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The Effect of Squad Jump And Knee Tuck Jump On Leg Explosive Power of Volleyball Athletes

Clement Sudamara[1A-E*], Humaedi[2B-D], Andi Saparia[3B-D], Muh. Saldi[4B-D]

[1,2,3,4] Universitas Tadulako, Sulawesi Tengah, Indonesia.

clementsudamara2426@gmail.com[1*], humaedi@untad.ac.id[2], sapariaandi@gmail.com[3], saldysya@untad.ac.id[4]

ABSTRACT

Leg explosive power is a fundamental physical component that strongly influences performance in volleyball, particularly in executing jumping-based skills such as spiking, blocking, and serving. Plyometric training is widely recognized as an effective approach to enhance explosive power through neuromuscular adaptations. This study aimed to examine the effect of squat jump and knee tuck jump exercises on the leg explosive power of volleyball athletes at Mandala Club. The study employed a pre-experimental method using a one-group pretest–posttest design. The participants consisted of 14 volleyball athletes, all of whom were included as the research sample using total sampling. Leg explosive power was measured using the vertical jump test, a valid and reliable instrument commonly applied in volleyball performance assessment. The training intervention was conducted for six weeks, and data were analyzed using descriptive statistics and inferential analysis with a paired-sample t-test. The results showed that squat jump training increased the average vertical jump score from 49.00 cm in the pretest to 58.57 cm in the posttest, indicating an improvement of 19.53%. Meanwhile, knee tuck jump training increased the average score from 59.00 cm to 66.71 cm, representing an improvement of 13.07%. Statistical analysis revealed that both squat jump and knee tuck jump exercises produced significant improvements in leg explosive power ($t > t\text{-table}$, $p < 0.05$). In conclusion, squat jump and knee tuck jump exercises are effective plyometric training methods for improving leg explosive power in volleyball athletes. These findings provide empirical evidence supporting the integration of simple, equipment-free plyometric exercises into volleyball training programs, particularly at the club development level.

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A. Conception and design of the study;
B. Acquisition of data;
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INTRODUCTION

Sport is a planned interactive process that functions to develop an individual's physical, psychological, and social potential through training, games, and competitions oriented toward achievement. In the context of national development, sport plays a strategic role in developing healthy, productive, character-based, and globally competitive human resources, while also

serving as a means of enhancing the nation's prestige internationally. Therefore, the development of competitive sports is inseparable from a systematic, measurable, and empirically evidence-based scientific approach (Yuni, 2023; Bompa & Buzzichelli, 2019).

Volleyball is one of the most popular and competitive team sports in the world, characterized by fast-paced, high-intensity play and an intermittent work pattern that simultaneously demands physical and technical abilities. The large number of national federations affiliated with the Fédération Internationale de Volleyball (FIVB) demonstrates volleyball's global appeal and high level of competition. Physiologically and biomechanically, volleyball demands optimal explosive jumping ability, particularly in smashing and blocking, which are key determinants of a team's performance (Sheppard et al., 2016; Palao et al., 2018).

However, in club-level coaching practices, fundamental problems related to athletes' low leg muscle explosiveness are still found, which directly impacts jump height, attack effectiveness, and defensive quality. Field observations at Club Mandala showed that athletes had not received a structured plyometric training program, particularly for squat jumps and knee tuck jumps, and exhibited poor landing patterns after jumping. This condition not only hinders performance improvement but also increases the risk of lower extremity injuries due to weak neuromuscular control and leg muscle strength (Hewett et al., 2016; Lloyd et al., 2021).

Current literature confirms that physical condition, particularly leg muscle explosiveness, is a key foundation for supporting technical mastery and tactical effectiveness in volleyball. Physical components such as strength, speed, explosive power, flexibility, and coordination contribute specifically to vertical jump performance and movement efficiency during competition (Kadafi & Irsyada, 2021; Suchomel et al., 2018). Athletes with strong leg explosiveness have been shown to excel in smashing, blocking, and rapid movement transitions during rallies (Ziv & Lidor, 2010; Tillaar & Marques, 2013).

Plyometric training is widely recognized as an effective training method for increasing muscle power through the stretch-shortening cycle (SSC) mechanism. Research shows that plyometric training can significantly increase motor unit recruitment, muscle contraction velocity, and neuromuscular efficiency (Markovic & Mikulic, 2019; Ramirez-Campillo et al., 2020). Exercise variations such as squat jumps and knee tuck jumps have the advantage of being specific, easy to implement, and relevant to jumping movement patterns in volleyball (Slimani et al., 2016; Moran et al., 2017).

