Journal of Physical Education and Sport ® (JPES), Vol. 24 (issue 3), Art 76, pp. 638 - 648, March 2024
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Impact of plyometric training on agility, sprint and vertical jump functional performance in junior level basketball players

AHAMED THAJUDEEN ANVERSHA[1], VINODHKUMAR RAMALINGAM[2], JAI PRABHU SOMASUNDARAM PREMALA KUMARI[3], SEETHARAMAN VOORAKARAI SUGUMARAN[4]
[1] Research Scholar, [1,2,4] Professor, [3]Assistant Professor
[1,2] Saveetha College of Physiotherapy, Saveetha Institute of Medical and Technical Sciences, Chennai, Tamilnadu, INDIA
[1,4] Department of Physiotherapy, Sri Ramakrishna Institute of Paramedical sciences, Coimbatore, Tamilnadu, INDIA
[3]Department of Anatomy, Karpagam Faculty of Medical, Science and Research, Coimbatore, Tamilnadu, INDIA

Published online: March 31, 2024
(Accepted for publication March 15, 2024
DOI:10.7752/jpes.2024.03076

Abstract:
As a dynamic team sport, basketball emphasizes the need for customized training programs for junior players, given its unique demands characterized by varied movement patterns. While existing research predominantly addresses injury prevention and performance enhancement in other sports, there is a discernible gap in similar studies focusing on Asian junior basketball athletes. Recognizing basketball's intermittent and dynamic nature, this study investigates the efficacy of an eight-week plyometric training program on agility, sprint performance, and explosive leg power in junior players. Sixty-four participants, meeting specific inclusion criteria, voluntarily participated in the study and were randomly assigned to either the regular activity group (RAG, N = 32) or the plyometric training group (PTG, N = 32) via randomized controlled trial. The plyometric training program, spanning eight weeks with three sessions per week, featured a carefully designed program to enhance power, speed, and explosiveness. Ethical clearance was obtained, and the study was registered under the Clinical Trial Registry (CTRI/2023/04/052010). Assessments, including the "T" test for agility, the 30-m sprint test for speed, and the Sargent jump test for jump height and leg power, were conducted at pre-, mid-, and post-training stages. Statistical analyses, including independent samples t-test and repeated measures ANOVA, were employed to examine the statistical significance of observed variances. The results consistently demonstrated the PTG's superior performance in agility, sprint speed, and jump height over the RAG. These findings provide valuable insights into optimizing the athletic performance of junior basketball players through a well-structured plyometric training program. The study underscores the reliability and robustness of observed effects while acknowledging the modest practical significance of small effect sizes in terms of statistical significance. These results provide a foundation for further exploration and improvement of training protocols in sports science, offering practical recommendations to coaches, trainers, and sports professionals to enhance the functional performance of junior basketball players.
Key Words: **Basketball, Plyometric, junior, agility, sprint, vertical jump, functional performance**

Introduction

Basketball is a dynamic team sport played on a court. This game is characterized by continuous transitions between offense and defense, encompassing various movements. Basketball requires high-intensity actions such as sprinting and jumping and lower-intensity activities such as running and shuffling (Bal, B. S., Kaur, P. J., & Singh, D. 2011). Previous research has explored the physical demands of basketball matches, analyzing player movements and physiological responses (Stojanović E et al., 2018). However, the participation of individuals in competitive sports, particularly junior-level players, exposes them to an increased risk of injury. Existing research predominantly focuses on injury prevention and performance enhancement in professional and semi-professional soccer, rugby, and football athletes in Europe, Australia, and the United States, revealing a distinct lack of comparable studies for junior-level basketball athletes in the Asian region (McLean BD, Strack D, Russell J, et al., 2019). Basketball matches are characterized by their highly intermittent nature, with players engaging in diverse activities and altering their movement patterns every 1–3 s. During a typical 40-min match, players cover 5–6 km at a high physiological intensity, with their heart rates reaching up to 85% of their maximum capacity (Scanlan AT, Dascombe B, & Reaburn P. 2011). The diverse activity patterns in basketball sports encompass standing, moving, walking, jogging, running, sprinting, shuffling, jumping, and dribbling, all performed with rapid hand-eye coordination and mental stability. Recognizing and understanding these multifaceted activity patterns are of paramount importance when designing effective training programs tailored to basketball players (Scanlan AT et al., 2015).

Corresponding Author: AHAMED THAJUDEEN ANVERSHA, E-mail: ahamptsp@gmail.com

Traditionally, heavy static resistance strength training has been a prevalent approach in sports-related fitness for decades, employed to improve functional performance and prevent injuries (Finch CF. 2006). However, this methodology may not be universally applicable to all sports, particularly in the context of basketball. In basketball, optimal functional performance necessitates not only enhanced muscle strength but also specific attributes like explosive leg power, agility, and sprinting prowess. Plyometrics, commonly known as "jump training," consists of exercises in which muscles produce maximum force in short intervals (Sayers.M. 2000). This training method has become increasingly popular among athletes participating in dynamic sports, incorporating movements such as jumping, hopping, skipping, and bounding to improve dynamic muscular performance. Plyometric training is a safe and effective strategy for enhancing physical performance in young basketball players, seamlessly complementing their regular training routines.

