



**Impact of Plyometric Exercises on the Explosive Strength of Lower Limbs
in Junior High School Volleyball Players: A Study at SMP Negeri 3
Palembang**

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Abstract
Objectives. The objective of this study was to determine the effect of plyometric training on the explosive power of the lower limbs in male volleyball extracurricular students at SMP Negeri 3 Palembang. The research aimed to investigate whether a structured plyometric training program could significantly improve vertical jump height as an indicator of lower limb power. Materials and Methods. This research employed a quantitative experimental method using a one-group pretest-posttest design. The population consisted of 30 students (20 males and 10 females) enrolled in the volleyball extracurricular program. A purposive sampling technique was applied, resulting in 20 male students as the study sample. The instrument used to collect data was a vertical jump test. The training intervention consisted of plyometric exercises conducted over a defined period. Data were analyzed using the Shapiro-Wilk test for normality and the paired sample t-test to assess the significance of differences between pretest and posttest results. Results. The findings revealed a statistically significant improvement in lower limb explosive power following the plyometric training intervention. The paired sample t-test showed a t-value of 12.601, which exceeded the critical t-table value of 2.093. The significance level was 0.000 ($p < 0.05$), indicating a significant difference between pretest and posttest scores. The mean posttest score increased to 31.05, compared to a mean pretest score of 22.50, confirming the positive impact of the training program. Conclusions. study concludes that plyometric training has a significant effect on enhancing the explosive power of the lower limbs in male students participating in extracurricular volleyball activities at SMP Negeri 3 Palembang. The substantial increase in vertical jump performance after the intervention supports the effectiveness of plyometric exercises in improving athletic performance among adolescent volleyball players.
Keywords: Plyometric Training, Lower Limb Explosive Power, Volleyball

Introduction

Sport is an essential activity for every individual, contributing not only to physical fitness and mental clarity but also to enhanced productivity. Beyond health benefits, sport plays a vital role in achievement, education, and in strengthening national unity—ultimately supporting national development. This aligns with Law No. 3 of 2005 of the Republic of Indonesia on the National Sports System, particularly Article 4, which states that national

sports aim to maintain and improve health, physical fitness, achievement, human quality, and instill moral values, noble character, sportsmanship, discipline, and unity to preserve national integrity (Saputra & Aziz, 2020).

Volleyball is one of the sports that has grown in popularity across various social levels. Originally intended as a leisure activity for fun and relaxation, volleyball has evolved into a competitive sport featured in numerous official competitions. Despite its shift toward achievement-oriented development, its recreational value remains intact. Volleyball's advantages include flexibility in the number of players—from two in beach volleyball to six in standard competitions—its entertaining and social nature, minimal equipment requirements, and adaptability for both indoor and outdoor settings. It is played by two teams of two to six players each, with the objective of sending the ball over the net so the opposing team cannot return it (Susila, 2021).

As a team sport, volleyball demands close collaboration and mutual support among players to form a cohesive team. This cohesion relies on individual mastery of fundamental techniques such as underhand passing, overhead passing, serving, spiking, and blocking. Unfortunately, many athletes neglect these basic skills, which are deeply interconnected and essential for optimal performance. Without solid foundational skills, athletes may struggle to compete effectively and limit their potential for growth (Jamil et al., 2022).

In volleyball, one of the often-overlooked yet crucial techniques is the serve. Sound technique depends on biomechanical principles and scientific training methods. Among the core volleyball skills—serving, passing, setting, spiking, and blocking—serving holds significant strategic importance (Raihanati & Wahyudi, 2021).

One of the critical physical attributes for performing explosive movements in volleyball—such as spiking and blocking—is lower limb explosive power. This physical component allows players to generate maximal force in short bursts, essential for jumping, sprinting, and changing direction. Explosive strength in the legs is vital for elevating the body during jumps and withstanding the physical demands of high-intensity play (Studi et al., 2023).