Several empirical studies have reported significant improvements in vertical jump height and explosive performance in volleyball athletes after 6–8 weeks of plyometric intervention (Stojanović et al., 2017; Chaabene et al., 2019). However, training effectiveness is strongly influenced by the type of exercise chosen, volume, intensity, and characteristics of the study subjects, so results are not always consistent across coaching contexts.

Although research on plyometric training has advanced rapidly, significant research gaps remain. First, most studies focus on combinations of multiple plyometric exercises without isolating the specific contributions of squat jumps and knee tuck jumps to leg muscle explosiveness. Second, research conducted in the context of local club coaching, particularly on development-level athletes, is still relatively limited, particularly in the Indonesian volleyball coaching environment (Keswando et al., 2022; Sudarmanto et al., 2019).

Furthermore, few studies link increased leg muscle explosiveness to qualitative observations of landing quality and potential injury risk. These aspects are crucial for sustainable development and sports injury prevention (Myer et al., 2015; Fort-Vanmeerhaeghe et al., 2016). Therefore, more focused research is needed to evaluate the effectiveness of these two simple yet applicable forms of plyometric training in the club coaching context.

Based on the aforementioned research problems and gaps, this study aims to analyze the effect of squat jumps and knee tuck jumps on increasing explosive leg muscle power in volleyball athletes at the Mandala Club. This research is also expected to provide an empirical overview of the relevance of bodyweight-based plyometric training to the specific physical demands of volleyball.

The novelty of this research lies in: (1) focusing on two basic plyometric training forms that are applicable and low-risk, (2) applying them to a local club coaching context rarely explored in international literature, and (3) providing an empirical basis for developing more effective, safe, and contextual plyometric training programs for development-level volleyball athletes. The findings of this study are expected to enrich the body of sports coaching knowledge and support evidence-based coaching practices towards sustainable performance improvement.

METHODS

This study employed a quantitative experimental approach using a pre-experimental one-group pretest–posttest design, which is commonly applied in sports training research to examine the direct effect of specific training interventions on physical performance variables when randomization and full control groups are limited (Fraenkel et al., 2019; Thomas et al., 2015). This design allows researchers to identify performance changes attributable to the training stimulus by comparing measurements before and after the intervention period (Hopkins et al., 2009).

The participants consisted of 14 male volleyball athletes from Mandala Volleyball Club, who were actively involved in regular training and competition. Participant selection used total sampling, as all athletes met the inclusion criteria: (1) actively training for at least one year, (2) free from musculoskeletal injury during the last three months, and (3) willing to follow the full training program. Prior to intervention, all participants provided informed consent and were briefed on the research procedures in accordance with ethical principles for sports science research (Harriss & Atkinson, 2015).

To ensure balanced initial ability, participants were assigned into two training groups using the ordinal pairing technique, based on their pretest vertical jump scores. This method is recommended in small-sample experimental studies to minimize baseline performance bias and increase internal validity (Sugiyono, 2021; Turner et al., 2015). The two groups consisted of a squat jump group and a knee tuck jump group, each receiving a specific plyometric intervention.

The training intervention was conducted for six weeks, with a frequency of three sessions per week, following established recommendations for plyometric training adaptation (Markovic & Mikulic, 2019; Ramirez-Campillo et al., 2020). Each training session begins with a standardized warm-up including dynamic stretching and low-intensity

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clementsudamara2426@gmail.com[1*]

movement drills, followed by the main plyometric exercises and a cool-down phase. The squat jump emphasizes concentric force production from a static semi-squat position, while the knee tuck jump focuses on maximal vertical displacement and rapid hip–knee flexion during flight. Both exercises were selected due to their biomechanical relevance to volleyball jumping actions such as smash and block (Sheppard et al., 2016; Slimani et al., 2016).

The vertical jump test was used as the primary measurement instrument to assess leg explosive power, as it is widely recognized for its validity, reliability, and practical applicability in volleyball performance evaluation (Sattler et al., 2012; Bosco et al., 2018). Pretest measurements were conducted one week before the intervention, while posttest measurements were performed 48 hours after the final training session to minimize fatigue effects (Chaabene et al., 2019). Each athlete performed three trials, and the highest jump height was recorded for analysis.

The data were analyzed using descriptive statistics and inferential analysis. Normality was assessed using the Shapiro–Wilk test, followed by paired-sample t-tests to examine differences between pretest and posttest scores within each training group. Statistical significance was set at $p < 0.05$, consistent with conventions in sports performance research (Field, 2018; Hopkins et al., 2009). This analytical approach has been widely applied in previous plyometric training studies to determine training effectiveness on explosive power outcomes (Stojanović et al., 2017; Moran et al., 2017).

RESULTS AND DISCUSSION

Result

The results of the initial test (pre-test) and the final test (post-test) of leg muscle explosive power in volleyball athletes at the Mandala Club before and after being given squat jump and knee tuck jump training.

