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Original Article

Physiotherapy Section

Effect of Sport-specific Polarised Training on Agility in Elite and Subelite Badminton Players: A Randomised Controlled Study

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ABSTRACT

Introduction: Training Intensity Distribution (TID) is used by elite athletes prior to their competitions to enhance their performance. It has been employed in various endurance sports like running and cycling, but it is underutilised in sports where other components such as agility, strength and coordination are also part of the training. Badminton is one such game that requires aerobic fitness, skill, coordination, along with agility for rapid changes of direction and movements such as jumping, squatting and lunging. Badminton players need to practise these movement patterns to strike the shuttlecock and keep moving back and forth on the court.

Aim: To evaluate the effect of sport-specific polarised training via a badminton field test on agility in badminton players.

Materials and Methods: This double-blinded randomised controlled was conducted in an indoor badminton court at Manav Rachna Sports Academy in Faridabad, Haryana, India. Twenty badminton players aged between 15 to 26 years participated in this study, in which players were randomly assigned to two groups: an Experimental Group (EG) (n=10) and a Control Group (CG) (n=10). Over a 9-week period, the EG engaged in sport-specific polarised training via a badminton field test using BlazePod agility lights and an Edge lactate analyser to differentiate between three zones of training, while the CG followed the traditional training prescribed by their coach. In the badminton field test, the speed of the lights was kept at 16 lights per minute for low intensity (zone 1), 20 lights per minute for threshold intensity (zone 2), and above 22 lights per minute up to exhaustion for high-intensity training (zone 3). A four-corner agility test was used to evaluate the agility of the badminton players before and after the 9-week training protocol. Statistical analysis was conducted using a One-way Analysis of Variance (ANOVA).

Results: The results showed that an 11.8% improvement was observed in the polarised training or EG, compared to a 3.6% improvement in the CG. This indicates that performing repeated sport-specific movements at different intensities, as done in polarised training, increases aerobic capacity and also improves agility in badminton players.

Conclusion: There was an improvement in the agility of badminton players following sport-specific polarised training.

Keywords: High-intensity training, Low-intensity training, Threshold training, Training intensity distribution

INTRODUCTION

Badminton, often perceived as a leisurely backyard game, is a high-intensity sport that demands significant endurance. It involves quick decision-making and fast-paced rallies characterised by rapid movements, explosive sprints and powerful jumps. A professional match can last over an hour, requiring athletes to maintain a high energy level and focus throughout. Thus, the sport necessitates superior cardiovascular and muscular endurance [1]. Players cover considerable distances through short, sharp bursts of speed and their heart rates can escalate to levels comparable to those observed in more traditionally recognised endurance sports like running or cycling. This continuous movement within the court pushes both the aerobic and anaerobic systems to their limits. Endurance training for badminton players often includes running, interval training and circuit training to enhance their cardiovascular capacity and improve muscle endurance, enabling them to sustain high-intensity efforts throughout their matches [2].

An athlete's agility, which is the ability to swiftly change direction, accelerate, decelerate and maintain balance, is critical for effectively covering the court. It distinguishes badminton as one of the most dynamic and physically demanding racket sports [3]. The shuttlecock can travel at high speeds, especially in professional games, requiring players to react and move quickly to position themselves for each shot. Agility enables players to perform complex footwork patterns and transition smoothly between defensive and offensive positions, allowing them to respond to their opponent's shots with precision and speed [4]. This agility is developed through specialised drills that focus on foot speed, reaction time and balance. Drills such as ladder exercises, cone drills and shuttle runs help enhance a player's ability to make quick, accurate movements. Furthermore, agility training contributes to injury prevention by improving joint stability and muscle coordination, which is crucial given the high-impact nature of the sport and the frequency of directional changes [5-7].