Sprinting plays a crucial role in achieving success in basketball sports (Figueira B et al. 2021). Various training methods are utilized to improve sprinting performance, including sprint drills, overspeed training, resistance sprinting, weight training, and plyometric exercises (Rimmer Edwin & Gordon sleivert. 2000). Various training methods are utilized to improve sprinting performance, including sprint drills, overspeed training, resistance sprinting, weight training, and plyometric exercises. Agility, vital for basketball, entails rapid acceleration, deceleration, and directional changes while maintaining proper form. Agility relies on neuromuscular efficiency. Plyometric drills emphasizing varied movements are key to enhancing agility. (George J Davies, & Bryan Riemann. 2020). Explosive leg power, particularly evident in vertical jumping, is essential for basketball performance. Jumping, being a complex multi-joint action, demands the production of force and a high-power output (Jeffrey A Potteiger et al., 1999). Improving coordination, refining movement skills, and maximizing the utilization of the stretch-shortening cycle in muscles are pivotal factors for optimizing vertical jump performance (Ioannis G. Fatouros et al., 2000). Plyometric training emerges as a valuable tool for advancing vertical jump capabilities, accelerating sprint performance, strengthening leg strength, rapidly change directions, enhancing muscular power, improving joint awareness, refining skill development, and elevating functional performance in the competitive realm of basketball sports. Integrating plyometric training, encompassing agility, sprinting, and vertical jumps, into conditioning drills is paramount for enhancing explosive leg power and overall performance among junior basketball players. Thus, this research aims to evaluate the impact of plyometric training on agility, sprint performance, and explosive leg power in junior basketball players. Additionally, the study aims to compare its impact on functional performance between the Plyometric Training Group (PTG) and the Regular Activity Group (RAG) in junior level basketball players.

Material & Methods

Ethical Clearance

Ethical approval was obtained at Sri Ramakrishna Hospital with Ethical Clearance Certificate Number. EC/2023/0702/CR-02 before recruiting participants for this research. This study was registered on Clinical Trial Registry (CTRI) Register Number. CTRI/2023/04/052010.

Participant Selection Criteria

A total of sixty-four junior-level basketball players who regularly engaged in basketball practice and satisfied the inclusion criteria were invited to fill out the informed consent form and were enrolled for the period from May to September 2023. The inclusion criteria are set as male junior basketball players who have a minimum of one year of basketball training with three sessions per week; age between 12 and 18 years; and players who have an interest in participating in the training protocol for 8 weeks. The participants involved in any type of plyometric training, players with musculoskeletal injuries in the lower limb, players with a history of any congenital deformities, and players with any respiratory complication were excluded.

Randomized Controlled Trial

The 64 participants were divided into two groups through a randomized controlled trial (RCT). Specifically, 64 participants were numbered sequentially from 1 to 64. A randomization process was used to generate a randomized list of 64 unique numbers. Subsequently, participants were randomly assigned to either the regular activity group (RAG, N = 32) or the plyometric training group (PTG, N = 32) based on this randomized list, maintaining allocation concealment to uphold the trial's randomness and minimizing selection bias. This approach establishes a strong basis for comparing outcomes between the groups, thereby enhancing the study's internal validity. Ethical guidelines for research involving human subjects were strictly observed during the trial's implementation and monitoring phases. By employing randomization, this research design enhances the study's robustness, enabling a thorough examination of the intervention's impact.

Training Intervention Procedure

The training followed 8 weeks duration with three times intervention per week. The training workout routine includes a 10-minute warm-up with jogging and stretching to prepare the body for more intense physical activity and reduces the risk of injury, 60 minutes - regular training for RAG as given in Table 1 and plyometric training for PTG designed to enhance power, speed, and explosiveness as given in Table 2, and a 10-minute cool-down with walking, jogging and stretching that helps the body recover after an intense workout.

Table 1. Regular Training plan for RAG

Regular Training for RAG	Exercise	Time	Repetitions
Warm Up (10 mins)	Jumping jacks	3 mins	
	Dynamic stretches (leg swings, arm circles)	5 mins	
	Relax	2 mins	
Regular Training Workout Plan (60 mins)	Slow jogging	10 mins	3 x 30 meters
	Sprint running	10 mins	3 x 30 meters
	Duck walking	10 mins	3 x 20 steps
	Duck walk jumping	10 mins	3 x 20 jumps
	Forward jumping	10 mins	3 x 20 jumps
	Push-ups	10 mins	3 x 10
Cool-down (10 mins)	Relax	2 mins	
	Brisk walking/ jogging	3 mins	
	Static stretches for major muscle groups	5 mins	

Table 2. Plyometric Training for PTG

Plyometric Training for PTG		Week1	Week2	Week3	Week4	Week5	Week6	Week7	Week8
Warm Up (10 mins)									
Plyometric Training Workout Plan (60 mins)	**Practice Time**	5 mins							
	Workout Time	5 mins				5 mins			
	Ankle hops to the sideways	Sideways jumps with a focus on ankle control, keeping feet together for quick, controlled movements.							
		2x10		2x10		2x10	2x10	2x10	2x10
	Kangaroo Jumping	Explosive jumps with a squatting motion resembling a kangaroo, targeting lower body power.							
		2x10		2x10		2x10	2x10	2x10	2x10
	Vertical Jumping	Jumping straight up with an emphasis on height, engaging lower body muscles							
		2x10		2x10		2x10	2x10	2x10	2x10
	Hexagon Drill	Quick movements through a hexagon pattern, enhancing agility and coordination.							
			2x10		2x10	2x10	2x10	2x10	2x10
	Zig-Zag Drill	Lateral movements in a zig-zag pattern, promoting agility and quick directional changes.							
			2x10		2x10	2x10	2x10	2x10	2x10
	Jumping forward over the cone	Jumping over a cone in a forward direction, emphasizing both distance and power.							
		2x10		2x10		2x10	2x10	2x10	2x10
	Jumping to the side over the cone	Lateral jumps over a cone, focusing on side-to-side movement and coordination.							
		2x10		2x10		2x10	2x10	2x10	2x10
	Barrier Jumping	Jumping over barriers at various heights, challenging vertical and horizontal power.							
		2x10		2x10		2x10	2x10	2x10	2x10
	Box jump	Explosive jumps onto a box or platform, targeting lower body strength and power.							
			2x10		2x10	2x10	2x10	2x10	2x10
	Single Leg Squat Jumps with a Pause	Jumping on one leg with a pause in the squat position, improving balance and strength.							
			2x10		2x10	2x10	2x10	2x10	2x10
	Alternating Step-Up Jumps	Step-up movements with dynamic jumps, alternating legs to enhance lower body power and coordination.							
			2x10		2x10	2x10	2x10	2x10	2x10
	Single Leg Medial Hops	Hopping laterally on one leg, targeting medial stability and improving body's ability to sense its position, movements, and actions in space.							
			2x10		2x10	2x10	2x10	2x10	2x10
Cool-down (10 mins)									

Note: 2x10 => 2 sets of 10 repetitions
Adapted from study conducted by*;* Morzia Khatoon & Senthilkumar Thiyagarajan (2020).

