnant or had musculoskeletal disorders were excluded from the study. All participants were provided written informed consent in both English and Urdu. Group A had a structured concentric resistance training program. Group B was administered an eccentric training program of identical time and frequency. The eccentric protocol was of wall sits, straddle sitting single-leg holds, and full squats. Agility was measured through the lateral change of direction change of direction test. A stopwatch or an automatic timing gate was used to measure time. Due to non-parametric data, comparisons of pre- to post-intervention scores within groups were carried out using the Wilcoxon signed-rank test, while comparisons of groups were conducted using the Mann-Whitney U test. **Results:** The training group has an average age of 26.09±3.76. Within-group analysis has shown a significant improvement in agility for the concentric group (p=0.000); however, eccentric exercises have shown a similar significant trend in pre- and post-values. There is no significant difference in the performance of the concentric and eccentric training groups on both outcome measures (p=0.780). **Conclusion:** Both training groups showed statistically significant change in pre- and post-values for agility and speed. But when it came to agility, concentric training performed marginally better than eccentric training. However, speed performance was improved in both groups with no significant differences between them..

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INTRODUCTION

The Badminton World Federation (BWF) estimates that over 200 million people play badminton globally, and thousands of players compete in a variety of global events and competitions.[1, 2] A wide range of variations in the posture, for example, changes in direction, lunge movements, hops and quick movements of the arm are used in competitive badminton. On the court, there is a need to maintain a good balance and control; the movement entails taking the fewest feasible steps to reach the shuttle.[3] The qualities of badminton players to enhance the accuracy of shots include repetitive movements with high intensity, covering smaller distances with rapid movements over short distances and agile movements of the feet.[4] To guarantee the accuracy of every shot, players must travel to designated spots on the court and return to the center as quickly as possible.[5] Numerous physiological indicators and badminton performance are strongly correlated. VO2max, lactate/anaerobic threshold, and running efficiency in particular have positive correlations with aerobic capacity and intermittent exercise performance.[6]

It is commonly known that muscle strength is essential for enhancing and sustaining athletic performance, including quickness, agility, and explosive strength. It also helps to build motor function. It is known that resistance training works well to increase explosive power.[7] A crucial component of physical exercise is resistance training. This kind of training can greatly enhance muscular mass and strength and aid in the management and prevention of chronic illnesses. Training volume, muscle contraction speed, frequency, mode, sequence, training intensity, and intermittent time are the primary components of a resistance training exercise prescription.[8] The use of resistive motion can be divided into contractile activities that are static (isometric) and dynamic (isokinetic and isokinetic). Enhancing muscle strength, endurance, and different adaptive changes in muscles can be achieved through resistance training with both fixed load and variable load dynamic contraction.[9]

Steep turns, lunges towards the net, and rapid arm movements necessary to hit the shuttlecock from a range of postural positions raise the risk of injury.[10] The ability to change direction and move has been validated as a crucial component of physical exercise training in recent years by many individuals working on various projects.[11] Moving in a different direction during movement training can quickly follow the right path and ultimately turn into a training technique to enhance athletic performance.[12] The performance of footwork is analysed by the ability of an athlete to move forward and backwards on the court.[13] The simplest and most effective method of training for increasing agility is plyometric training.[14] To create a post activation increase in the performance and power, the necessary quantity of repetitions of the resistance conditioning workouts combined with a vigorous warm-up.[15] One of the most important skills for badminton players to develop is jumping, particularly when smashing and putting.[16]

When performing plyometric exercises, high-velocity resistance training is used by rapidly contracting the muscle in an eccentric (lengthening) fashion, which is crucial for the badminton sport. This contraction is then quickly reversed with a resisted contraction of the same muscle, which helps to activate proprioceptors, which in turn promotes increased muscle recruitment in a short period.[17] In the context of badminton, where players need to swiftly change direction, stop abruptly, and lunge explosively, both concentric and eccentric training play crucial roles. Concentric training could potentially enhance the explosive power required for sudden bursts of movement, such as quick sprints across the court and powerful smashes. On the other hand, eccentric training might facilitate controlled deceleration, essential for sudden stops, direction changes, and injury prevention. Different levels of resistance may have different effects on the performance and recovery of the athletes.[18]