TID is a fundamental concept in sports science that plays a pivotal role in optimising athletic performance. It refers to the distribution of training volume across various intensity zones over a designated period. This methodology aims to achieve specific physiological adaptations while minimising the risk of overtraining and injury. Understanding TID is crucial for coaches, athletes and sports scientists seeking to design effective training programmes tailored to individual needs and goals [8]. The concept of TID gained prominence through the pioneering work of sports physiologists and coaches who recognised the importance of balancing training loads to maximise performance gains. Traditional approaches to training often emphasised high-intensity workouts, assuming that greater effort would inevitably lead to better results [9]. However, this one-dimensional approach neglected the significance of varying intensity levels and their distinct physiological effects on the body. TID advocates a more nuanced approach by categorising training intensity into three primary zones: low, moderate and high. Each zone corresponds to specific physiological responses, including aerobic endurance, lactate threshold and maximal effort. By strategically distributing training volume across these zones, coaches can elicit targeted adaptations in energy systems, muscle fibres and metabolic pathways [8,10-12].

In endurance sports such as rowing, running, skating, swimming, and cycling, athletes train with variable intensities (low, moderate and high-intensity training) during the precompetition phase to enhance their performance [13]. Therefore, the correct distribution of these intensities is crucial for optimising performance and preventing burnout or injury. Polarised training is a training strategy in which approximately 80% of training is conducted at low intensity, where athletes work at a comfortable pace and around 20% is done at high intensity, where they push near their maximum effort. Very little or no time is spent in the moderate-intensity range. This model has gained popularity in endurance sports due to its effectiveness in enhancing both aerobic capacity and high-intensity performance [14,15].

The key advantage of polarised training is that it allows athletes to maximise the benefits of both low and high-intensity efforts while minimising the fatigue and risk of overtraining associated with moderate-intensity work. Low-intensity sessions are typically long and slow, focusing on improving aerobic efficiency and endurance without accumulating significant fatigue. In contrast, high-intensity sessions are short but intense, designed to push the limits of the athlete's aerobic and anaerobic systems, leading to substantial improvements in speed, power and lactate threshold. The combination of these two extremes, with minimal time spent in the moderate-intensity zone, helps reduce overall training stress and enhances recovery, thereby allowing athletes to train consistently and effectively over long periods [16-18].

While badminton is not a traditional endurance sport, the demands of the game require a unique blend of endurance, speed, agility and power. By incorporating polarised training, badminton players can benefit from the aerobic adaptations achieved through low-intensity training, which enhances their ability to recover quickly between points and maintain a high level of performance throughout a match [19,20]. The high-intensity component of polarised training can be particularly beneficial for badminton, as it replicates the explosive movements and rapid directional changes that characterise the sport [21]. This training helps improve the anaerobic capacity and muscular power required for powerful smashes, quick sprints and rapid changes in direction [22].

Over the years, it has also been observed that athletes and their coaches are increasingly inclined towards polarised training, particularly in endurance sports, to enhance performance. However, little to no research has been conducted in racquet sports like badminton, where other fitness components, such as agility, are also involved [23]. Therefore, this study aimed to investigate whether a well-structured, sport-specific polarised training protocol can significantly affects on-court agility in badminton players.