Data collection

Initially subject profile data such as age, height, and weight were recorded. During the training period, data were collected from the tests conducted at the pre-training (beginning of the first week), mid-training (end of the fourth week), and post-training (end of the eighth week) intervention stages to assess agility, speed, and leg muscle power results for both groups.

Test protocols

The "T" test was employed to evaluate agility, the 30-meter sprint test was used to gauge speed, and the Sargent jump test, also referred to as the vertical jump test, was utilized to measure jump height and leg muscle power.

a. Agility "T" test:

The t-test (Pauole, Kainoa et al., 2000) is used to assess the agility of athletes, involving directional changes through forward, lateral, and backward running around four sets of cones as shown in Fig 1. The subject starts running from cone A to B, touches it with the right hand, shuffles to C, touching it with the left hand, then shuffles to D, touching it with the right hand. They shuffle back to B, touch it with the left hand, and run backward to A. The stopwatch stops as they pass cone A. The best time from three successful trials, accurate to the nearest 1/10th of a second, is recorded. Failed trials involve crossing feet while shuffling, missing cone touches, or not facing forward during the test.

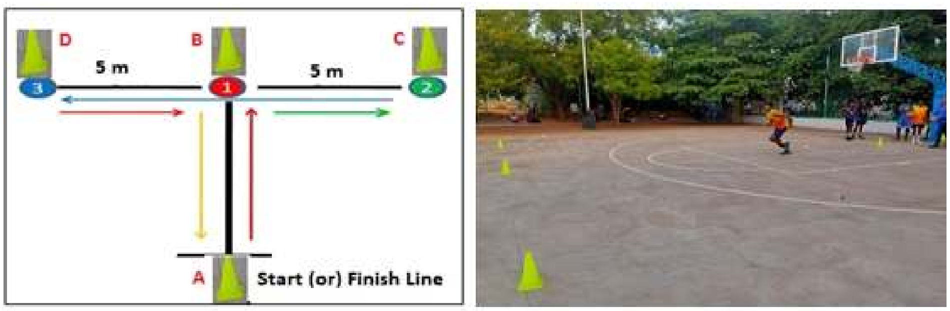


Fig.1**:** Agility "T" Test

b. 30-meters linear sprint test:

The 30-m linear sprint test (Wen N. 2018) aims to gauge the athlete's acceleration and transition to full speed. As shown in Fig.2 this test consists of 3 × 30 m runs from a standing start, with a full recovery period between each run. The best result of the three sprints is recorded. The athlete uses the first 15m to build up maximum speed and then maintains the speed throughout 30m. Analysis of the result is by comparing it with the results of previous tests.

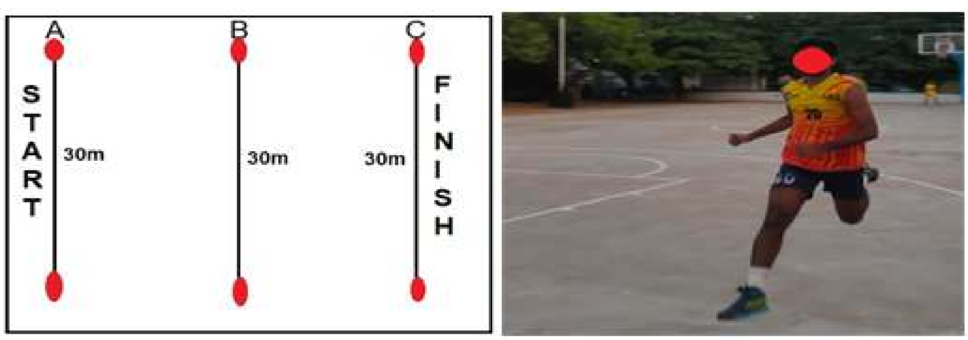


Fig.2**:** 30-Meters Linear Sprint Test

c. Sargent jump test:

In Sargent jump test (Paulo Gil da Costa et al., 2012), the subject begins with both feet positioned on the platform and performs a vertical jump, allowing free movement of the upper limbs and full flexibility in the lower limb joints as shown in Fig.3. All volunteers jumped three times, with a minimum interval of 45 seconds between the jumps, and the highest value was considered.

Fig.3**:** Sargent Jump Test

Statistical analysis

Social Science Statistical Package (IBM SPSS version 29.0) was used to analyze the data of this study. Descriptive data analysis involved calculating mean values and standard deviations (Mean±SD). The significance level for all analyses was set at $p < 0.05$ and confidence interval at 95%. Unpaired T-tests were used to determine the significant differences between the study groups respectively. The effect size is measured using Cohen's D indicating the standardized difference between the mean outcomes in two different intervention groups. Effect size magnitude was categorized as negligible (<0.20), small (0.20–0.49), medium (0.50–0.79), and large (0.80 or more). Repeated Measures ANOVA was used to assess the significance differences between repeated measurements taken at pre, mid and post training sessions.

