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Original Article

Effects of Plyometric Training on the Agility, Speed, and Explosive Power of Male Collegiate Badminton Players

Suresh Chandra, Ankita Sharma, Nitesh Malhotra*, Moattar Raza Rizvi, Sunita Kumari

Department of Physiotherapy, Faculty of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India

Background: Plyometric training involves dynamic activities such as hopping, jumping, skipping, and bounding, and is used to improve dynamic muscle performance. The study aims to determine the effects of a 3-week plyometric training program on the explosive strength (standing broad jump [SBJ]), speed (30-meter sprint), and agility (t-test) of badminton players.

Methods: The study recruited 102 eligible subjects who were randomly divided into two groups (51 per group). Both groups were initially tested for agility, speed, and strength. Thereafter, the experimental group underwent the plyometric exercise program twice per week for 3 weeks with a 2-day recovery period in between sessions. During the 3 weeks, the control group continued its routine exercise without plyometric training. After 3 weeks, the study tested both groups for agility, speed, and strength.

Results: The agility of the experimental group after plyometric training (pre = 10.51±0.35 vs. post = 9.74±0.39 s) was significantly improved [t (100) = 9.941, p < 0.001] compared with the control group (10.65±0.29 vs. 10.53±0.33 s). Performance in terms of speed was significantly increased [t (100) = 4.675, p < 0.001] for the experimental group (pre = 4.58±0.35 vs. post = 4.06±0.45 s) compared with the control group (pre = 4.62±0.29 vs. post = 4.47±0.34 s). The experimental group (pre = 181.17±6.05 vs. post = 178.30±5.97 s) exhibited a substantial improvement [t (100) = 4.95, p < 0.001] in terms of explosive power compared with that of the control group (pre = 183.02±3.89 vs. post = 183.88±3.91 s).

Conclusion: The findings emphasize the benefits of plyometric training in increasing the performance level required during movements in badminton. Plyometrics can help badminton players enhance their agility, speed, and explosive power.

Keywords: Agility, Functional performance, Plyometric exericise, Power

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*Corresponding author:
Nitesh Malhotra
Department of Physiotherapy, Faculty of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Sector 43, Faridabad, Haryana 121004, India
Tel: 91-129 4198989
E-mail: malhotra.nitesh@gmail.com

INTRODUCTION

Badminton is one of the most famous sports performed worldwide. In general, badminton jumping movements have two objectives: obtaining maximal height and reaching a certain spot with a specific body movements. Both objectives are critical in badminton and they are considered when conducting practical training sessions and transferring techniques. When it comes to badminton, plyometric workouts like running and jumping can aid with speed, agility, and movement patterns specific to the sport [1,2].

In dynamic sports, plyometric movements including jumping, hopping, skipping, and bounding are commonly used to improve dynamic muscular performance through plyometric training. Athletes usually utilize Plyometric training across all dynamic sports to improve strength and explosiveness. They involve quick muscle stretching followed by focus or shortening of the same muscle and connective tissue. When combined with a periodic strength-training program, plyometric exercise has been shown to improve the ability to jump higher and faster (vertical jump), as well as the strength and coordination of one's legs and muscles (joint awareness, and proprioception) have all been demonstrated to benefit from this exercise [3].

Regardless of the mechanisms, different athletes used plyometric training to improve their performance in sports. This includes increasing or improving strength, power and speed that include agility [4]. Plyometric workouts "generally involve stopping, starting and changing directions in an energetic manner" and these are the actions necessary for badminton [5]. Many plyometric training routines have demonstrated benefits for players in terms of their athletic performance but the number of training sessions used has been considerably longer. There is lack of data available on the effects of short-term plyometric training protocol on player's athletic performance. The goal of this study is to determine the effect of a 3-week plyometric training program on agility, speed, and explosive power of badminton players.

MATERIALS AND METHODS

1. Participants

The present study design pre and post experimental.