Table 1.
Squad Jump Group

Name	Pretest	Postest
Abdi	44cm	49cm
Iksan	47cm	64cm
Alan	52cm	59cm
Dede	49cm	69cm
Adrian	62cm	70cm
Onci	43cm	47cm
Riyad	46cm	52cm

Table 2.
Knee Tuck Jump Group

Name	Pretest	Postest
delon	57cm	61cm
Aziz	52cm	60cm
Boy	69cm	75cm
Andi	48cm	65cm
Soros	67cm	70cm
Ikky	70cm	73cm
Adit	50cm	63cm

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clementsudamara2426@gmail.com[1*]

Based on Table 1 above, the results of the squat jump exercise test for volleyball athletes at the Mandala Club before being given the training show that from the 7 athletes, the highest test result was 62 cm, while the lowest was 44 cm. After obtaining the initial vertical jump test results related to the explosive power of the leg muscles of the volleyball athletes at the Mandala Club before the training was administered, the next step was to provide the treatment. The treatment in this case was a programmed training regimen conducted three times a week for approximately six weeks. After completing the squat jump training within the specified period, a final test (post-test) in the form of a vertical jump test was administered to measure the explosive power of the leg muscles. The data obtained were then recorded and analyzed. Based on Table 1 above, the post-test results of the vertical jump test on the explosive power of the leg muscles after receiving the treatment namely the squat jump training show that from the 7 athletes, the highest test result was 70 cm, while the lowest test result was 49 cm.

Based on Table 2 above, the results of the knee tuck jump test for volleyball athletes at the Mandala Club before receiving the training show that from the 7 athletes, the highest test result was 70 cm, while the lowest was 50 cm. After obtaining the initial vertical jump test results related to the explosive power of the leg muscles of the volleyball athletes at the Mandala Club before the training was administered, the next step was to provide the treatment. The treatment in this case was a structured training program conducted three times a week for approximately six weeks. After completing the knee tuck jump training within the specified period, a final test (post-test) in the form of a vertical jump test was administered to measure the explosive power of the leg muscles. The data obtained were then recorded and analyzed. Based on Table 2 above, the post-test results of the vertical jump test on the explosive power of the leg muscles after receiving the treatment—namely the knee tuck jump training—show that from the 7 athletes, the highest test result was 75 cm, while the lowest test result was 60 cm.

Inferential statistics

A normality test is a test used to determine whether the data obtained has a normal distribution so that it can be used in statistical analysis. In other words, a normality test is conducted to assess whether the empirical data collected from the field conforms to a certain theoretical distribution, in this case, the normal distribution. The purpose of the normality test is to determine whether the distribution of a dataset approaches a normal distribution.

Table 3.
The normality test results of the Squad Jump training data

Variable	Test	Nilai Sig	Nilai α	Criteria
Squad Jump	Pretest	0,200	0,05	Normal
	Posttest	0,200		Normal

Table 4.
The normality test results of the Knee Tuck Jump training data

Variable	Test	Nilai Sig	Nilai α	Criteria
Knee Tuck Jump	Pretest	0,200	0,05	Normal
	Posttest	0,200		Normal

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clementsudamara2426@gmail.com[1*]

The normality test using the SPSS application with the Kolmogorov-Smirnov method shows that the significance value for the initial test of the Squad Jump training is 0.200 > 0.05, and the significance value for the final test is 0.200 > 0.05. Furthermore, the significance value for the initial test of the Knee Tuck Jump training is 0.200 > 0.05, and the significance value for the final test is also 0.200 > 0.05. Therefore, it can be concluded that the data for both the initial test and the final test of the two training programs are normally distributed.

The hypothesis test used in this study is the t-test, because this test aims to determine whether there is an effect of squat jump and knee tuck jump training on the explosive power of the leg muscles of volleyball athletes at the Mandala Club. Based on the available t-test table, the results show that there is an effect on the leg muscle explosive power of the volleyball athletes at the Mandala Club. It can be concluded that the alternative hypothesis (Ha) is accepted if it falls within the acceptance region of Ha, and the null hypothesis (Ho) is rejected. Therefore, the subsequent analysis can be carried out using a parametric test with the t-test.