Results

a. *Subject Profile Summary*

Subject profile data was summarized as Mean ± SD (standard deviation) measurements for Regular Activity Group (RAG) and Plyometric Training Group (PTG), as presented in Table 3. The uniformity of the two groups was tested using Levene's test for equality of variance. At the baseline, these variables were observed to exhibit similarity, with p-value > 0.05 indicating no statistically significant difference between the two groups.

Table 3. Subject Profile Summary in Mean ± SD (*p-value > 0.05)

Category	RAG (N=32)	PTG (N=32)	Levene's Test for Equality of Variance (p-value)
Age (years±SD)	15.35 ± 1.79	15.09 ± 1.78	0.965*
Height(cm±SD)	160.86 ± 11.35	162.04 ± 11.24	0.958*
Weight(kg±SD)	51.97 ± 8.45	51.78±7.85	0.813*

b. *Agility "T" test:*

Fig4. shows the agility progress in box plot analysis and Fig5. shows the estimated marginal means of Agility between RAG and PTG.

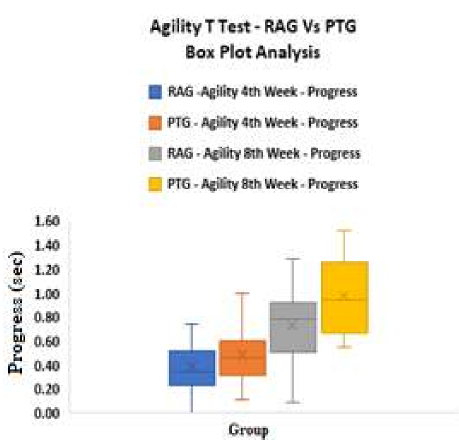


Fig.4**:** Agility T test progress– Box Plot Analysis

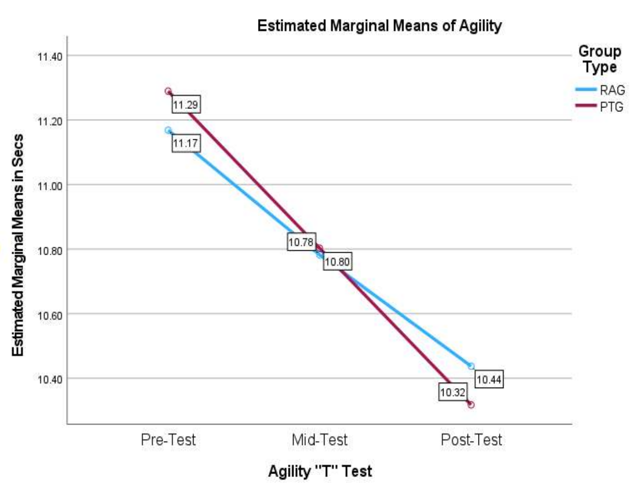
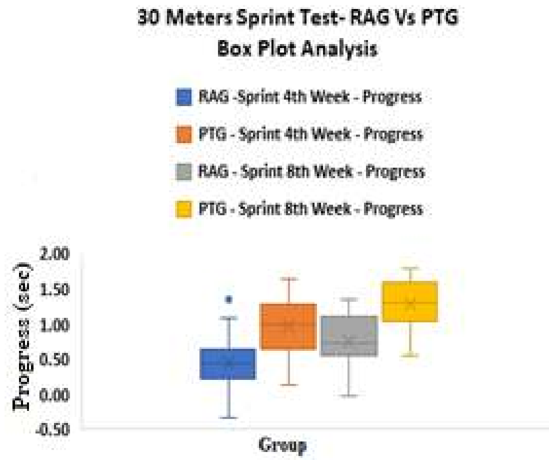


Fig.5**:** Estimated Marginal Means of Agility – RAG Vs PTG

c. 30-meters linear sprint test:

Fig6. shows the sprint progress in box plot analysis and Fig7. shows the estimated marginal means of sprint speed in seconds between RAG and PTG.



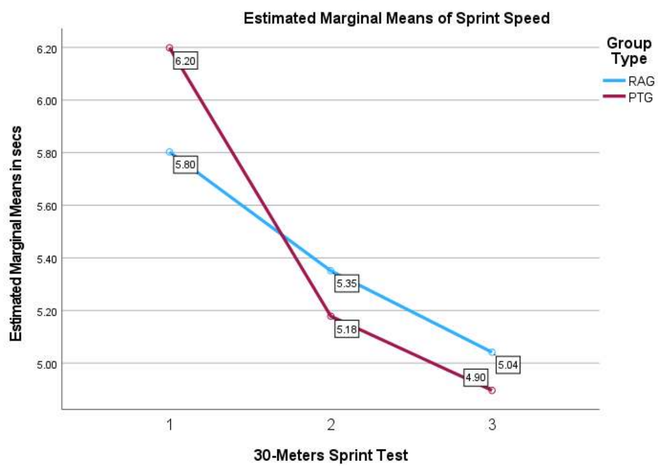
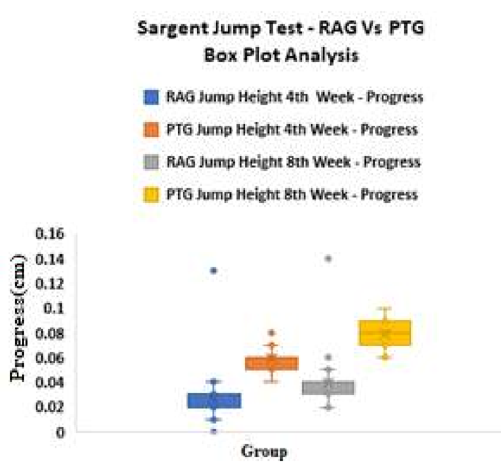


Fig.6**:** 30-meters sprint test progress-Box Plot Analysis Fig.7**:** Estimated Marginal Means of Sprint – RAG Vs PTG

d. Sargent Jump test:

Fig8. shows the sargent jump test progress in box plot analysis and Fig9. shows the estimated marginal means of jump height between RAG and PTG.