A more detailed analysis of resistance training and its different types is needed to determine the best practice for badminton players. In concept, top badminton players might enter a hypoxemia state later in the match and extend the oxygen supply period due to improvements in their body's ability to absorb oxygen. This could significantly enhance their match performance during the tournament. Furthermore, we discovered that there was no discernible rise in VO^2 max following the SIT, despite specific studies displaying disparities in findings. It follows that variables like the subjects' body weight, frequency of training, and degree of training would all influence how effective this technique is. Players' performance on the court is directly impacted by their aerobic recovery capacity. During a competition, high-intensity, high-load exercise would cause physiological exhaustion and a significant buildup of lactate in the skeletal muscle. Players may experience physical dysfunction and a drop in their level of athletic performance due to alterations in their bodies' internal reactions. Consequently, the most important requirement for a respectable technical and physical performance during the tournament is the capacity to recover quickly.[19]

Thus, it is important to compare these two types of resistance training to determine their differential impacts on agility and speed in badminton players. Investigating these effects can provide insights into the most effective training methods for optimising performance in this sport. To ascertain the impact of eccentric dynamic resistance training versus lower limb concentric training on badminton players' speed and agility.

METHODOLOGY

A clinical trial (ClinicalTrials.gov identifier: NCT06509607) was conducted to contrast concentric and eccentric dynamic resistance training's influence on badminton players' agility and speed. The trial was conducted for 10 months upon approval of the research outline in November 2023. A purposive sampling strategy was used to recruit participants from badminton clubs and sports centres in Faisalabad, such as Crescent Sports Complex and Al-Fatah Sports Complex. The sample size was estimated using OpenEpi based on the Lateral Change of Direction Test. A total of 64 participants were estimated, and considering an attrition rate of 10%, to final number was 68. All these participants were randomly allocated into two groups of 34 each using the lottery method.

The inclusion criterion included male and female badminton players aged 18 to 35 years, having one year of experience in badminton, no comorbidities, and no previous six-month history of traumatic injury. All participants who were pregnant, had musculoskeletal disorders, or were physically incapable of following the exercise protocols were excluded from the study. All participants were provided written informed consent in both English and Urdu. The trial used an unblinded design where the participants did not know the details of the intervention administered to the comparison group. Blinding of clinicians and assessors was not possible due to the protocols of training involved. Baseline assessments of agility and speed were taken pre-intervention, and the same tests were conducted following the intervention.

Group A had a structured concentric resistance training program. A 30-minute training session of the lower limbs, two times a week, for six weeks, comprising squats, lunges, and leg extensions, was part of it. Each session was supervised by researchers and was followed by a standard 90-minute badminton training session run by team coaches. Group B was administered an eccentric training program of identical time and frequency. The eccentric protocol was of wall sits, straddle sitting single-leg holds, and full squats, which were supervised by researchers and were succeeded by an identical badminton training protocol as Group A. Both training programs were aimed at training the major muscles of the lower limbs and were of identical volumes and intensities.

Agility was measured through the lateral change of direction (COD) test, which involved sprinting and moving sideways among three cones that were 5 meters apart. The trial started at the first movement from the starting cone and stopped upon reaching the starting position. Agility has an accurate intraclass correlation coefficient (ICC=0.96) that is indicative of excellent reliability. The 60-meter sprint test, which involved running from a standing start to a line marked on the ground, was used to measure speed. A stopwatch or an automatic timing gate was used to measure time, and there was acceptable reliability of the test (ICC>0.75). Analyses were conducted using SPSS, version 25 and demographic data were calculated as means, standard deviations, frequencies, and percentages. For normality testing, Kolmogorov-Smirnov was employed. Due to non-parametric data, comparisons of pre- to post-intervention scores within groups were carried out using the Wilcoxon signed-rank test, while comparisons of groups were conducted using the Mann-Whitney U test. A $p<0.05$ was taken as statistically significant.[20]