Based on an observation conducted on October 14, 2024, during volleyball extracurricular activities at SMP Negeri 3 Palembang, located on Jl. Ariodillah No. 2280, Ilir Timur 1 District, Palembang City, the researcher found that many students exhibited suboptimal jump height during spiking and blocking. Interviews with the coach further confirmed that students lacked sufficient jumping power, resulting in subpar volleyball

performance and repeated losses in competitions. The training program, held four times weekly, lacked emphasis on improving this specific skill component.

Effective training plays a crucial role in enhancing physical capacity. Plyometric training, characterized by explosive movements, is widely acknowledged as one of the most effective methods to increase lower limb power. It induces physiological adaptations that enhance the muscles' ability to produce explosive force (Mahindra, 2019). Among the various forms of plyometric exercises, the double-leg vertical jump stands out for its simplicity and effectiveness in strengthening lower body musculature.

Plyometric training involves exercises that combine speed and strength to produce powerful movements. These exercises utilize the stretch-shortening cycle, in which a muscle is rapidly stretched before contracting, thereby enhancing power output (Karola, 2014). The double-leg vertical jump, a plyometric drill used in this study, consists of repetitive jumps that improve muscular endurance, coordination, and overall explosiveness in the legs (Nurdiansyah & Susilawati, 2018).

Materials and Methods

Study Participants.

This study was conducted at SMP Negeri 3 Palembang, located at Jl. Ariodillah No. 2280, Ilir Timur 1 District, Palembang City, South Sumatra Province. The population consisted of all students participating in the volleyball extracurricular activities at the school, totaling 30 students (20 male, 10 female).

The sampling technique used was purposive sampling, focusing only on male students due to performance homogeneity considerations. Therefore, the final sample consisted of 20 male students who met the following inclusion criteria: (1) active participation in the volleyball extracurricular program, (2) willingness to undergo physical testing, and (3) absence of physical injuries that may hinder performance during jumping exercises.

Study organization.

This research employed a quantitative approach using a pre-experimental design with a one-group pretest-posttest model. In this design, the sample group underwent a pretest to assess vertical jump height (as a measure of lower limb explosive power), followed by a treatment phase consisting of plyometric training using the double-leg vertical jump method, and finally a posttest to measure outcomes.

The study was conducted over 16 sessions within a one-month period, with training held four times per week. The treatment began with one session of orientation and pretest, followed by 14 training sessions of plyometric standing jumps (double-leg vertical jump), and concluded with a posttest in the final session.

The specific steps included:

1. **Pretest (O1):** Measurement of vertical jump ability before training.
2. **Treatment (X):** Plyometric training focused on double-leg vertical jump exercises.
3. **Posttest (O2):** Re-assessment of vertical jump height to determine the effect of the intervention.

Vertical Jump Test Procedure:

The **vertical jump test** was conducted by having the subject stand next to a flat wall and reach upward with one hand, marking the highest point possible without jumping using chalk. Then, the subject performed a maximal vertical jump from a standing position, again making a chalk mark at the peak of the jump. The vertical jump score was calculated by measuring the difference between the initial standing reach and the jump height mark. Each participant was allowed three attempts, and the best score among the three was recorded as the final result.

The scoring classification for male participants is presented in the table below:

Table 1. Vertical Jump Score Classification for Male Participants

Rating	Score Range (cm)
Excellent	> 70
Very Good	61 – 70
Good	51 – 60
Fair	41 – 50
Average	31 – 40
Poor	21 – 30
Very Poor	< 21

Statistical analysis.

It is required to provide a detailed description of the various methods of mathematical statistics and their purposes. The objective is to explain the application of mathematical statistical techniques comprehensively, covering topics such as probability distributions, hypothesis testing, regression analysis, and multivariate analysis. The purpose of this analysis is to enable the reader to gain a thorough understanding of the statistical techniques used to analyze data in various fields, ranging from business to science to social sciences.

The statistical methods used in this study included normality testing and hypothesis testing.