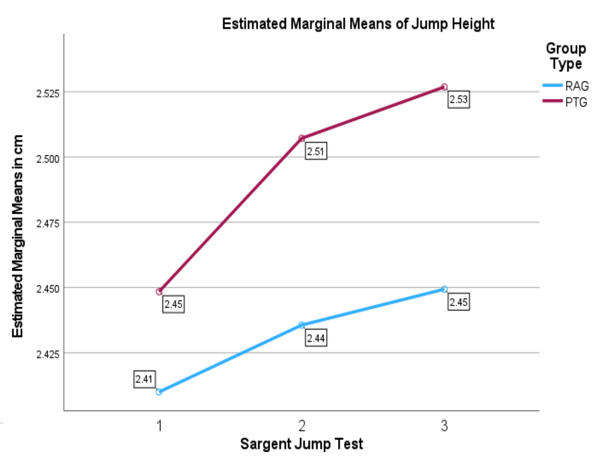


Fig.8: Sargent Jump test progress– Box Plot Analysis Fig.9**:** Estimated Marginal Means of Jump Height– RAG Vs PTG

Table 4. presents the descriptive statistical analysis of agility T test, 30-meters linear sprint test and sargent jump test data recorded at pre, mid and post training sessions.

	Mean Score ± SD			**Pre Vs Mid**		**Pre Vs Post**	
Group Type	**Pre-test**	**Mid-test**	**Post-test**	**4th Week Progress**	**Percentage Change Progress (%)**	**8th Week Progress**	**Percentage Change Progress (%)**
Agility T Test (in sec)							
RAG	11.17 ± 0.78	10.78 ± 0.75	10.44±0.69	0.38±0.19	3.49%	0.73±0.27	6.54%
PTG	11.29 ± 0.65	10.80±0.67	10.32±0.57	0.48±0.23	4.34%	0.97±0.31	8.58%
30-Meters Sprint Test (in sec)							
RAG	5.80 ±0.48	5.35 ± 0.53	5.04±0.45	0.45±0.35	7.76%	0.97±0.42	13.1%
PTG	6.20 ± 0.47	5.17±0.49	4.89±0.44	1.02±0.35	16.6%	1.31±0.30	21.1%
Sargent Jump Test (in cm)							
RAG	2.41 ± .21	2.43±0.21	2.43±0.21	0.02±0.02	0.83%	0.04±0.02	1.66%
PTG	2.45 ±0.18	2.50±0.19	2.52±0.19	0.05±0.01	2.04%	0.08±0.01	2.86%

Table 4. Descriptive Statistics

Table 5. presents the statistical significance analysis of agility T test, 30-meters linear sprint test and sargent jump test data.

Table 5. Statistical Significance Analysis (*p < 0.05)

Statistical Test (RAG Vs PTG)	**Pre Vs Mid**	**Mid Vs Post**	**Pre Vs Post**
Agility T Test			
Independent Samples T-Test (p-value)	0.032*		<.001*
Cohen's D – Effect Size	0.21		0.29
Repeated Measures ANOVA (p-value) Agility * GroupType	0.065	0.044*	<.001*
30-meters Sprint Test			
Independent Samples T-Test (p-value)	<.001*		<.001*
Cohen's D – Effect Size	0.33		0.35
Repeated Measures ANOVA (p-value) Sprint Speed * GroupType	<.001*	0.647	<.001*
Sargent Jump Test			
Independent Samples T-Test (p-value)	0.003*		0.002*
Cohen's D – Effect Size	0.1		0.1
Repeated Measures ANOVA (p-value) Jump Height * GroupType	<.001*	0.007*	<.001*

In the agility t-test, the PTG initially exhibited slightly better performance than the RAG, boasting a marginally lower average time. Both groups displayed a similar pattern of improvement, with the RAG and PTG exhibiting reductions in their respective average times by 3.49% and 4.34% at the mid-test stage, indicating comparable progress. The PTG maintained its lead by the post-test assessment, demonstrating an 8.58% improvement over the RAG's 6.54%, indicating a consistently better performance with a lower average time. Notably, the PTG consistently exhibited more significant improvements in the 4th and 8th weeks, displaying larger reductions in average time compared to the RAG. Statistical analysis revealed a significant effect between the groups, with a p-value of 0.032 for pre–mid assessments and a highly significant p-value < .001 for pre–post with a small effect size of 0.29. The Pre-Post comparison between RAG and PTG indicated highly significant differences p-value <0.001 than pre-mid with no significance (p=0.065) and mid-post with significance (p=0.04), showing significant changes over time for Agility * Group Type intercept using repeated measures ANOVA.

In the 30-m sprint test, the pre-test phase commenced with the RAG demonstrating an average sprint time of 5.80 s (±0.48 SD) and the PTG at 6.20 s (±0.47 SD). By the mid-test stage (fourth week), the RAG exhibited gradual improvements, reducing their sprint time by 0.45 s (±0.35), while the PTG displayed more substantial enhancements, with a reduction of 1.02 s (±0.35). At the post-test assessment, the PTG showed a significant improvement of 21.1% over the RAG's 13.1%. Between the groups, showed statistically significant p-value <0.001 for pre-mid and pre-post with small effect size 0.3. Findings emphasize significant improvements over specific intervals, particularly from Pre to Post assessments p<0.001 than pre-mid with significance (p<0.001) and mid-post with no significance (p=0.647) for Sprint Speed * GroupType intercept in repeated measures ANOVA test.