A priori power test was applied to calculate the suitable sample size for this study. The G*POWER software (ver. 3.1.9.2, HeinrichHeine-University, Düsseldorf, Germany) was used to calculate the suitable sample size for the t test using the effect size (d = 0.5), probability error ($\alpha = 0.05$), and power (1-β) probability = 0.8. Grounded on the above-mentioned assumptions, the sample size needed for this study was 51 in each group.

A total of about 102 recreational badminton players aged 18-25 years were recruited from two different sport complexes. In order to reduce the level of possible fatigue/pain, players were advised not to take part in any of the exercise 24-48 hours prior to the test or training session. Inclusion criteria for being a part of this study was players with 18 to 25 years age, playing badminton from last 3 years and not involved in any plyometric training program. Recent injury, trauma to the lower or upper limb, any major systemic disease, incorrect landing technique, and ligament reconstruction surgery were all considered in exclusion criteria.

Players were screened for inclusion & exclusion criteria. Informed consent was taken. Pre-training Evaluation of agility, speed and explosive power was done in both experimental and control groups respectively. Implementation of a 3-week plyometric training program in experimental group & control group performing regular training but no plyometrics for 3 weeks.

Ethical approval was obtained from the ethical committee at Faculty of Allied Health Sciences in accordance to Ethical Principles for Medical Research Involving Human (WMA Declaration of Helsinki) having reference No. MRI-IRS/FAHS/DEC/2021-M03 dated 9th April, 2021.

2. Plyometric training protocol

All participants received training that was administered twice a week for three weeks (Table 1). Plyometric exercise and the American College of Sports Medicine's Foundations of Strength Training and Conditioning recommendations for intensity and volume were used to design the training regimen [6,7]. During the 3 weeks of training, the amount of contacts varied between 90 and 120 feet per session,

Table 1. Plyometric training protocol

Wk	Training volume (foot contacts)	Plyometric drill	Sets*Reps	Training intensity
1	90	Side to side ankle hops	2*15	Low
		Standing jump and reach	2*15	Low
		Front cone hops	5*6	Low
2	120	Side to side ankle hops	2*15	Low
		Standing long jump	5*6	Low
		Lateral jump over barrier	2*15	Medium
		Double leg hops	5*6	Medium
3	120	Side to side ankle hops	2*12	Low
		Standing long jump	4*6	Low
		Lateral jump over barrier	2*12	Medium
		Double leg hops	3*8	Medium
		Lateral cone hops	2*12	Medium

Sets*Reps = Sets × Repetitions.
Wk: week.

while the intensity of the exercises increased [5,8]. Hops and standing jumps were included in plyometric session. Over a 3-week period, the experimental group underwent plyometric exercise twice a week, with a 2-day rest period between sessions. The plyometric practice lasted approximately 35 minutes and included a 10-minute warm-up (jogging and dynamic stretching), twenty minutes of plyometric activities, and a 5-minute cool-down (jogging and static stretching). Prior to the training session, the control group warmed up and stretched dynamically for ten minutes. They participated in their routine badminton drills. They did not underwent any kind of plyometric training during course of three weeks. The players were under close supervision during the training session, and were told to do each exercise. Throughout the experimental phase, both groups continued their routine badminton practices and were not permitted to perform any other training, which would have an effect on the study. Post training evaluation of both experimental and control groups respectively was done after period of three weeks of study. Outcome measures of the study involve three tests for agility, speed and aerobic capacity respectively using t-test agility, 30-meter sprint test and broad jump test.

3. T-test agility

The t-test agility was used to determine player agility. The four cones were arranged in a symmetrical fashion. Cone A was the starting point for each player. He ran to cone B, ten meters away, and touched the base of the cone with his right hand as instructed by time. Using his left hand to contact the base of cone C, he then took a 5-meter side stride to the left. He then walked 10 meters to his right to cone D, where he touched the base with his right hand. His left hand rested on the base of cone B while he walked 5 meters back to cone A. As soon as the player passed through the cone, the timer started ticking [9].