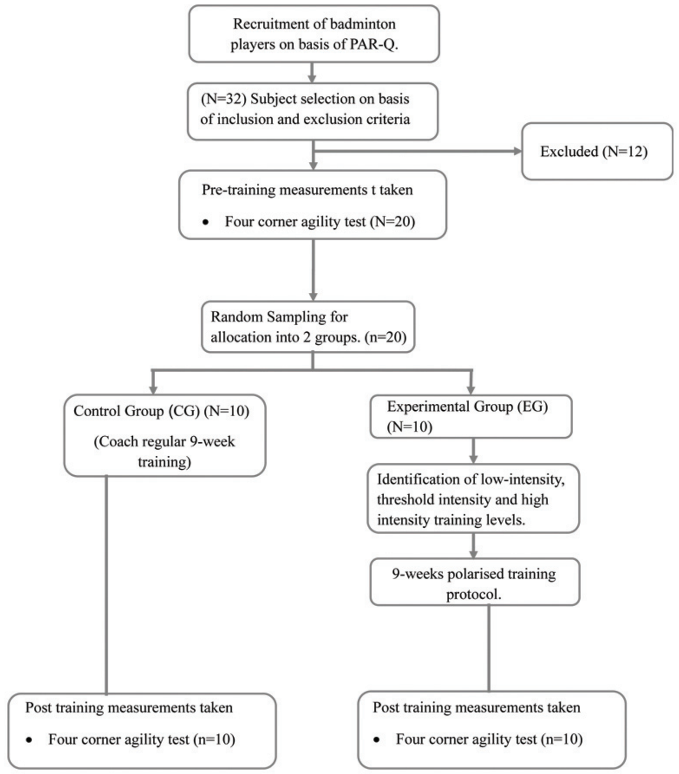
MATERIALS AND METHODS

The research utilised a double-blinded randomised controlled study design. The polarised training was conducted in an indoor badminton court via a badminton field test at Manav Rachna Sports Academy in Faridabad, Haryana, India, during June to August 2024. Approval from the research ethical committee was obtained, with approval number EC/2023-24/039.

Inclusion criteria: The players, aged between 15 and 26 years, who were competing at either state or national level and were not consuming caffeine or alcohol [24], nor engaging in strenuous exercise 48 hours before the start of the research protocol, were included in the study. The Physical Activity Readiness Questionnaire (PAR-Q) was utilised to identify any contraindications that might prevent players from participating in the study, such as any heart conditions, medications, or musculoskeletal injuries/pain [25].

Exclusion criteria: Players who had sustained any injuries in the past six months or who were pregnant were also excluded from the study.

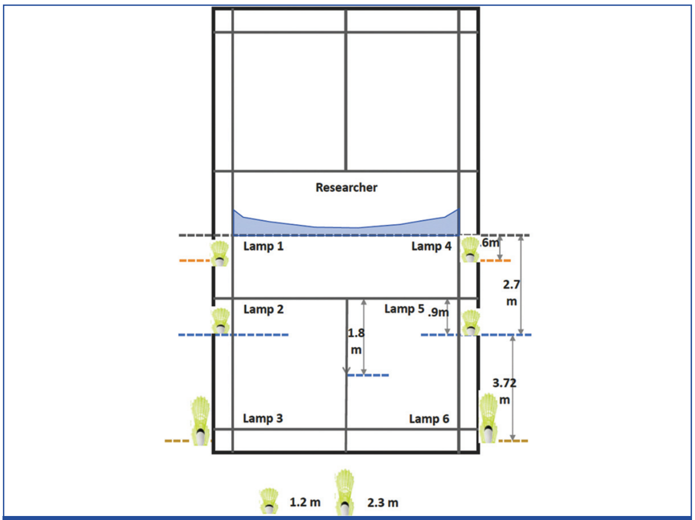
Sample size: The minimum sample size required for the execution of the research study was 20, with 10 participants in each group, as calculated using G*Power (version 3.1.9.7) for optimal statistical accuracy. The badminton players were equally divided into two groups, namely the traditional training (control) group and the polarised training (experimental) group, through simple random sampling [Table/Fig-1].



[Table/Fig-1]: Consort's flowchart.

Study Procedure

All players were asked to report in a well-hydrated state. An ambient temperature of 28-32° Celsius was monitored inside the badminton court [26]. The dependent variable was polarised training via the badminton field test [Table/Fig-2], while the independent variable was the four-corner agility test [Table/Fig-3] [27].



[Table/Fig-2]: Badminton field test.

After applying the inclusion and exclusion criteria, players were equally divided into the experimental and CGs. In the EG, the badminton field test was used to determine the low intensity, threshold intensity and high-intensity zones of training before the beginning of the 9-week polarised training protocol. Following the determination of these zones, polarised training was also administered via the badminton field test in the EG.