In the Sargent jump test, the pre-test phase revealed an average jump height of 2.41 cm (±0.21 SD) for the RAG and 2.45 cm (±0.18 SD) for the PTG. By the fourth week, the RAG experienced a slight increase to an average of 2.43 cm (±0.21 SD), whereas the PTG displayed more significant progress, achieving 2.52 cm (±0.19 SD) at the mid-test stage. The PTG demonstrated higher jump height progress at the post-test assessment, showing a 2.86% improvement over the RAG's 1.66%. During the testing period, the PTG consistently improved jump height more than the RAG.Between the groups, showed statistically significance for pre-mid (p=0.003) and pre-post (p=0.002) with small effect size 0.1. Repeated measure ANOVA test highlight constant significant improvements over all intervals, pre-mid, mid -post and pre–post assessments with p<0.001 for Jump Height * GroupType intercept.

The presence of a small effect size alongside high statistical significance suggests that, despite the modest magnitude of the effect, the observed difference between groups is likely to be genuine and not merely a result of random chance. Small effect sizes are frequently examined alongside statistical significance to emphasize the reliability and robustness of the observed effects, recognizing their modest practical significance.

Discussion

This study aimed to assess the effects of plyometric training on agility, sprint, and vertical jump performance among junior-level basketball players The findings revealed that an 8-week plyometric training program significantly enhanced functional performance compared to a regular training regimen. Consistent with the findings of a systematic review by Anversha A.T. and Ramalingam V. (2023), it was anticipated that a systematic application of plyometric training lasting 4–12 weeks would lead to improved functional performance Studies conducted by Charan Singh (2018) and Kryeziu et al. (2019) also support the notion that plyometric training programs lasting 4–12 weeks can yield significant improvements. Aligning with these expectations, the basketball players in this study, engaging in plyometric training three times a week for eight weeks, demonstrated significant enhancements in the measured variables.

Sudhakar et al.'s (2016) earlier study explored the effects of a six-week plyometric training regimen, involving 12 sessions, on a group of 24 basketball players, encompassing the Illinois Agility and T-tests as evaluation parameters. The outcomes of this study underscore the affirmative influence of plyometric training on the development of explosive force in lower extremities and agility. Building on this foundation, Charan Singh (2018) reported a positive association between plyometric training and enhancements in agility tests, particularly beneficial for athletes requiring swift movements in their respective sports. Kryeziu AR et al. (2019) further elucidated the positive impact of the plyometric training model on achieving crucial motor tasks. Improvements in explosive force and agility indicators underscore the efficacy of the program in elevating these skills, contributing to the overall impact of the training. This study confirms the potential for significant progress, particularly evident in the PTG undergoing the plyometric training model, which underscores the efficacy of this approach in enhancing training strategies for coaches working with players. In line with our findings, Androutsopoulos P. et al. (2021) observed significant improvements in speed and agility among young elite professional athletes following a four-week plyometric training (PT) regimen involving three sessions per week during the competitive season. Similarly, Huang H. et al. (2023) highlighted the pronounced positive effect of an eight-week PT program on the physical fitness of elite male basketball players. Their study, focusing on pre- and post-test values for the 20-m sprint and t-test agility run, revealed significant improvements in speed, agility, and explosive strength performance among elite college basketball players. In our study's agility test, both groups exhibited an improved trend, with the PTG consistently demonstrating more substantial enhancements in the fourth and eighth weeks. The agility test results underscored the PTG's consistently superior performance, initiating with a slight advantage and maintaining an 8.58% improvement over the RAG at the post-test. This improvement was evident not only in the overall comparison but also in specific intervals, with significant differences observed in both pre-mid and pre-post comparisons. In essence, our study aligns with and extends the existing body of research, affirming the positive impact of plyometric training on agility and athletic performance among basketball players.

The research conducted by Arede J et al. (2018) highlights the significant impact of an 8-week combined plyometric training program on the sprint speed of young basketball players, specifically demonstrated through the S10m test. Aksović N et al. (2019) have confirmed the utility of plyometric training in basketball practice, highlighting its crucial role in developing sprint abilities. They emphasize the need for meticulous program design, considering factors such as age, warm-up, exercise selection, technical execution, equipment, and surface. The study conducted by Marek T. et al. (2023) found that the combined plyometric and speed training program over six weeks was more effective in developing selected speed and strength parameters in U14 soccer players compared to a speed program without plyometric training. Paes P.P. et al. (2022) have concluded that a six-week plyometric training program yields significant enhancements in S20m sprint and agility tests. They recommend that coaches integrate plyometric training into the training periodization for young athletes, aiming to enhance sprint performance and speed of change of direction. Consistent with these previous findings, our study observes a notable 21.1% improvement in sprint speed for the PTG compared to a 13.1% improvement in the RAG during the 30-m sprint test at the post-test. This underscores the effectiveness of the plyometric training intervention in enhancing sprint speed.

The 4-week plyometric training in male university basketball players pilot study by Poomsalood S. & Pakulanon S. (2015) demonstrated the lack of significant differences in the vertical jump test between the training group and the control group may be attributed to the study's limitations, including a small sample size of 10 participants (5 subjects in each group) and a short training duration. Lee J et al.'s (2021) practical implication suggest that enhancing lower body power, balance, and reaction time in collegiate basketball athletes requires training programs lasting a minimum of 6 weeks period. The discussion extends its focus to the effect of Plyometric Training (PT) on young basketball athletes, emphasizing a 6-week PT program that resulted in a substantial improvement of 24.1% in vertical jump for the experimental group with PT compared to a control group with regular training (Asadi A. 2013), this improvement is consistent with previous findings in semi-professional basketball athletes and supports the idea that PT contributes to significant gains in vertical jump performance (Asadi A. & Arazi H. 2012). The study by Chaabene H & Negra Y. (2017) compared high-volume plyometric training (HPT) and low-volume plyometric training (LPT) in pre-pubertal soccer players and the results indicate that both training types of significantly improved squat jump (SJ) and counter movement jump (CMJ), emphasizing the equal efficacy of PT at different intensities in influencing sports performance. The studies by Faigenbaun et al. (2007), Shallaby H.K. (2010), & Demir M.E. (2022) strengthen the argument for the beneficial effects of plyometric training on vertical jump, confirming its role in enhancing explosive power performance. Our study, utilizing the Sargent jump test, consistently demonstrates the PTG achieving greater progress in jump height, resulting in a 2.86% improvement over the RAG at the post-test. Statistical analyses, including Independent Samples T-Tests and Repeated Measures ANOVA, supported the observed improvements, highlighting significant effects and providing evidence of the PTG's superior performance over specific time intervals aligning with previous research outcomes. These studies not only corroborate the increase in vertical jump performance but also highlight improvements in anaerobic power parameters among elite athletes undergoing plyometric training.

