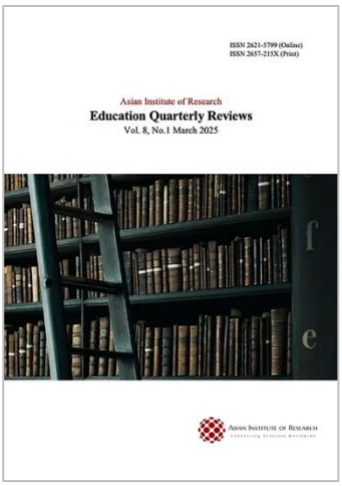

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The Effects of Plyometric Training Program on Leg Muscle Power of Basketball Players at Guangxi Polytechnic of Construction

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Abstract
This research aimed to develop and compare the effects of a plyometric training program on the leg muscle power of basketball players. The sample group consisted of 30 basketball players from Guangxi Polytechnic of Construction in Guangxi Province, China, selected through purposive sampling. The participants were divided into two groups: an experimental group of 15 players who trained using a plyometric program developed by the researcher and a control group of 15 players who trained using a standard training program. The training lasted for eight weeks, with sessions conducted three days a week, lasting 40 to 50 minutes per session. The Vertical Jump Test measured leg muscle power. Data were analyzed by calculating the mean and standard deviation. The Wilcoxon Signed Ranks Test was used to compare mean differences in leg muscle power within the control and experimental groups before and after training. Moreover, the Mann-Whitney U Test compared mean differences in leg muscle power between the control and experimental groups before and after training. The research results indicated that the plyometric program developed by the researcher was effective. The experimental group exhibited significantly better leg muscle power than the control group, with statistical significance at the 0.05 level. Additionally, both the experimental and control groups experienced substantial improvements in leg muscle power after training compared to before training, also with statistical significance at the 0.05 level. These findings indicate that the plyometric program developed is a valuable resource for enhancing agility and leg muscle power in basketball players. It offers practical guidelines for athletes, trainers, and anyone interested in basketball to improve athletic performance in the future.

Keywords: Plyometric Training Program, Leg Muscle Power, Basketball Players

1. Introduction

Basketball originated in the United States and was invented by a Canadian named James Naismith. At the time, he was working at the YMCA International Training School in Springfield, Massachusetts (now Springfield College). During the winter in Massachusetts, snowfall typically begins in November, making outdoor sports impossible. Meanwhile, the only indoor activity available in the gymnasium was the gymnastics equipment, which made students feel bored and uninspired. Wanting to create a team sport that could be played indoors and engage

students' interest, Naismith sought to develop a game that would bring joy and excitement to everyone. (Chen, 2007)

However, to enjoy and have fun playing basketball, it is essential to have good physical fitness, including muscle strength and endurance, flexibility, and the endurance of the circulatory and respiratory systems. In particular, leg muscle power is critical and necessary, as basketball requires muscle strength for jumping to score points. Physical fitness refers to the body's ability to function efficiently and includes various physiological capabilities that help protect individuals from diseases caused by a lack of exercise. It is considered a key factor or indicator of good health. These abilities can be improved, developed, and maintained through regular exercise. (Tulyakul, 2020; Zhou, 2013; Zhang, 2005)

As a result, it has been found that muscular power is a crucial and essential component of physical fitness for basketball players. Scoring in basketball requires jumping, enabling players to reduce the distance of the ball between themselves and the hoop, making scoring easier. The higher a player can jump, the greater their chances of successfully making a basket, as the height from the court to the basketball hoop is 3.05 meters. Moreover, strong muscular power enhances a player's overall movement efficiency. Whether moving in a straight line or multiple directions, speed and agility are key factors, both of which rely on muscular power as a fundamental component. Additionally, in a basketball game, every action demands muscle energy. When muscle energy consumption reaches high levels, an athlete's concentration and accuracy decline, affecting their performance and disrupting their body's balance. Therefore, basketball players must maintain an optimal level of muscular power to sustain their physical fitness, stay focused during the game, and ensure efficient coordination of all body movements. Players with well-developed muscular power can demonstrate better balance, agility, and skill execution, which are essential for technical performance in basketball. As a result, muscular power training has become an indispensable part of basketball training and should be incorporated into regular basketball practice. Basketball coaches should understand the principles of muscle power training and apply scientific methods to enhance their players' muscular strength and performance. (Popular Sports, 2022)