RESULTS

The results showed the comparison of two training groups: concentric and eccentric training, across several variables. The average age of participants in the concentric training group is 24.47±2.9, while the eccentric training group has an average age of 26.09±3.76. Both groups have the same average height of 1.69 meters, with standard deviations of 0.078 and 0.083, respectively. The average weight is 63.91±8.79 for the concentric training group and 60.67±10.36 for the eccentric training group. The body mass index (BMI) is 22.07±2.14 for those in concentric training and 21.09±2.22 for the eccentric training participants. Additionally, the years of badminton experience are similar, with the concentric training group averaging 2.64±0.98 and the eccentric training group averaging 2.67±0.94.

The results of normality tests for two performance metrics: the pre-lateral COD test and the Pre 60-meter test, using the Kolmogorov-Smirnov test for the pre-lateral COD test, the Kolmogorov-Smirnov statistic is 0.116 with a degree of freedom (df) of 68, and a significance value of 0.024 and for the PRE 60-meter test, the Kolmogorov-Smirnov statistic is 0.133 with a df of 68, and a significance value of 0.004. These significance values indicate that the data for both tests do not follow a normal distribution, as the p>0.05. The results indicate that, based on the Mann-Whitney U test, there is no evidence to conclude a significant difference in performance outcomes between the concentric and eccentric training groups for these particular tests.

For the concentric training group, the mean age was 24.47 years with a standard deviation (SD) of 2.905, whereas the eccentric training group had a mean age of 26.09 years with an SD of 3.769. Both groups have identical mean heights of 1.69 meters, with the concentric group having an SD of 0.078 and the eccentric group an SD of 0.083. The mean weight for the concentric group was 63.91±8.791, while the eccentric group had a slightly lower mean weight of 60.67±10.36. Regarding BMI, the concentric group has a mean of 22.07±2.14, and the eccentric group has a mean of 21.09±2.22. Finally, both groups have similar years of badminton experience, with the concentric group having a mean of 2.64±0.98 and the eccentric group a mean of 2.67±0.94.

For the lateral COD test, both groups consist of 17 participants each, with a mean rank of 17.5. The z-value for the concentric group is -7.169, and the p-value is 0.00, indicating a highly significant improvement post-training. The eccentric group's results are similar, with a mean rank of 17.5, implying that the test was not calculated separately but shows the same significant trend in Table 1. Both training groups demonstrated significant improvements in agility and speed after the intervention. For lateral change of direction, both the concentric and eccentric groups (n=17) showed a mean rank of 17.50. The concentric group had a z-value of -7.169 with a p-value of 0.000, indicating a highly significant post-training improvement. The eccentric group also had a mean rank of 17.5, reflecting a similar trend of improvement. In the 60-meter sprint, both groups again showed substantial gains. The concentric group recorded a z-value of -7.171 and a p-value of 0.000, with a mean rank of 17.5. The eccentric group mirrored this result with the same mean rank, indicating a significant enhancement in sprint performance following the training, as shown in Table 2.

When comparing the two training groups, no statistically significant differences were observed in either variable at pre- or post-test stages. For lateral change of direction, the pre-test mean ranks were 32.78 (concentric) and 36.22 (eccentric), while post-test mean ranks were 36.60 (concentric) and 32.4 (eccentric), with p-values of 0.47 and 0.38, respectively. For the 60-meter sprint, the pre-test mean ranks were Overall, both concentric and eccentric training 36.6 (concentric) and 32.88 (eccentric), and the post-test mean ranks were 33.69 (concentric) and 35.31 (eccentric), with p-values of 0.5 and 0.73, respectively. Protocols significantly improved agility and speed within their respective groups, yet no meaningful differences were found when comparing the two training methods directly.