Across multiple physical fitness measures, this eight-week study reveals consistently superior performance and notable enhancements in the PTG compared to the RAG. . However, as highlighted by Lehnert et al. (2013) and Latorre Román et al. (2018) in their respective studies, individuals with higher initial fitness levels may encounter difficulty achieving significant improvements through plyometric training. The considerable variability in individual responses to plyometric training suggests that improvement levels may not be uniform across all athletes. Moreover, the study underscores the importance of longer training durations, as advocated by Lee J et al. (2021). However, the specific optimal duration for maximizing improvements in functional performance warrants further exploration. The study also suggests the need for additional investigations, especially in assessing bone mass enhancement through the plyometric training model and exploring other physical variables contributing to balance and anaerobic resistance.

Conclusions

In summary, this research offers valuable insights into the effectiveness of an eight-week plyometric training program for enhancing agility, sprint performance, and explosive leg power in junior basketball players. It demonstrates that a well-structured plyometric program can significantly improve key physical performance parameters. The fact that the PTG consistently outperforms the RAG highlights the potential advantages of incorporating plyometric exercises into basketball training routines. These findings have practical implications for coaches and trainers working with young athletes, emphasizing the importance of tailored training approaches. Overall, this study contributes to the growing body of knowledge in sports science, laying the groundwork for further investigations and improvement of training protocols to optimize athletic performance.

Acknowledgement

The authors are grateful to Sri Ramakrishna Hospital for providing ethical clearance, allowing for the ethical conduct of the research presented in this paper. The authors extend their sincere appreciation to Falcon Scientific Editing (https://falconediting.com) for their meticulous proofreading of the English language in this paper. Their expertise ensured the clarity and coherence of the manuscript, greatly enhancing its readability and quality.

Conflicts of interest - The authors did not disclose any potential conflicts of interest related to authorship and/or publication of the article.

References:

Aksović N., Berić D., Kocić M., Jakovljević S., Milanović F. (2019). Plyometric Training and Sprint Abilities of Young Basketball Players. *Facta Universitatis. Series: Physical Education and Sport,* 17(3), pp.539–548.

Androutsopoulos P., Blantas I., Papadopoulos K., Lapsanis K., Eleftheriadis G., Alexopoulos P. (2021). The Effectiveness of Plyometric Training in Speed and Agility in Young Basketball Players. *Journal of Modern Education Review*, 11(9), pp. 947–956.

Anversha A.T., Ramalingam V. (2023). A Systematic Review: Significance of Plyometric Training on Functional Performance and Bone Mineral Density in Basketball Players of Different Age Groups. *Sports medicine: research and practice*, 13(2), pp. 62-76.

Arede, J., Vaz, R., Franceschi, A., Gonzalo-Skok, O., & Leite, N. (2018). Effects of a combined strength and conditioning training program on physical abilities in adolescent male basketball players. *The Journal of Sports Medicine and Physical Fitness*, 59(8), pp. 1298-1305.

Asadi A, Arazi H. (2012). Effects of high-intensity plyometric training on dynamic balance, agility, vertical jump and sprint performance in young male basketball players. *J Sport Health Res*, 4(1), pp.35-44

Asadi A. (2013). Effects of in-season short-term plyometric training on jumping and agility performance of basketball players. *Sport Sci Health,* 9(3), pp.133-137.

Bal, B. S., Kaur, P. J., & Singh, D. (2011). Effects of a short term plyometric training prograshort-termty in young basketball players. *Brazilian Journal of Biomotricity*, 5(4), pp.271–278.

Chaabene H, Negra Y. (2017). The effect of plyometric training volume on athletic performance in prepubertal male soccer players. *Int J Sports Physiol Perform*, 12(9), pp.1205-1211.

Charan Singh. (2018). Assessment of Plyometric Training on Agility in Basketball Players. *International Journal of Physical Education and Sports Sciences*, 13(06), pp. 45-50.

Demir M.E., Dağlıoğlu Ö. (2022). The Effect of Plyometric Training Program on Physical Performance in Basketball Players. *European Journal of Physical Education and Sport Science*, 9(3), pp. 86– 96.

Faigenbaun, A. D., McFarland, J. E., Keiper, F. B., Tevlin, W., Ratamess, N. A., Kang, J., & Hoffman, J. R. (2007). Effects of a short-term plyometric and resistance training program on fitness performance in boys age 12 to 15 years. *Journal of Sports Science and Medicine*, 6(1), pp.519 –525.

Figueira B, Gonçalves B, Abade E, Paulauskas R, Masiulis N, Kamarauskas P, Sampaio J. (2021). Repeated Sprint Ability in Elite Basketball Players: The Effects of 10 × 30 m Vs. 20 × 15 m Exercise Protocols on Physiological Variables and Sprint Performance. *J Hum Kinet*., 77 (1), pp.181-189

Finch CF. (2006). A new framework for research leading to sports injury prevention. *J Sci Med Sport*., 9(1), pp. 3–9.