This study focuses on leg muscle power, directly affecting an athlete's speed, strength, and jumping ability. There are many methods for improving leg muscle power. Colson et al. (2010) conducted a study on the effects of vibration training on basketball players' jumping ability. The study involved an experimental group using vibration training and a control group, conducted over eight weeks. Pre and post-experiment jump tests showed that the experimental group had significantly improved muscle power and initial jump speed compared to the control group. Similarly, PK (2024) investigated holistic training methods to enhance leg muscle power in sprinters. The study divided athletes into two groups: Single-leg jump training group and Two-leg jump training group. The results showed that both training methods effectively enhanced muscle power in sprinters. Additionally, studies by Peng and Bi (2000); De Vos et al. (2005) explored weightlifting-based training, which also proved effective in increasing muscular power.

Plyometric training is among the most popular methods for developing muscular power among various training techniques. This approach emphasizes explosive movements and requires proper techniques to prevent injuries and maintain motivation. Key considerations include: 1. Avoiding excessive repetition of a single exercise for too long can lead to boredom and long-term injuries. 2. Incorporating station-based training to keep workouts engaging. 3. Gradually increasing intensity, such as raising the height of jump boxes or increasing repetitions. Typically, plyometric jump box heights range from 20 cm to 1.1 meters, depending on an athlete's age and fitness level. The duration of training must also be adjusted accordingly. Additionally, athletes' individual physiological and fitness differences must be taken into account—especially muscle strength, which serves as the foundation for plyometric training. If an athlete lacks sufficient base strength, plyometric training may result in injuries rather than improvements. The specific characteristics of basketball should also be considered. (Shi et al., 2024)

In China, basketball is extremely popular and may even be the most favored sport in certain provinces. One of the key reasons for its popularity is the presence of Yao Ming, a highly renowned basketball player who competed professionally in the NBA. His success has contributed significantly to the widespread admiration for basketball in China. As a result, basketball tournaments are held at all levels across the country, including school,

college/university, provincial, and national levels. Similarly, Guangxi Polytechnic of Construction has a basketball team preparing for the University Championship. However, past performances have been unsatisfactory, and the team has yet to secure a gold medal. According to an analysis conducted by the coaching staff, one of the key weaknesses among the players is insufficient leg muscle power. Players struggle to jump high enough to score effectively when facing physical contact with opponents or playing multiple consecutive games. This issue aligns with physical fitness assessments, particularly the Vertical Jump Test, which has revealed that most players have low to moderate muscle power levels. Additionally, the current training programs for the basketball team do not focus specifically on developing muscle power, leading to slow progress and minimal improvements in this area.

Considering these challenges, the researcher, who serves as both a basketball coach and instructor at Guangxi Polytechnic of Construction, aims to develop a plyometric training program designed to improve leg muscle power. The objective is to boost the athletic performance of basketball players, making them more effective on the court.

1.1. Research objectives

1. To develop a plyometric training program on the leg muscle power of basketball players
2. To compare the leg muscle power within a plyometric training program created by the researcher group and a regular training program group between before and after 8 weeks of training.
3. To compare the leg muscle power after 8 weeks of training between a plyometric training program created by the researcher and a regular training program

2. Research methods

This research is experimental. The researcher conducted the study using the Pretest Posttest Control Group Design (Gall, Borg, and Gall, 1996). The group involved in this research consisted of 30 male basketball players from Guangxi Polytechnic of Construction in Guangxi Province, China, who were selected through purposive sampling. The participants in this study were required to train for eight weeks, three days a week, specifically on Monday, Wednesday, and Friday, for 40-50 minutes each day.

2.1 Methods for Dividing Sample Groups

1. 46 male basketball players from Guangxi Polytechnic of Construction are in Guangxi Province, China.
2. Test leg muscle power by the Vertical Jump Test (Mackenzie, 2007) in all participants.
3. Arrange the leg muscle power values from the highest to the lowest of all participants.
4. Then, the 1st to 16th were deleted to the sample group due to their having high leg muscle power.
5. Handle the matching method and divide the sample into groups of 15 people each (even numbers and odd numbers). This method ensured that the two groups had no different or similar abilities before training.
6. Analyze the data of both groups before the training using the statistics Mann Whitney U-Test (Srisa-at, 1995).
7. Randomize the two groups of samples to create the experimental group and the control group by drawing lots. It seems that the even-numbered group was trained using the regular training program, while the odd-numbered group underwent a plyometric training program developed by the researchers.