DISCUSSION

The present study aimed to evaluate the effects of concentric and eccentric dynamic resistance

Table 1: Wilcoxon signed-rank test

Variables	Groups	Mean Rank	z-value	p-value
Pre-post lateral change of direction	Concentric	17.5	-7.169	0.000
	Eccentric	17.5		
Pre-post 60-meter speed	Concentric	17.5	-7.171	0.000
	Eccentric	17.5		

Table 2: Summary of results

	Variable	Group	Mean Rank	z-value	p-value
Lateral change of direction	Pre-post	Concentric	17.50	-7.169	0.000
		Eccentric	17.50		
	Pre-treatment	Concentric	32.78	-0.718	0.473
		Eccentric	36.22		
	Post-treatment	Concentric	36.60	-0.877	0.380
		Eccentric	32.40		
60-meter Speed	Pre-post	Concentric	17.50	-7.171	0.000
		Eccentric	17.50		
	Pre-treatment	Concentric	36.60	-0.675	0.500
		Eccentric	32.88		
	Post-treatment	Concentric	33.69	-0.337	0.736
		Eccentric	35.31		

training on agility and speed in badminton players. The demographic data indicated comparable profiles between the two groups in terms of age, height, weight, BMI, and years of playing experience. While the concentric group had a slightly higher proportion of male participants, both groups demonstrated similar baseline physical characteristics, ensuring a fair comparison of training effects. Normality testing using the Kolmogorov-Smirnov test indicated that data for both the lateral change of direction and 60-meter sprint tests significantly deviated from a normal distribution ($p<0.05$), justifying the use of non-parametric statistical methods for subsequent analyses. These findings align with the inherent variability often observed in performance-based data in athletic populations. Both concentric and eccentric training methods led to statistically significant improvements in agility and speed within each group.[21]

The within-group comparison revealed highly significant improvements in post-training performance for both lateral change of direction and 60-meter speed, as indicated by Wilcoxon signed-rank test results ($p=0.000$ for both variables). These outcomes affirm the efficacy of both resistance training modalities in enhancing neuromuscular performance parameters relevant to badminton. These findings are consistent with earlier studies that have demonstrated the effectiveness of resistance training in improving agility and speed. Previous research has emphasised the utility of eccentric training in badminton for its role in facilitating rapid neuromuscular activation and agility development due to the high-velocity deceleration demands inherent in the sport.[21]

Kamalden et al. also supported the effectiveness of eccentric exercises, highlighting their role in optimising nerve impulse transmission during sport-specific movements.[22] Despite significant within-group improvements, between-group comparisons using the Mann-Whitney U test showed no statistically significant differences in post-training performance between concentric and eccentric training groups. For both agility and speed tests, the p-values exceeded the 0.05 threshold, indicating similar levels of improvement regardless of the training modality. These findings suggest that although both training strategies are effective, neither holds a clear advantage over the other in the short term.

Safavi's work further supports these conclusions, suggesting that incorporating both concentric and eccentric exercises can be beneficial not only for performance enhancement but also for injury prevention in badminton athletes.[23] This reinforces the potential value of a combined or periodized approach to resistance training that includes both contraction types to maximize athletic development and resilience. Future studies should include a control group, longer intervention duration, and clearly defined training parameters. Use sport-specific tests and advanced measurement tools. Monitor adherence and consider broader populations to enhance generalizability.

CONCLUSION

There is a statistically significant difference between pre- and post-values for agility and speed in both training groups, i.e. concentric and eccentric training. However, for agility concentric training showed slightly better results as compared to eccentric training. On the other hand, speed showed somewhat better results when participants were subjected to eccentric training. The study lacked a control group, limiting causal inference. The training duration may have been insufficient to observe long-term effects. Details on training intensity and volume were not provided. Measurement errors and unmonitored participant adherence could have influenced results.

DECLARATIONS

Consent to participate: Written consent had been obtained from patients. All methods were performed following the relevant guidelines and regulations.

Availability of data and materials: Data will be available on request. The corresponding author will submit all dataset files.

Competing interests: None

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CONSORT Guidelines: All methods were performed following the relevant guidelines and regulations.

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