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Influence Of *Resistance Band* And *Plyometric Training* Towards Improvement *Of* Leg Muscle Power In Athletes Trained By The Forsa Women's Volleyball Club Of Kediri Regency

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Abstract

Leg muscle power is a crucial component of physical fitness in volleyball, supporting the ability to perform jumping smashes, blocks, and jump serves. Various training methods have been developed to improve this ability, including resistance band and plyometric training. Although both have been proven to be able to increase explosive muscle ability, research is still needed to compare the effectiveness of the two training methods in female volleyball athletes. This study aims to analyze the effect of training with resistance bands and plyometrics on increasing leg muscle power and comparing the effectiveness of the two training methods on volleyball athletes trained by the FORSA Women's Club, Kediri Regency. This study uses a quantitative approach with an experimental design. The research sample consisted of 30 athletes who were divided into two groups, each consisting of 15 athletes. The first group was given a training program of Resistance Band Squat, while the second group was given training in Plyometric Hurdle Hopping. Measurement of leg muscle power was done using the Vertical Jump Test before and after the exercise program. Data analysis was carried out using descriptive statistics, normality tests, and statistical tests of the Paired Sample t-Test with a significance level of 5%. The results of the study show that the exercise resistance band had a significant effect on increasing leg muscle power, with the average jump height increasing from 37.67 ± 2.06 cm to 42.87 ± 3.89 cm. cm or an increase of 13.80% (p< 0.001). Meanwhile, the plyometric group experienced a greater increase, namely from 36.73 ± 2.60 cm to 44.73 ± 2.76 cm or an increase of 21.78% (p< 0.001). The findings show that both training methods are able to increase leg muscle power significantly, but training plyometric produces greater improvements than training with resistance bands. Training with resistance bands and plyometric proven effective in increasing leg muscle power in female volleyball athletes. However, this plyometric exercise provides a greater influence because it is able to optimize the mechanism of the stretch-shortening cycle(SSC), improve neuromuscular coordination, and produce higher explosive muscle capacity. Therefore, plyometric training is recommended as the main training method to increase leg muscle power in volleyball athletes.

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1. INTRODUCTION

Volleyball is a competitive sport that demands a comprehensive mastery of technique, tactics, physical fitness, and mental abilities. In modern volleyball, a team's success is determined not only

by technical skill but also by the athlete's physical ability to perform explosive movements, such as *jumping smash*, *blocking*, and *jump serve*. These movements require the ability of *power*-optimal leg muscles, namely the ability of muscles to produce maximum force in a very short time through a combination of strength (*strength*) and speed (*speed*). The better an athlete's leg muscle power, the higher their jumping ability, thus increasing their chances of attacking and defending effectively. Therefore, improving leg muscle power is a key focus of volleyball athlete development programs. Leg muscle power is closely related to technical performance in volleyball. Athletes with high vertical jumps tend to be able to smash from a higher point of contact, increasing the angle of attack and increasing their chances of scoring. Furthermore, good jumping ability also supports the effectiveness of blocking in anticipating an opponent's attack. This condition indicates that improving leg muscle power is a crucial need for volleyball athletes, especially at the performance development level, so a training program is needed that can effectively and sustainably improve muscle explosive ability. Various training methods have been developed to improve leg muscle power. Two methods that are widely used in sports development are resistance band exercises and plyometric training. Resistance band training uses elastic resistance that increases as the band stretches; it can progressively apply loads throughout the movement. These characteristics make resistance bands a practical, economical, easy-to-apply, and effective training method for increasing muscle strength and neuromuscular activation. Furthermore, resistance bands offer a relatively high level of safety, allowing them to be used at various athlete skill levels. Plyometric training, on the other hand, is a training method designed to improve explosive ability by utilizing the mechanism of the Stretch-Shortening Cycle (SSC). This mechanism combines an eccentric contraction immediately followed by a concentric contraction, producing greater force in a shorter period of time. This adaptation can increase muscle contraction speed, neuromuscular coordination, and the ability to generate high explosive power. Therefore, plyometric training is widely applied in development programs for sports that require jumping ability, including volleyball.