1. **Normality Test:** The Shapiro-Wilk test was used to assess the normal distribution of the data, as the sample size was fewer than 50 participants. If the significance value is greater than 0.05, the data are considered normally distributed.
2. **Hypothesis Testing:** To evaluate the effect of plyometric training on lower limb explosive power, a paired-samples t-test (dependent t-test) was performed using SPSS version 26.
 1. **Null Hypothesis (H_0):** There is no significant effect of plyometric training on lower limb explosive power.
 2. **Alternative Hypothesis (H_1):** There is a significant effect of plyometric training on lower limb explosive power.

The results showed a t-value of 12.601, which was greater than the t-table value of 2.093, with a significance level of 0.000 (< 0.05), indicating that the null hypothesis was rejected and the alternative hypothesis accepted. Thus, the plyometric training had a significant positive effect on improving lower limb explosive power in male volleyball extracurricular students at SMP Negeri 3 Palembang.

Results

This section provides a detailed account of the findings of the study. It includes a concise description of the main results, supported by statistical analyses and tables that illustrate the findings.

Implementation of the Research

The study was conducted at SMP Negeri 3 Palembang, located at Jalan Ariodillah No. 2280, Ilir Timur 1 District, Palembang City, South Sumatra Province. The participants were 20 male students enrolled in the school's volleyball extracurricular program. The research followed a structured plyometric training plan, conducted four times per week for 120 minutes per session. Data collection occurred over one month, from April 10 to May 9, 2025.

The objective was to determine the effect of plyometric training on the explosive power of the lower limbs in the students. Data were obtained over four weeks (16 sessions), using vertical jump tests before (pretest) and after (posttest) the intervention.

Pretest Stage

Prior to the treatment, all participants underwent a pretest to assess their initial vertical jump ability. Each student performed three vertical jumps, reaching as high as possible using their extended arm, and the best result was recorded as the initial data.

Plyometric Training (Treatment) Stage

The treatment consisted of a double-leg vertical jump plyometric training program conducted over 14 sessions. The detailed plan was as follows:

- 1. Training frequency: 4 times per week
- 2. Training duration: 120 minutes per session

Posttest Stage

After completing the training program, students took a posttest using the same vertical jump test procedure. The results were compared to the pretest to determine any improvement in jump height.

Research Results (Description and Data Analysis)

Data from the research were analyzed to understand the influence of plyometric training on lower limb explosive power.

Table 2. Pretest and Posttest Vertical Jump Scores

No	Name	Pretest (cm)	Posttest (cm)
1	RF	35	43
2	RN	26	32
3	MD	24	29
4	PT	21	32
5	AQ	20	30
6	ZK	25	37
7	RJ	21	33
8	JV	27	33
9	JN	35	40
10	RD	37	42
11	RY	32	35
12	KF	11	21
13	GL	23	31
14	RZ	16	26
15	RM	16	27
16	RI	25	30
17	CC	12	21
18	WJ	13	27
19	DF	15	26
20	HB	16	26

Pretest Data Description

Pretest data helped identify students' initial vertical jump capabilities, as shown in the following distribution:

Table 3. Pretest Vertical Jump Frequency Distribution

Rating	Range (cm)	Frequency	Percentage (%)
Excellent	>70	0	0%
Very Good	61-70	0	0%
Good	51-60	0	0%
Fair	41-50	0	0%
Average	31-40	4	20%
Poor	21-30	8	40%
Very Poor	<21	8	40%

Posttest Data Description

Posttest data after the intervention showed improvement:

Table 4. Posttest Vertical Jump Frequency Distribution

Rating	Range (cm)	Frequency	Percentage (%)
Excellent	>70	0	0%
Very Good	61-70	0	0%
Good	51-60	0	0%
Fair	41-50	2	10%
Average	31-40	8	40%
Poor	21-30	10	50%
Very Poor	<21	0	0%

Descriptive Statistics of Pretest and Posttest

Table 5. Descriptive Statistics

	Min	Max	Mean	Std. Deviation
Pretest	11	37	22.50	7.904
Posttest	21	43	31.05	6.160

These results show a notable increase in the mean vertical jump score from pretest to posttest.