4. 30-meter sprint test

The test consisted of doing a single maximum sprint over 30 meters and recording the timing. Warm-up session was conducted prior to the start of the session, which included practice starts and accelerations. Beginning with one foot in front of the other, in a stationary stance. The front foot was either parallel to or behind the starting line. Prior to the start, this starting position was held for two seconds, in addition, there were no rocking motions allowed. The tester gave them tips on how to maximize their speed (such as staying low and driving hard with their arms and legs) and encouraged them to keep running hard until they crossed the finish line. Two trials were permitted, and the best time to the nearest two decimal places was recorded. Timing began with the first movement and ended when the chest reached the finish line (using a timer) [10].

5. The broad jump test

The broad jump test was used to measure the anaerobic capacity of an athlete. The subjects were instructed to stand with both feet on ground and the point of their shoes were parallel to a definite line, keeping the knees flexed at 90 degrees and the arms on the sides. The subjects were asked to leap forward as far as they can. The measurements were obtained from the designated line to the heel closest to it. Subjects took leaps for three times, 1-minute break was included in each jump and the best jump value was recorded both at the time of pre- and post measurements [11].

6. Data analysis:

Statistical analysis was performed with the help of SPSS 25.0 (SPSS Inc.,). Unless otherwise specified, data are presented as mean and standard deviation. Prior to conducting parametric testing, the Shapiro-Wilk test was used to evaluate the normality assumptions. In all groups, paired t-test were utilized to determine the difference between pre and post intervention. Independent t-test were used to compare the post-intervention measures of all groups, including the control group, in order to determine if there was any difference in the intervention's effectiveness. The significance threshold was set at 0.05 and the confidence interval was set at 95%.

RESULTS

Age matched badminton players were randomly selected for this study and were divided into control (20.5±1.59 years) group and experimental group (20.6±1.43 years). There was no significant difference in the body mass index (BMI) of both group (Control vs. Experimental = 22.3±0.94 vs. 20.4±1.59). However, both the data for age and BMI was not normally distributed as evident from the p value of Shapiro-Wilk test.

1. Agility

The mean score of agility in control group measured initially before starting any exercise protocol was 10.65±0.29 seconds while post measurement of agility following routine warmup exercise was 10.53±0.33 seconds. In the experimental group, pretest of the agility was 10.51±0.35 seconds while posttest following plyometric training was 9.74±0.39

seconds (Table 2).

Independent sample test was done to check the difference in the agility before and after the intervention in control and experimental group (Table 3). It was found that there was no significant difference between the baseline pretest measurement of agility between both the group [t (100) = 1.558, p = 0.123], however the post measurement of agility between the control group (following warm up exercise) and experimental group (following plyometric training) was found to be significant [t (100) = 9.941, p < 0.001].

Table 2. Pre- and post measurement of agility, sprint and standing broad jump between the groups

Outcome variables	Group	N	Mean ± SD
Agility			
Pre-	Control	51	10.65 ± 0.29
	Experimental	51	10.51 ± 0.35
Post	Control	51	10.53 ± 0.33
	Experimental	51	9.74 ± 0.39
Sprint			
Pre-	Control	51	4.62 ± 0.29
	Experimental	51	4.58 ± 0.35
Post	Control	51	4.47 ± 0.34
	Experimental	51	4.06 ± 0.45
SBJ			
Pre-	Control	51	183.02 ± 3.89
	Experimental	51	181.17 ± 6.05
Post	Control	51	183.88 ± 3.91
	Experimental	51	178.30 ± 5.97

Values are presented as number only or mean±standard deviation.
SBJ: Standing broad jump.