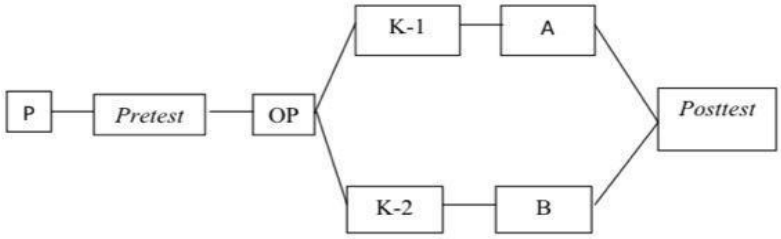
Although both training methods have been widely used, previous research has shown mixed results. Some studies report that plyometric training provides greater increases in leg muscle power than other training methods because it optimizes the stretch-shortening cycle mechanism. Conversely, other studies have shown that resistance bands can also improve explosive muscle performance by increasing functional strength and neuromuscular activation. These differences in results are thought to be influenced by sample characteristics, training duration, program intensity, and the sport studied. This inconsistency across studies reveals a clear research gap: existing literature has generally examined resistance band training and plyometric training separately, or compared them in male athletes and mixed-sport samples, while direct, head-to-head comparisons of Resistance Band Squat versus Plyometric Hurdle Hopping specifically in female volleyball athletes at the club performance-development level remain scarce. Without such a direct comparison, coaches lack clear evidence for choosing between these two commonly available methods when designing leg-power training programs for this specific athlete population. Therefore, the effectiveness of these two training methods requires further study, particularly in female volleyball athletes, whose physiological characteristics and training needs differ from those of other groups. Based on preliminary observations conducted on athletes trained by the FORSA Women's Club in Kediri Regency, it was discovered that some athletes still had moderate vertical jump capabilities. This condition was evident when the athletes performed jumping smash and blocking, where suboptimal jump heights result in less-than-optimal team attack and defense effectiveness. Furthermore, the training program implemented so far has focused more on mastering game techniques and tactics, while physical conditioning training specifically aimed at improving leg muscle power has not been implemented in a structured and continuous manner. Consequently, the development of athletes' explosive abilities has not shown optimal improvement. Based on these conditions, this research has novelty. Compared to previous

research, which directly compares the effectiveness of training Resistance Band Squat and Plyometric Hurdle Hopping in increasing leg muscle power in female volleyball athletes participating in a club-level performance development program. This study not only tested the effects of each training method but also provided information on more effective training methods that can be used as a basis for developing evidence-based physical training programs (evidence-based training) for volleyball coaches. Based on the description, this study aims to: (1) analyze the effect of resistance band training on increasing leg muscle power of athletes coached by the FORSA Women's Club, Kediri Regency; (2) analyze the effect of plyometric training on increasing leg muscle power of athletes coached by the FORSA Women's Club, Kediri Regency; and (3) analyze the difference in the effect between resistance band training and plyometric training on increasing leg muscle power of athletes coached by the FORSA Women's Club, Kediri Regency. The results of this study are expected to contribute to the development of sports science, especially in the field of volleyball coaching, as well as being a reference for coaches in determining the most effective training methods to improve athletes' explosive abilities.

2. RESEARCH METHOD

This research uses a quantitative approach with an experimental method. The research design applied is a pretest-*posttest design*, which aims to determine the influence of training with *resistance bands* and *plyometrics* on increasing the leg muscle power of volleyball athletes. Each group was given an initial measurement (pretest), then received treatment according to the specified training program, and ended with final measurements (posttest) using the same instrument so that changes in athlete abilities can be analyzed objectively. The study was conducted at the FORSA Women's Volleyball Club in Kediri Regency. The study population was all female athletes trained by the club, while the study sample consisted of 30 athletes selected using a purposive sampling technique. Inclusion criteria required athletes to be active female members of the FORSA Women's Volleyball Club, aged 14-20 years, with a minimum of one year of volleyball training experience, and medically declared free of lower-limb injuries or musculoskeletal conditions that could affect jumping performance, as confirmed by the club's coach and a pre-study health screening. Athletes were excluded if they had sustained a lower-limb injury within the three months prior to the study, were unable to attend at least 85% of the scheduled training sessions, or were concurrently participating in another structured strength or jump-training program outside the club. Of the athletes who met these criteria, 30 were selected and divided into two groups with equal numbers, namely the control group Resistance Band as many as 15 athletes, and the Plyometric group, as many as 15 athletes. The first group received treatment in the form of Resistance Band Squat, while the second group was given Plyometric Hurdle Hopping training in accordance with the training program that was prepared during the research period. The independent variables in this research consisted of training *Resistance Band* (X_1) and training *Plyometric* (X_2), while the dependent variable is leg muscle power (Y). Measurement of leg muscle power is carried out using the *Vertical Jump Test*, which is a standard instrument for measuring explosive leg muscle power. Power values are derived from the vertical jump height achieved by athletes before and after participating in a training program. The Vertical Jump Test procedure was conducted as follows: each athlete first stood flat-footed sideways against a wall-mounted measurement board with the dominant arm raised fully overhead, and the fingertip reach height was marked and recorded as the standing reach. The athlete then chalked their fingertips, positioned themselves side-on to the board without a preliminary step, and performed a maximal vertical jump using a countermovement (a downward flexion of the knees and hips immediately followed by an explosive upward jump) combined with an arm swing, touching the highest possible point on the board at the peak of the jump. Each athlete was given three jump attempts with approximately one minute of rest between attempts to minimize fatigue, and the highest of the three