The badminton field test was conducted on a badminton court. BlazePod training lights [Table/Fig-4] were placed beneath six posts,

[Table/Fig-3]: Four corner agility test.

with a shuttlecock hanging at each post. These lights were connected to the BlazePod mobile application on the researcher's phone. Two training lights were positioned near the forecourt by the net at a height of 1.2 m, the next two at midcourt at the same height, and the final two at the rear court at a height of 2.3 m. Variation in training intensity was achieved by adjusting the speed of the BlazePod training lights through its mobile application. The subjects were instructed to run from a central point towards each post where the BlazePod training light flashed and to strike the shuttlecock. For the forecourt and midcourt, subjects were to perform lunges. For the rear court flashes, they were to execute a backward jump, similar to a smash, before returning to the central point [26].

[Table/Fig-4]: Blazepod agility lights.

In the EG, the low-intensity, threshold intensity, and high-intensity protocols for each individual player were determined using the badminton field test, as shown in [Table/Fig-1]. Each badminton player performed a standardised warm-up protocol before the badminton field test for each intensity level. The warm-up protocol consisted of seven minutes of stretching the leg muscles and light jogging, followed by six dynamic exercises (speed skips, heel kicks, toe-in-toe-out, trunk twists, push-ups and high knee skips) of moderate to high intensity lasting for one minute each, with a 10-second rest period [28].

In the badminton field test, BlazePod agility lights [Table/Fig-4] were used to determine the different intensity levels of training for the badminton players. The speed of the agility lights via the BlazePod mobile application was set at 16 lights per minute for low intensity, 20 lights per minute for threshold intensity, and above 22 lights per minute up to exhaustion for high-intensity training. The test consisted of multiple levels, each lasting three minutes of exercise followed by a 45-second rest period.

A level of exhaustion was deemed to have been achieved if the next BlazePod light flashed before the previous one was touched by the subject [26]. After each set, the blood lactate level was measured to determine the duration of time spent at each intensity level. To measure blood lactic acid levels using the Edge lactate meter, blood was drawn from the fingertip of the non dominant hand during a 45-second rest interval between each level. During the low-intensity training session, the time was recorded once the blood lactate crossed 2 mmol/L; for threshold intensity, the time was measured when the blood lactate level crossed 4 mmol/L; and for high intensity, the time was recorded when a player reached their level of exhaustion [8]. In the CG, no intervention was made by the authors; training was conducted by the players' badminton coaches. The CG performed shuttle runs, stretching, ladder drills, sprints, shadow training and matches against one another three times a week.

Each intensity level was determined on the second day and a fixed warm-up protocol was followed by each player before the test. After determining all three intensity levels for a badminton player in the EG, the polarised training commenced on the seventh day (9-week protocol) with the same warm-up protocol that each player followed. The polarised training was provided in three blocks of three weeks each, where in the first two weeks, low-intensity and high-intensity training were alternated on different days. In the third week, each type of training- low, threshold, and high intensity- was conducted once on alternate days. In the CG, each player completed regular training, which was supplemented by their coach for the duration of the nine weeks. Outcome measures were assessed again post-intervention in both groups using the four-corner agility test.

The four-corner agility test was performed on one side of the badminton court. It involves diagonal movement actions similar to those executed during a badminton game, along with rapid changes in direction. Four shuttlecocks were placed upside down at each corner of half of the badminton court, as shown in [Table/Fig-3]. The subjects were instructed to follow a particular sequence in their movements. The sequence of movement to be followed was as follows:

- Right-Handed Subjects:

  Centre → A → Centre → B → Centre → C → Centre → D → Centre.

- Left-Handed Subjects:

  Centre → C → Centre → D → Centre → A → Centre → B → Centre.

The players were instructed to perform movements that mirrored how they would move inside the court during a game, with a racquet in their dominant hand, and then to strike the upturned shuttlecocks in the specified sequence. This process was repeated until the subject had struck all 16 shuttlecocks. Each subject performed two trials with a 5-minute rest between them, and the best performance time from the two trials was recorded as their test result [27].