Normality Test

A normality test using Shapiro-Wilk was conducted to determine the distribution of the data.

Table 6. Normality Test Results (SPSS 26)

	Shapiro-Wilk Statistic	df	Sig.
Pretest	0.945	20	0.295
Posttest	0.958	20	0.507

Since the significance values are greater than 0.05, the data is normally distributed.

Hypothesis Testing

A paired sample t-test was performed to evaluate the effect of the treatment.

Table 6 Paired Sample T-Test Results (SPSS 26)

1. t-count = 12.601
2. t-table = 2.093
3. Significance = 0.000

Since $t\text{-count} > t\text{-table}$ and $\text{significance} < 0.05$, the hypothesis is accepted. Thus, it can be concluded that plyometric training significantly improved the explosive power of the students' lower limbs.

Discussion

This study aims to determine the effect of plyometric training on the explosive power of the lower limbs in male volleyball extracurricular students at SMP Negeri 3 Palembang. The sample in this study consisted of 20 male students who participated in the school's volleyball extracurricular program. Data collection was conducted twice—during the pretest and posttest phases—while the treatment was administered over approximately one month, consisting of 14 training sessions. Data were obtained through a vertical jump test to measure the jumping height of the participants.

Based on the results of the data analysis using a paired sample t-test, plyometric training was found to have a significant effect on the explosive power of the lower limbs. This is evidenced by a calculated t-value of 12.601, which is greater than the t-table value of 2.093, and a significance value of 0.000, which is less than 0.05.

These t-test results indicate a statistically significant difference. An increase in the students' jump height was observed after the plyometric training intervention, as shown by higher posttest scores compared to pretest scores. The average posttest result was 31.05, which was higher than the pretest average of 22.50. This clearly shows that plyometric training had a positive impact on the explosive power of the lower limbs in the volleyball extracurricular students at SMP Negeri 3 Palembang. Through plyometric training, students who initially had lower jump heights were able to improve significantly.

Therefore, based on the presented explanation and data, it can be concluded that the previously formulated research question has been answered. The findings of this study confirm that plyometric training significantly affects the explosive power of the lower limbs in volleyball extracurricular students at SMP Negeri 3 Palembang.

These results are consistent with a study conducted by Karola (2014), titled *"The Effect of Plyometric Training on Lower Limb Explosive Power,"* which found that plyometric training had a significant impact on the lower limb explosive power of volleyball players at

SMAN 8 Padang. The average lower limb explosive power during the pretest was 95.3146 kg-m/sec, which increased to 100.8915 kg-m/sec in the posttest (an improvement of 72.5 kg-m/sec). This conclusion was further supported by the results of the t-test, which showed a calculated t-value of 6.628, greater than the t-table value of 2.179 at a significance level of $\alpha = 0.05$.

Conclusions

This study aimed to examine the effect of plyometric training on the explosive power of the lower limbs in volleyball extracurricular students at SMP Negeri 3 Palembang. Based on the findings obtained, it can be concluded that plyometric training has a significant impact on improving jump height. This conclusion is supported by the results of the paired sample t-test analysis, which showed that the calculated t-value (12.601) was greater than the critical t-table value (2.093), with a significance level of $0.000 < 0.05$. These results indicate a significant difference between the pretest and posttest measurements.

Furthermore, the findings also revealed a notable increase in students' jump height following the plyometric training. The average posttest score was 31.05, which was considerably higher than the pretest average of 22.50. This increase demonstrates that plyometric training can effectively enhance lower limb explosive power among volleyball extracurricular students.

In summary, the results of this study confirm that plyometric training positively influences the explosive power of the lower limbs, particularly in improving jump height among students. Therefore, it can be concluded that *“plyometric training has a significant effect on the lower limb explosive power of volleyball extracurricular students at SMP Negeri 3 Palembang.”*

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this study.

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