Data analysis: The researcher analyzed the obtained data using a computer program as follows:

1. Statistical analysis to find the Mean and Standard deviation of the control group and experimental group
2. Compare the differences in leg muscle power training results within the control and experimental groups before and after eight weeks of training using the Wilcoxon Signed–Rank Test statistics.

3. Compare the differences in leg muscle power training results between the control and experimental groups after eight weeks of training using Mann – Whitney U-test statistics.

3. Research results

1. Develop a plyometric training program that affects the leg muscle power of basketball players. Five experts assessed the plyometric training program's quality to determine its suitability using the Index of Item-Objective Congruence (IOC) method. The program, which trains the leg muscles of male basketball players at Guangxi Polytechnic of Construction in Guangxi Province, China, had an IOC value ranging from 0.80 to 1.00, which was appropriate and usable.

2. A comparison of the differences in leg muscle power results within the control group and the experimental group before and after eight weeks of training. The study found that the leg muscle power of basketball players in the experimental group after eight weeks of training was significantly better than before training at the .05 level. Similarly, the leg muscle power of basketball players in the control group after eight weeks of training also showed significant improvement compared to before training at the .05 level, as shown in Table 1 - Table 2.

Table 1: Differences in leg muscle power results within the control group before training and after 8 weeks of training.

Period of training	**N**	**Control group**			
		Mean	**SD.**	**Z**	***P***
Before training (C_1)	15	49.13	4.80	-3.460	0.01*
After training (C_2)	15	50.93	4.44		

*(*P*<.05)

Table 2: Differences in leg muscle power results within the experimental group before and after 8 weeks of training.

Period of training	**N**	**Experimental group**			
		Mean	**SD.**	**Z**	***P***
Before training (E_1)	15	50.13	3.56	-3.451	0.01*
After training (E_2)	15	58.86	2.64		

*(*P*<.05)

3. Comparing the differences in the leg muscle power result between the control group and the experimental group before and after eight weeks of training, the two groups found that the leg muscle power of basketball players after training between the experimental and control groups was better than before training at statistically significant at the .05 level as shown in Table 3.

Table 3: shows the leg muscle power results of basketball players before training and after 8 weeks of training.

Group	**N**	**The result of test**							
		Before training				**After eight weeks of training**			
		Mean	**SD.**	**Z**	***P***	**Mean**	**SD.**	**Z**	***P***
Control group (C)	15	49.13	3.56	- 0.466	.653	50.93	4.44	- 4.350	.001*
Experimental group (E)	15	50.13	4.80			58.86	2.64		

*(*P*<.05)

4. Discuss the results

The effects of a plyometric training program on the leg muscle power of basketball players at Guangxi Polytechnic of Construction are discussed based on the research objectives as follows:

The first objective of this study was to develop a plyometric training program to improve basketball players' leg muscle power. The researcher submitted the plyometric training program to a panel of five experts for quality assessment to determine its appropriateness using the Index of Item-Objective Congruence (IOC). The threshold for IOC was set at 0.5 or higher. Upon evaluation, the experts provided feedback and assigned an IOC score ranging from 0.8 to 1.00 for all assessment criteria, indicating a high level of congruence between training theory and training objectives.

Furthermore, the researcher incorporated the experts' recommendations, such as structuring exercises from simple to complex and applying taping around the knees and ankles to prevent injuries during training. The plyometric program was also tested and refined to address any issues or weaknesses, ensuring its highest quality. This refinement process was facilitated by the researcher's prior study of training principles, as well as the design and development methods of a plyometric program. The researcher developed the training program based on the F.I.T.T. principle, which is widely recognized for enhancing physical fitness. This principle aligns with Naternicola (2015), who identified four key factors in physical fitness development:

- F (Frequency): Exercise should be performed 3–5 times weekly for optimal effectiveness.
- I (Intensity): The intensity should gradually increase by increasing difficulty or adding more exercises.
- T (Time): Each training session should last from 15 to 60 minutes.
- T (Type): The plyometric training method was chosen for its effectiveness in developing muscle power.