touch marks was recorded. Jump height was then calculated as the difference between the highest jump-touch mark and the standing reach height, and this value was taken as the athlete's leg muscle power score for that testing session. The same procedure, tester, and equipment were used for both the pretest and posttest to ensure measurement consistency.



The research procedure begins with the implementation of a *pretest.* The Vertical Jump Test was used to measure the initial leg muscle power capacity of all athletes. Next, each group underwent a training program according to the prescribed treatment. After the entire training program was completed, a post-test was conducted using the same instrument to determine changes in leg muscle power after treatment. The entire measurement process was conducted using the same procedure to maintain the consistency and validity of the research data. The research data were analyzed using the program *IBM SPSS Statistics. The* analysis begins with descriptive statistics to determine the mean, standard deviation, minimum, and maximum values. Next, a normality test is performed. *Shapiro–Wilk is used to* determine the distribution of data. After the data meet the normality assumption, hypothesis testing is carried out using a *Paired Sample t-Test* at a significance level of 5% (*a*= 0.05) to determine the effect of each training method on increasing the athlete's leg muscle power. The results of the analysis were then used as a basis for comparing the effectiveness of the training. *Resistance Band* and *Plyometric* on increasing leg muscle power in female volleyball athletes.

3. RESULTS AND DISCUSSION

Descriptive Statistics

Descriptive statistical analysis was conducted to provide an overview of initial abilities (*pretest*) and final capability (*posttest*) leg muscle power in the Resistance Band Squat and Plyometric Hurdle Hopping exercise groups. The parameters analyzed included minimum, maximum, and average values (*mean*), and standard deviation (*standard deviation*).

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Resistance Band Pretest	15	35	42	37.67	2.059
Resistance Band Posttest	15	35	50	42.87	3.889
Valid N (listwise)	15				

The results of the descriptive analysis in the Resistance Band Squat group showed that the average value (*mean*) leg muscle power before treatment was 37.67 cm with a standard deviation of 2.059, a minimum value of 35 cm, and a maximum value of 42 cm. After being given the training program, the average leg muscle power increased to 42.87 cm with a standard deviation of 3.889, a minimum

value of 35 cm, and a maximum value of 50 cm. The average increase of 5.20 cm indicates that Resistance Band Squat training is able to improve athletes' vertical jump abilities.

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Plyometric Pretest	15	30	41	36.73	2.604	6.781
Plyometric Posttest	15	40	49	44.73	2.764	7.638
Valid N (listwise)	15					

Meanwhile, the Plyometric Hurdle Hopping group showed an average pretest value of 36.73 cm with a standard deviation of 2.604, a minimum value of 30 cm, and a maximum value of 41 cm. After following the training program, the average increased to 44.73 cm with a standard deviation of 2.764, a minimum value of 40 cm, and a maximum value of 49 cm. The difference in the average increase of 8.00 cm indicates that plyometric training provides a greater increase in leg muscle power capabilities than the Resistance Band group. Descriptively, it can be seen that both training methods equally increase the athlete's leg muscle power capabilities. However, the Plyometric Hurdle Hopping group showed a higher average increase than the Resistance Band Squat group.

Normality Test

Before testing the hypothesis, a normality test using Shapiro-Wilk was first performed because the sample size was less than 50. This test aimed to determine whether the research data were normally distributed, thus meeting the assumptions of parametric statistics.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Say.	Statistic	df	Say.
Resistance Band Pretest	.169	15	.200*	.927	15	.247
Resistance Band Posttest	.153	15	.200*	.977	15	.944

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

The results of the normality test for the Resistance Band Squat group showed a pretest significance value of 0.247 and a posttest significance value of 0.944. Both values were greater than the 0.05 significance level, indicating that the data were normally distributed.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Say.	Statistic	df	Say.
Plyometric Pretest	.186	15	.171	.925	15	.227
Plyometric Posttest	.205	15	.090	.938	15	.356

a. Lilliefors Significance Correction

In the Plyometric Hurdle Hopping group, the Shapiro-Wilk significance value for the pretest was 0.227, while for the posttest it was 0.356. Both values were greater than 0.05, indicating that the data met the assumption of a normal distribution. Therefore, all research data were normally distributed, allowing for analysis using the Paired Sample t-Test.