George J Davies, Bryan Riemann. (2020). Current concepts of plyometrics for the lower extremity. *International journal of sport and physical therapy*, pp. 277-304.

Ioannis G. Fatouros, Athansios Z. Jamurtas, D. Leontsini, Kyriakos Taxildaris, N. Aggelousis, N. Kostopoulos & Philip Buckenmeyer. (2000). Evaluation of Plyometric Exercise Training, Weight Training, and Their Combination on Vertical Jumping Performance and Leg Strength. *The Journal of Strength and Conditioning Research*, 14(4).

Jeffrey A. Potteiger, Robert H. Lockwood, Mark D. Haub, Brett A. Dolerzal, Khalid S, Almuzaini, Jan M. Schroeder and Carole J. Zebas. (1999). Muscle power and fiber characteristics following 8week of plyometric training. *Journal of strength and conditioning Research*, 13(3), pp. 275-279.

Huang H., Huang W.Y., Wu C.E. (2023). The Effect of Plyometric Training on the Speed, Agility, and Explosive Strength Performance in Elite Athletes. *Applied Sciences*, 13(6): pp. 3605.

Kryeziu A R, Begu B, Asllani I, Iseni A. (2019). Effects of the 4-week plyometric training program on explosive strength and agility for basketball players. *Turk J Kinesiol*, 5(3), pp.110-116.

Latorre Román PÁ, Villar Macias FJ, García Pinillos F. (2018). Effects of a contrast training programme on jumping, sprinting and agility performance of prepubertal basketball players. *J Sports Sci.,* 36(7), pp. 802-808.

Lehnert, Michal, Karel Hůlka, Tomáš Malý, Jaroslav Fohler, and František Zahálka. (2013). The Effects of a 6 Week Plyometric Training Programme on Explosive Strength and Agility in Professional Basketball Players. *Acta Gymnica*, 43(4), pp. 7–15.

Lee J, Martin J, Wildehain R, Ambegaonkar J. (2021). Plyometrics or balance training effects on lower body power, balance and reactive agility in collegiate basketball athletes: A randomized control trial. *Turk J Sports Med*., 56(1). pp. 5-12.

Marek Tvrdý, Miroslav Holienka, et al., (2023). Effects of combined explosive, plyometric, and sprint training on the physical fitness of soccer players. *Journal of Physical Education and Sport (JPES*), 23 (7), pp. 1729 – 1735.

McLean BD, Strack D, Russell J, et al., (2019). Quantifying physical demands in the national basketball association-challenges around developing bestpractice dodels for athlete care and performance. *Int J Sports Physiol Perform*,14(4), pp. 414-20

Morzia Khatoon, Senthilkumar Thiyagarajan. (2020). Comparative Study to Find out the Effectiveness of Core Strengthening Training (Pilates) versus Plyometric training to Promote Dynamic Balance and Agility in Elite Indian Badminton Players. *Indian Journal of Physiotherapy & Occupational Therapy*, Print- (ISSN 0973-5666) and Electronic –(ISSN 0973-5674), 15(1), pp. 85–92.

Pauole, Kainoa; Madole, Kent; Garhammer, John; Lacourse, Michael; Rozenek, Ralph, (2000). Reliability and Validity of the T-Test as a Measure of Agility, Leg Power, and Leg Speed in College-Aged Men and Women. *Journal of Strength and Conditioning Research*, 14(4), pp. 443-450.

Paulo Gil da Costa Mendes de Salles, Vasconcellos FV, de Salles GF, Fonseca RT, Dantas EH. (2012). Validity and Reproducibility of the Sargent Jump Test in the Assessment of Explosive Strength in Soccer Players. *Journal of Human Kinetics*, 33(1).

Paes P.P., Correia G.A.F., Damasceno V.D.O., Lucena E.V.R., Alexandre I.G., Da Silva L.R. (2022). Effect of plyometric training on sprint and change of direction speed in young basketball athletes. *Journal of Physical Education and Sport (JPES)* ,22(2), pp. 305–310.

Poomsalood S., Pakulanon S. (2015). Effects of 4-Week Plyometric Training on Speed, Agility, and Leg Muscle Power in Male University Basketball Players: A Pilot Study. *Kasetsart J. Soc. Sci.,* 36(3): pp. 598–606.

Rimmer Edwin and Gordon sleivert. (2000). Effects of a Plyometric intervention program on Sprint Performance. *Journal of Strength and Conditioning Research*, 14(3), pp. 295–301.

Scanlan AT, Dascombe B, Reaburn P. (2011). A comparison of the activity demands of elite and sub-elite Australian men's basketball competition. *J Sports Sci*., 29(11), pp. 1153–60.

Scanlan AT, Dascombe BJ, Kidcaff AP, et al. (2015). Gender-specific activity demands experienced during semi professional basketball game play. *Int J Sports Physiol Perform*., 10(5), pp. 618–25.

Sayers.M, (2000). Running techniques for field sport players. *Human movement and sports science*, 23(1), pp. 26-27.

Shallaby, H.K. (2010).The effect of plyometric exercises use on the physical and skillful performance of basketball players. *World Journal of Sport Sciences*, 3(4), pp. 316–324.

Stojanović E, Stojiljković N, Scanlan AT, Dalbo VJ, Berkelmans DM, Milanović Z. (2018). The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. *Sports Med*., 48(1), pp. 111-135.

Sudhakar S, Mohan Kumar G, Ramanathan K, Vasanth P. (2016). Efficacy of 6 week Plyometric training on agility performance in collegiate male basketball players. *Indian Journal of Physiotherapy & Occupational Therapy*; 2(2), pp. 1-8.

Wen N, Dalbo VJ, Burgos B, Pyne DB, Scanlan AT. (2018). Power Testing in Basketball: Current Practice and Future Recommendations. *J Strength Cond Res*.,32(9), pp. 2677-2691.