The IOC results obtained in this study also align with Phusi-on's (2015) statement that an acceptable IOC value should not be lower than 0.5. The plyometric training program was refined based on expert recommendations, particularly regarding progressive exercise sequencing, appropriate training duration, and exercise complexity. Subsequently, the researcher implemented the developed training program for basketball students at Guangxi Polytechnic of Construction to identify any issues or obstacles before collecting data. This step ensured that the program was appropriate and effective. This approach is consistent with Pipitkul (2018), who defined validity (which in this context refers to the program's ability to meet its training objectives) as the extent to which test items measure what they are intended to measure and align with theoretical frameworks. The plyometric training program developed in this study effectively improved leg muscle power in basketball players. This shows that the training program was successful in enhancing athletic performance, especially in building leg muscle power specifically for basketball players.

The second objective of this study was to compare the differences in mean leg muscle power between the control and experimental groups before and after training. The results showed that, after eight weeks of training, both groups demonstrated a statistically significant improvement in leg muscle power at the 0.05 level compared to their pre-training performance. For the group that followed the plyometric training program to develop leg muscle power, the significant improvement may be attributed to the proper application of training principles that emphasize strength and speed. This aligns with the concept that muscle power combines two key physical fitness components: muscular strength and speed. Muscle power requires resisting force while contracting muscles at high velocity, which generates explosive force for jumping. Consequently, plyometric training led to an increase in leg muscle power among basketball players.

This finding is consistent with Davies, Riemann, & Manske (2015), who stated that plyometric training must integrate both muscular strength and speed in movement execution to develop muscle power effectively. Similarly, Nikolic (2018) emphasized that muscle power training requires a foundation of muscular strength and speed, as power training is highly intensive and may pose a higher risk of injury if these two components are underdeveloped. Furthermore, specific training movements, such as the Squat Jump, Deep Jump, and Long Jump Movement, play a crucial role in developing leg muscle power. These exercises combine strength and speed, significantly improving muscle power (Ramirez-Campillo et al., 2022).

However, the research findings also indicated that the control group, which participated in a regular training program, demonstrated an improvement in mean leg muscle power after eight weeks, even without following a structured or optimized training program. This suggests the body can still develop leg muscle power through various movement patterns and jumping activities over eight weeks. This finding aligns with Thani (2020), who stated that body movement and mobility can enhance both physical fitness and sports skills. Additionally, Powers et al. (2020) emphasized that engaging in physical activity at least 3-5 days per week, which includes jumping, movement, and mobility exercises, can significantly improve physical fitness. This suggests that structured exercise is not always necessary for developing physical fitness, as general physical activity can also contribute to overall improvement.

The last objective is to compare the mean leg muscle power between the control and experimental groups after 8 weeks of training. The research findings revealed that basketball players who trained using the plyometric training program developed by the researcher had higher mean leg muscle power than those who followed a regular training program. This outcome can be attributed to the fact that the plyometric training program was designed based on sound training principles to enhance the leg muscle power of basketball players. Specifically, the plyometric training program developed in this study was structured according to the F.I.T.T. principle, which consists of four key components: 1. Frequency (F): Athletes trained three days per week. 2. Intensity (I): The number and difficulty of exercises were progressively increased every two weeks. 3. Time (T): Each training session lasted 40–50 minutes. 4. Type (T): The plyometric training method was employed, recognized as an effective approach for developing muscle power. These findings are consistent with Muhmut (2019), Heyward (1991), and Naternicola (2015), who emphasized that the F.I.T.T. principle is fundamental in designing training programs to enhance athletes' physical fitness. Similarly, research by Bal, Kaur, and Singh (2011) applied the F.I.T.T. principle to a study involving 30 basketball players aged 18–24 years, using a 6-week plyometric training program. Their results indicated that the experimental group, which followed a plyometric training regimen, showed significantly greater improvements in muscle power than the control group at a significance level of .05. Additionally, research by Aksović et al. (2021) examined the effects of plyometric training based on the F.I.T.T. principle in basketball players, demonstrating that plyometric exercises significantly enhanced explosive power. Furthermore, a study by Bouteraa et al. (2020) involved 26 female basketball players who underwent an 8-week plyometric training program, incorporating Squat Jump, Countermovement Jump, and Drop Jump exercises. Their findings showed that the experimental group had significantly greater muscle power improvements than the control group at a significance level of .05. Therefore, it can be concluded that plyometric training using the F.I.T.T. principle, which includes various jumping exercises, is considerably more effective at developing leg muscle power in basketball players than a conventional training program, with statistical significance at the .05 level.

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