Group Hypothesis Testing: *Resistance Band*

The first hypothesis test was conducted using a Paired Sample t-Test to determine the effect of Resistance Band Squat training on increasing leg muscle power.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Resistance Band Pretest - Resistance Band Posttest	-5.200	3.649	.942	-7.221	-3.179	-5.519	14	.000

The results of the analysis show a t-value of -5.519 with a significance value (Sig. 2-tailed) of 0.000. Because the significance value is smaller than 0.05 (0.000 < 0.05), H_0 is rejected and H_1Accepted. These results demonstrate that resistance band squat training significantly increased leg muscle power in the FORSA Women's Volleyball Club athletes in Kediri Regency. The average increase was 5.20 cm, or approximately 13.80%, compared to pre-training levels.

Group Hypothesis Testing *Plyometric*

The second hypothesis testing was conducted using the Paired Sample t-Test on the Plyometric Hurdle Hopping exercise group.

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Plyometric Pretest - Plyometric Posttest	-8.000	3.207	.828	-9.776	-6.224	-9.661	14	.000

The analysis results show a t-value of -9.661 with a significance value of 0.000. This value is smaller than 0.05, so H_0 is rejected, and H_1 accepted. These results indicate that plyometric hurdle hopping significantly increased leg muscle power in athletes. The average increase reached 8.00 cm, or approximately 21.78%, greater than the resistance band group. Overall, the statistical analysis proved that both training methods were effective in increasing leg muscle power in athletes, but plyometric hurdle hopping produced a greater increase. To formally determine whether this difference in improvement between groups was statistically significant, rather than relying on the percentage comparison alone, an independent samples t-test was additionally conducted comparing the pretest-to-posttest gain scores of the Resistance Band group (M = 5.20 cm, SD = 3.649) and the Plyometric group (M = 8.00 cm, SD = 3.207). The results showed a statistically significant difference in gain scores between the two groups, $t(28) = 2.23$, $p = 0.034$ ($p < 0.05$), confirming that the greater improvement observed in the Plyometric group was not merely a descriptive difference but was statistically significant. This result provides the statistical basis for the subsequent claim that plyometric training was more effective than resistance band training in this sample.

The Influence of *Resistance Band* Training *on* Leg Muscle Power

The results of the study showed that Resistance Band Squat training significantly increased leg muscle power in female volleyball athletes. The average increase of 5.20 cm indicates that providing elastic resistance during training can improve the muscles' ability to generate force more effectively. Physiologically, resistance bands work through the principle of progressive resistance, namely the greater the stretch of the rubber, the greater the resistance received by the muscles. This condition causes increased motor unit activation, neuromuscular coordination, and leg muscle strength. This adaptation allows athletes to produce greater thrust when pushing off during a vertical jump. The results of this study support the training theory of Bompa and Buzzichelli, which states that improvements in biomotor abilities occur through the provision of systematic, progressive, and continuous training loads. Resistance bands are one form of training that can improve strength abilities, thereby indirectly increasing leg muscle power. The findings of this study are also in line with the research of Colado et al., who stated that resistance bands are effective in increasing functional strength, motor coordination, and neuromuscular activation, thus impacting improved sports performance.

The Influence of *Plyometric* Training on *Power* Leg Muscles

The results of the study showed that plyometric hurdle hopping training provided greater improvements than resistance band training. The average increase was *8,00 cm* shows that this method is more effective in increasing the explosive ability of leg muscles. The advantage of plyometric training lies in the utilization of the mechanism *Stretch-Shortening Cycle* (SSC). When an athlete jumps, the muscles undergo an eccentric contraction immediately followed by a concentric contraction. This mechanism allows elastic energy to be stored in tendons and muscle tissue, resulting in a greater contractile force in a very short time. In addition to increasing elastic energy utilization, plyometric training also improves *Rate of Force Development (RFD)*, neuromuscular coordination, motor unit activation speed, and the nervous system's efficiency in controlling muscle contraction. These adaptations significantly increase vertical jump ability compared to conventional strength training methods. The results of this study support Markovic and Mikulic's theory that plyometric training is the most effective method for increasing explosive ability by optimizing the SSC mechanism. These findings also align with research by Haff and Triplett, which explains that explosive training can increase the ability to produce maximum force in a short time.