STATISTICAL ANALYSIS

Statistical analysis was conducted using Statistical Package for the Social Sciences (SPSS) Statistics 23.0 (IBM). The mean and standard deviation values for the research variables were calculated, and a One-way ANOVA test was employed for comparative analysis. A significance level of p-value <0.05 was established.

RESULTS

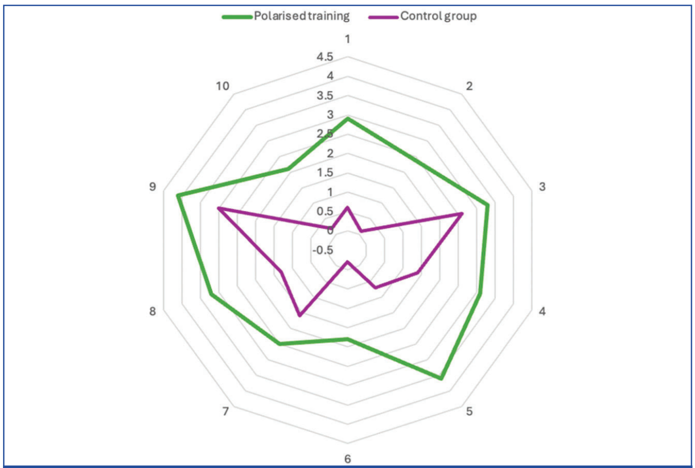
The polarised training group consisted of four male players (all right-handed) and six female players (five right-handed and one left-handed) badminton players, whereas the CG comprised five male players (one left-handed and four right-handed) and five female players (one left-handed and four right-handed). The polarised training group included two elite and eight subelite players, while the CG had one elite and nine subelite players. The mean age of players was 18.5±2.19 years in the polarised training group and 19.1±2.56 years in the CG. An independent t-test yielded a p-value of 0.1919, confirming no significant difference in mean age [Table/Fig-5].

Variable	Polarised training (Mean±SD)	Control Group (CG) (Mean±SD)	p-value
Age (years)	18.5±2.19	19.1±2.56	0.1919
Preagility score (sec)	28.8±1.79	30.99±2.3	0.0903
Postagility score (sec)	25.38±1.32	29.86±1.69	0.0003

[Table/Fig-5]: Age, mean value, and standard deviation of the independent variable in the two groups.

In the EG, the range for training duration was 45 minutes to 63 minutes and 45 seconds for low intensity, 26 minutes and 15 seconds to 45 minutes for threshold intensity, and 18 minutes and 15 seconds to 30 minutes for high intensity. The pretest range of time in the agility test for the polarised training group was 27 to 30.6 seconds, compared to 28.7 to 33.3 seconds in the CG. The range of post-test times was 24.0 to 26.7 seconds in the polarised training group, compared to 28.1 to 31.5 seconds in the CG. A One-way ANOVA was applied to the data, yielding a p-value of 0.0903 for the pretest agility score in both groups, suggesting that the difference in agility performance at baseline was not statistically significant. However, the p-value for the post-test agility score was 0.0003, which was less than 0.05, indicating a significant difference between the two groups and leading to the rejection of the null hypothesis. According to the mean and standard deviation data presented in [Table/Fig-5], the polarised training group experienced an 11.8% improvement, while the CG saw a 3.6% improvement in the timing of the four-corner agility test. Polarised training enhanced agility skills in badminton through improved aerobic endurance, enhanced neuromuscular coordination, and better high-intensity power output.

[Table/Fig-6] utilises a radar chart to represent the performance difference between the two groups. It demonstrates that the area formed in the radar chart by the variation in pre- and post-parameters of the polarised training group is substantially larger than that of the CG. Consequently, it appears to be more effective in improving the agility of these badminton players.



[Table/Fig-6]: Performance improvement radar chart.