2. Sprint 30 meter

The mean score of sprint in control group measured initially before starting any exercise protocol was 4.62±0.29 seconds while post measurement of sprint following routine warmup exercise was 4.47±0.34 seconds. In the experimental group, pretest of the sprint was 4.58±0.35 seconds while posttest following plyometric training was 4.06±0.45 seconds (Table 2).

Independent sample test was done to check the difference in the speed before and after the intervention in control and experimental group (Table 3). It was found that there was no significant difference between the baseline pretest measurement of speed between both the group [t (100) = 0.354, p = 0.724], however the post measurement of speed between the control following warm up exercise and experimental group following plyometric training was found to be significant [t (100) = 4.675, p < 0.001].

3. Standing broad jump

The mean score of explosive power in control group measured initially before starting any exercise protocol was 183.02±3.89 seconds while post measurement of explosive following routine warmup exercise was 183.88±3.91 seconds. In the experimental group, pretest of the explosive power was 181.17±6.05 seconds while posttest following plyometric training was 178.30±5.97 seconds (Table 2).

Independent sample test was done to evaluate the difference in the explosive power before and after the intervention in control and experimental group (Table 3). It was found that there was no significant difference between the

Table 3. Independent samples t-test for agility, sprint and standing broad jump (SBJ) in control and experimental group

Outcome variables	Time	Equal variances	Control group				Experimental group			
			F	Sig.	t	df	p-value	Mean ± SE	95% CI	
									Lower	Upper
Agility	Pre-	Assumed	2.38	0.127	1.558	100	0.123	0.14 ± 0.09	-0.04	0.31
		Not assumed			1.558	88.24	0.124	0.14 ± 0.09	-0.04	0.31
	Post	Assumed	0.965	0.329	9.941	100	< 0.001	0.8 ± 0.08	0.64	0.96
		Not assumed			9.941	98.291	< 0.001	0.8 ± 0.08	0.64	0.96
Sprint 30 m	Pre-	Assumed	11.837	0.001	0.354	100	0.724	0.03 ± 0.09	-0.15	0.22
		Not assumed			0.354	87.653	0.724	0.03 ± 0.09	-0.15	0.22
	Post-	Assumed	4.149	0.045	4.675	100	< 0.001	0.42 ± 0.09	0.24	0.59
		Not assumed			4.675	93.887	< 0.001	0.42 ± 0.09	0.24	0.59
SBJ	Pre-	Assumed	1.282	0.261	1.623	100	0.109	1.85 ± 1.14	-0.42	4.11
		Not assumed			1.623	88.483	0.109	1.85 ± 1.14	-0.43	4.12
	Post	Assumed	1.617	0.207	4.945	100	< 0.001	5.58 ± 1.13	3.33	7.83
		Not assumed			4.945	89.262	< 0.001	5.58 ± 1.13	3.33	7.83

Values are presented as number only or mean±standard error.
F: Statistics for Levene's test for equality of variance, Sig.: Significant, t: Statistics for independent sample test, df: degree of freedom.

baseline pretest measurement of explosive power between both the group [t (100) = 1.623, p = 0.109], however the post measurement of speed between the control following warm up exercise and experimental group following plyometric training was found to be significant [t (100) = 4.945, p < 0.001]. Scatterplot between control and experimental group for the pre and post measurement of different outcome variable showed that there was significant difference in the agility, sprint and explosive power before and after the intervention in the experimental group (Fig. 1).

DISCUSSION

The goal of this study was to investigate the effect of a 3-week plyometric training regimen on badminton players' power, speed, and agility. Subjects were recruited from the aforementioned sports complexes, including those between the ages of 18 and 25. The findings of this study indicated that three weeks of plyometric training might greatly increase the speed performance of badminton players. These findings corroborate multiple earlier research indicating that plyometric exercise can increase sprinting performance via the stretch-shortening mechanism [12]. Asadi and team discovered that plyometrics enhanced performance on a 20-meter sprint distance after six weeks of training on sand. Speed refers to the capacity to move fast on the ground or to rapidly move the limbs in order to grab or throw. Explosive movements or movements that measure strength and agility can enhance physical ability in many fast-paced sports and can minimize the risk of injury to an athlete during fast-paced activities requiring high power outputs, such as most rackets and field sports [13].