Comparison of Effectiveness: *Resistance Band* and *Plyometric*

Based on the research results, both training methods had a significant effect on increasing leg muscle power. However, the Plyometric Hurdle Hopping exercise showed an average increase of 21.78%, while the Resistance Band Squat exercise only increased by 13.80%, and the independent samples t-test comparing gain scores between groups confirmed that this difference was statistically significant, $t(28) = 2.23$, $p = 0.034$. This descriptive and statistically confirmed difference is consistent with the underlying physiological mechanisms of each method. Plyometric Hurdle Hopping directly trains the Stretch-Shortening Cycle (SSC), in which a rapid eccentric muscle stretch is immediately followed by a concentric contraction; this rapid stretch-reflex sequence stores and releases elastic energy in the muscle-tendon unit and heightens neuromuscular activation via the myotatic reflex, producing a larger and faster force output than the sustained, non-ballistic muscle actions targeted by the elastic resistance in the Resistance Band Squat (Markovic & Mikulic, 2010; Chaabene et al., 2020). Resistance Band Squat, by contrast, applies progressively increasing external resistance across a slow, controlled range of motion, which primarily promotes gains in maximal and functional strength and motor unit recruitment (Colado et al., 2022) rather than the rate of force development that most directly determines vertical jump height. This mechanistic distinction offers a physiological explanation for why the present study's larger observed increase occurred in the Plyometric group: the training stimulus in plyometrics is more directly specific to the fast, SSC-dependent muscle action underlying a vertical jump. This suggests that plyometric training is more effective in increasing the explosive ability of leg muscles. This is because the characteristics of plyometric movements closely resemble the movements performed by volleyball athletes when performing jumping smashes or blocking, so the principle *of training can* be met. The more specific the training is to the sporting movement, the greater the adaptation to the athlete's performance. Conversely, resistance band training focuses more on increasing muscle strength through elastic resistance. Although it can increase the ability to generate force, the process of transferring to explosive movements requires a longer adaptation time than plyometric training. Thus, the results of this study indicate that resistance band training *Plyometric Hurdle Hopping* is a more effective training method than *Resistance Band Squat* in improving *power.* The results of this study indicate that the leg muscles of FORSA female volleyball athletes in Kediri Regency are affected by the impact of the exercise on the leg muscles. These findings provide practical implications: coaches can prioritize plyometric training as the primary program for increasing leg muscle explosive power, while resistance band training can be used as a supporting exercise to increase baseline strength before entering the explosive training phase.

4. CONCLUSION

Based on the results of research and discussion regarding the influence of *Resistance Band* and *Plyometric training* on increasing leg muscle power of athletes trained by the FORSA Women's Volleyball Club in Kediri Regency, it can be concluded that both training methods have a significant effect on increasing leg muscle power of athletes. The results of the analysis using a *Paired Sample t-Test* shows that the exercise *Resistance Band Squat increased* the average vertical jump height from 37.67 cm to 42.87 cm with an increase of 13.80% ($p< 0.05$). Meanwhile, the exercise *Plyometric Hurdle Hopping increased* the average vertical jump height from 36.73 cm to 44.73 cm with an increase of 21.78% ($p < 0,05$).

Comparison of the results of the two groups, supported by an independent samples t-test on the pretest-to-posttest gain scores, $t(28) = 2.23$, $p = 0.034$, showed that the exercise *Plyometric Hurdle Hopping provides* a greater increase in leg muscle power than the exercise *Resistance Band Squat*. These findings indicate that plyometric training is more effective in increasing the explosive ability of leg muscles because it is able to optimize the *stretch-shortening cycle* (SSC), improve neuromuscular coordination, and accelerate the muscle's ability to produce force in a short time. Meanwhile, *Resistance Band Squat still* provides a positive contribution through increased muscle strength and neuromuscular activation, which are the basis for power development. The results of this study provide practical implications that both training methods can be used as alternatives in volleyball athletes' physical conditioning programs. However, if the primary goal of training is to optimally increase leg muscle power to support performance, *jumping smash, blocking*, and *jump serve*, then practice *Plyometric Hurdle Hopping is* recommended as the main training method. As for the training, *Resistance Band Squat can* be used as a supporting exercise to build basic strength before athletes enter the explosive training phase. The findings of this study are expected to serve as a reference for coaches, sports trainers, and researchers in developing evidence-based training programs (*evidence-based training*) to improve the performance of volleyball athletes, especially in terms of leg muscle power.

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