DISCUSSION

In the present study, combining polarised training with agility-focused drills in badminton has provided a balanced approach, particularly by incorporating these sports-specific movements at different intensities (low, threshold and high intensity). The high intensity, or time spent in zone 3 of polarised training, enhances fast-twitch muscle fibre recruitment and contractility, which improves muscle power, speed and coordination. This is directly linked to improvements in neuromuscular function and, consequently, better agility [29]. In contrast, low intensity or zone 1 in polarised training helps to improve aerobic capacity while avoiding overtraining or injury [30]. As a result, in-court agility among badminton players was enhanced in the polarised training group compared to the CG.

Kusuma DW et al., introduced a novel agility test specifically designed for badminton players, addressing the need for sport-specific agility training and assessments that reflect the unique demands of the sport, including rapid changes in movement patterns. The authors incorporated badminton-specific movements such as lunges, quick directional changes, jumps and shuttlecock interception to develop and validate a new agility test for a better evaluation of badminton players. Lights were used for visual feedback, prompting players to move towards specific points and the results demonstrated that the new test was reliable and valid for assessing agility in badminton players, thereby providing a more accurate measure of their on-court performance capabilities [31]. This new agility test was based on the badminton agility field test developed by Chin MK et al., and highlights the importance of sports-specific protocols for training and assessing agility in badminton players [26]. A similar study by Tan B et al., focused on the development and design of a distributed badminton agility training and testing system, leveraging technology to enhance sport-specific training and assessment. Their test also simulated game-like scenarios and tracked movements, allowing for personalised training programmes and evaluations of agility in players [32]. The same badminton field test involving sports-specific movements was utilised in the present study as part of the polarised training.

Wee Eh et al., examined the effects of high-intensity intermittent badminton multishuttle feeding training on aerobic and anaerobic capacity, strength and agility in badminton players. This sports-specific training resulted in a significant increase in aerobic capacity (VO_2 max), enhanced leg strength and improved agility in these players [33]. Although the increase in agility in their EG was 3.6%, there was a decrease in their CG (-0.11%). The modest increase in agility compared to the 11.8% increase observed in this study can be attributed to the shorter duration of additional training provided in their study, which lasted only four weeks. In contrast, this study followed a 9-week protocol, with the duration of training based on blood lactate levels defining low, threshold and high-intensity training.

Gamble P, highlights the relationship between training intensity and the development of agility in sports. Gamble P noted that high-intensity training, particularly interval-based and sport-specific drills, is crucial for improving agility as it closely mimics the demands of competitive environments. High-intensity training enhances anaerobic capacity, power output and reactive abilities, all of which are vital for effective agility performance. However, the author also emphasises the importance of balancing high-intensity sessions with adequate recovery and lower-intensity training to prevent overtraining and optimise adaptation. This approach underscores the need for a periodised training programme, also known as TID that incorporates varied intensities to develop agility effectively while minimising the risk of injury [34]. This perspective aligns with the understanding that agility is a complex skill requiring both physical and cognitive components, which can be optimally developed through a structured, intensity-based training regimen, as followed in this study.

While polarised training itself does not concentrate on agility-specific drills (e.g., cone drills or ladder drills), the badminton field test used to develop the polarised training protocol in this research replicates the on-field sports-specific movement patterns of badminton players, which, in turn, enhances the neuromuscular and metabolic systems required for quick movements in badminton. The supplementation of polarised training with agility-specific drills, i.e., badminton sport-specific movements, may have synergistic effects, with enhanced endurance and power facilitating quicker and more efficient changes in direction.

Limitation(s)

The limitation of this research was that only agility was tested in this study. In addition to agility, various other sports performance-related parameters, such as game skills and coordination, should also be evaluated.

CONCLUSION(S)

The findings of this study demonstrate that a 9-week polarised training programme, incorporating sport-specific movements with variable intensities (predominantly low intensity, supplemented by high intensity and minimal moderate intensity), significantly enhances agility in elite and subelite badminton players compared to traditional training methods. These findings should also be applied to a larger population so that the results can be generalised. Additionally, different modes of polarised training, such as combinations of plyometric, strength and endurance training, should be tested to further enhance the performance of badminton players.

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