One of the study also indicated that following eight weeks of plyometric lower limb training, soccer players' running speeds (40 meters) increased significantly. The quality of the adjusted training program tailored to badminton movements is likely to have an effect on the results achieved for the 30-meter sprint test in the current study after only three weeks of training. In terms of transitioning from plyometric training to sprinting, the best development in sprinting is expected to occur at a rate of muscle action that closely approximates the pace of muscle action employed in plyometric exercises [12].

The results of this study also showed that agility (t-test) improved by 3 weeks of plyometric training. This backs up previous studies. One more study also stated that plyometric training program is able to improve agility over duration of 6-weeks in badminton players [14]. Irawan [15] in their study stated that progressive plyometric training significantly improve lower limb muscle power, so it also influences agility of badminton players. Maybe an increase in power output is one of the essential variables for agility enhancement. Progressive plyometric training regime can be used by coaches or trainers to improve the strength of the lower limb muscle, which in turn can improve agility of badminton athletes [15].

These findings emphasize the critical role of plyometric training in enhancing performance in sports that require acceleration, deceleration, and direction change. Additionally, it is well established that agility requires the develop-

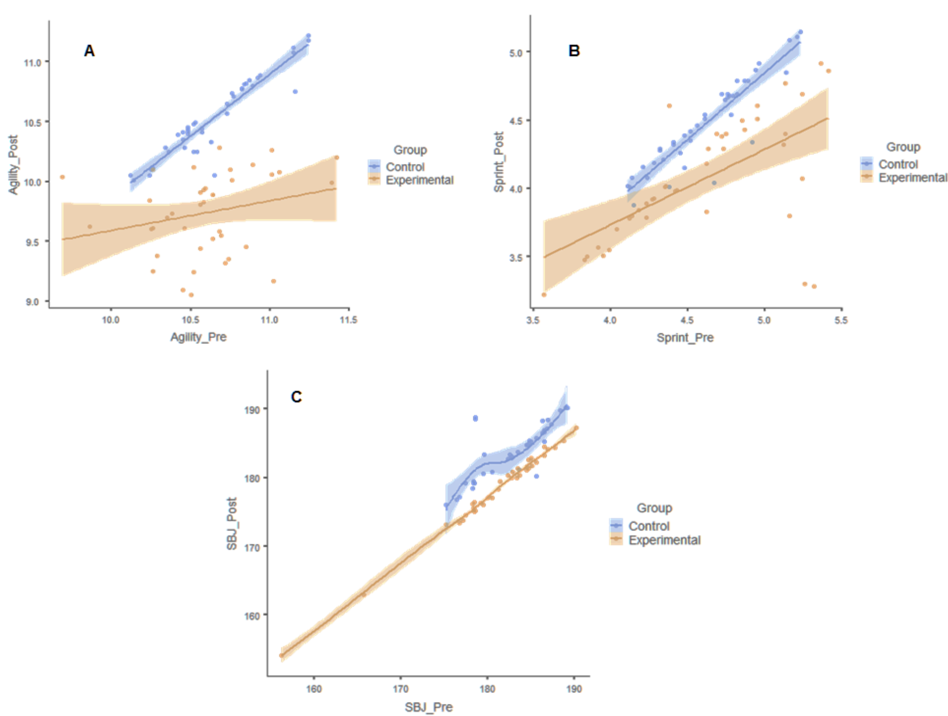

Fig. 1. Scatter plot showing the pre and post measurement of (A) Agility, (B) Sprint, and (C) Standing broad jump (SBJ) test in control and experimental group.

ment of muscular components (for example, strength and power) in order to increase lateral velocity change, and agility appears to be related to strength and power [16]. Additionally, brain changes and increased activation of motor units can contribute to improved agility tests [5,6]. The present study did not analyze neural adaptations to determine whether they happened because of synchronous motor neuron firing or improved facilitation of neural impulses to the spinal cord. Further research is required to determine the neurological alterations that occur because of plyometric training and how agility affects them.

The current research also showed that 3 weeks of plyometric training increased the explosive power of the lower limb (standing broad jump test). However, after three weeks of analysis, there was no substantial difference in the broad jump between the plyometric training group and the control group. This could have been due to the small number of samples and the short length of the plyometric training program, which lasted for three weeks. A longer-term plyometric training regimen may result in a substantial difference in standing broad jump.

Additionally, one of the previous study observed that plyometric training improved jumping strength or height, despite its effect on the technical element of the forehand overhead smash is fairly minimal in the context of a spatiotemporal change. Additional plyometric training may benefit junior badminton squad athletes' success in several jump criteria, such as the squat jump and drop jump. Nonetheless, it is critical to ensure that the form of the plyometric training matches the overall movement requirements of badminton and that contact does not have harmful consequences during regular badminton training [17]. This unique plyometric training regimen included a greater number of low and moderate intensity activities and omitted high intensity exercises. In future research, it is possible that a greater intensity program will provide even better results in terms of fitness measures. Changes in agility and speed performance of badminton players were statistically significant, and while the magnitude of change in standing broad jump may appear tiny, it is worth noting that in the majority of racquet sports, even a fraction of a second might affect the outcome of a match. A fraction of a millimeter can also alter the outcome of a game in sports that require jumps. Small differences in broad jump distance and agility times can contribute significantly to the outcome of a badminton match [17].

A 3-week plyometric training program improved the speed, agility, and power of male collegiate badminton players, according to this study. These findings are positive and can serve as a solid scientific foundation for coaches and trainers to continue improving the quality, effectiveness, and appropriateness of training programs for players of all levels of badminton. Concerning sports medical personnel, knowledge and application of specialized plyometric workouts will aid in the preventative and rehabilitative care of badminton athletes. The findings of this research may also be beneficial to other sporting organizations seeking to boost their national teams' performance and international reputation.

Limitations of the study: Major limitation of study was the small sample size though more samples could not be recruited due to corona pandemic. In addition, this study targeted only the male patients. Next, samples were recruited from two different sport complexes. Other factors such as nutritional factors, psychological factors and activities of daily living were not controlled during the study.

Future recommendation: A plyometric training protocol of longer duration could be used to see the effects on other parameters of physical performance amongst athletes. This type of plyometric training can also be combined with other forms of training to see effects on performance of athletes in other sports as well.

CONCLUSION

A 3-week plyometric training regimen can greatly increase badminton players' speed, agility, and jump performance. The findings of this study demonstrate the value of plyometric training specifically developed for badminton movements. Not only can badminton players employ plyometrics to mix up their training routine, but they can also use them to increase their speed, agility, and lower limb muscle power. Additionally, these favorable benefits can occur after only three weeks of training, which will be beneficial during badminton players' final preparatory period prior to in-season competition.

NOTES

- **ORCID**
  Suresh Chandra, https://orcid.org/0000-0001-5645-2477
  Ankita Sharma, https://orcid.org/0000-0002-8742-381X
  Nitesh Malhotra, https://orcid.org/0000-0003-4104-4520
  Moattar Raza Rizvi, https://orcid.org/0000-0001-8424-7163
  Sunita Kumari, https://orcid.org/0000-0001-6192-2744

- **Authors' contributions:** S.C., A.S., and M.R.R. participated in data collection and wrote the manuscript. A.S. and M.R.R. participated in the study design, performed the statistical analysis, and helped to draft the manuscript. S.C., N.M. and S.K. participated in the study design and coordination and helped to draft the manuscript. All authors read and approved the final manuscript.

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