Table 5.
Data Description of the Squad Jump Training Group

No	Name	Hasil Pretest dan Posttest		D (X2-X1)	d (D-MD)	d^2
		X1	X2			
1	Abdi	44	49	5	-4,57	20,8849
2	Iksan	47	64	17	7,43	55,2049
3	Alan	52	59	7	-2,57	6,6049
4	Dede	49	69	20	10,43	108,785
5	Adrian	62	70	8	-1,57	2,4649
6	Onci	43	47	4	-5,57	31,0249
7	Riyad	46	52	6	-3,57	12,7449
Jumlah ∑		**343**	**410**	**67**	**0,01**	**237,714**
Rata-rata M		**49,00**	**58,57**			
MD		**9,57**				
Peningkatan		**19,53**				

To calculate the Mean Deviation (MD), the following steps are used:

$$|MD| = \frac{\sum D}{N} = \frac{67}{7} \quad |MD| = 9{,}57$$

Next, the t-test calculation is continued using the following formula:

$$t = \frac{|MD|}{\sqrt{\frac{\sum d^2}{n(n-1)}}} = \frac{9{,}57}{\sqrt{\frac{237{,}714}{7(7-1)}}} = \frac{9{,}57}{\sqrt{\frac{237{,}714}{7(6)}}} = \frac{9{,}57}{\sqrt{\frac{237{,}714}{42}}}$$

$$= \frac{9{,}57}{\sqrt{5{,}659}} = \frac{9{,}57}{2{,}378} = 4{,}024$$

From the statistical calculation, the t-value for the squat jump training shows an improvement of 4.024. Using a 5% significance level with degrees of freedom d.f = (N – 1) = 7 – 1 = 6, the t-table value obtained is 1.943. This means that the calculated t-value is greater than the t-table value, or 4.024 > 1.943. The improvement between the pre-test and post-test is 67, with a mean deviation of 9.57 and a percentage increase of 19.53%.

Formula for calculating the percentage increase:

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clementsudamara2426@gmail.com[1*]

$$= \frac{\sum X2 - \sum X1}{\sum X1} \times 100\%$$
$$= \frac{410-343}{343} \times 100\%$$
$$= \frac{67}{343} \times 100\% = 19{,}53\%$$

Table 6.
Data Description of the Squad Jump Training Group

No	Name	Hasil Pretest dan Posttest		D (X2-X1)	d (D-MD)	d^2
		X1	X2			
1	Delon	57	61	4	-3,71	13,7641
2	Aziz	52	60	8	0,29	0,0841
3	Boy	69	75	6	-1,71	2,9241
4	Andi	48	65	17	9,29	86,3041
5	Soros	67	70	3	-4,71	22,1841
6	Iky	70	73	3	-4,71	22,1841
7	adit	50	63	13	5,29	27,9841
Jumlah ∑		**413**	**467**	**54**	**0,03**	**175,429**
Rata-rata M		**59,00**	**66,71**			
MD		**7,71**				
Peningkatan		**13,07**				

To calculate the Mean Deviation (MD), the following steps are used:

$| MD | = \frac{\sum D}{N} = \frac{54}{7}$ $| MD | = 7{,}71$

Next, the t-test calculation is continued using the following formula.

$$t = \frac{|MD|}{\sqrt{\frac{\sum d^2}{n(n-1)}}} = \frac{7{,}71}{\sqrt{\frac{175{,}429}{7(7-1)}}} = \frac{7{,}71}{\sqrt{\frac{175{,}429}{7(6)}}} = \frac{7{,}71}{\sqrt{\frac{175{,}429}{42}}}$$
$$= \frac{7{,}71}{\sqrt{4{,}176}} = \frac{7{,}71}{2{,}043} = 3{,}773$$

From the statistical calculation, the t-value for the knee tuck jump training shows an improvement of 3.773. Using a 5% significance level with degrees of freedom d.f = (N – 1) = 7 – 1 = 6, the t-table value obtained is 1.943. This means that the calculated t-value is greater than the t-table value, or 3.773 > 1.943. The improvement between the pre-test and post-test is 54, with a mean deviation of 7.71 and a percentage increase of 13.07%.

Formula for calculating the percentage increase:

$= \frac{\sum X2 - \sum X1}{\sum X1} \times 100\%$
$= \frac{467-413}{413} \times 100\%$
$= \frac{54}{413} \times 100\% = 13{,}07\%$

Discussion

The results of the study showed that both the Squat Jump and the Knee Tuck Jump significantly increased explosive leg muscle power, a crucial physical component in jump-based sports like volleyball. These findings confirm that specifically designed plyometric training interventions can improve athletes' explosive ability through

neuromuscular and biomechanical adaptations relevant to the demands of competitive performance (Markovic & Mikulic, 2019; Ramirez-Campillo et al., 2020).

In the Squat Jump group, the average increase in explosive power was 9.57 cm (19.53%), indicating that this exercise is effective in improving the ability of leg muscles to concentrically contract from a static position. Physiologically, the squat jump minimizes the contribution of the stretch-shortening cycle (SSC), thus requiring rapid maximal force production from the key muscles of the lower extremity, particularly the quadriceps, gluteus maximus, and gastrocnemius (Suchomel et al., 2018). This adaptation aligns with previous research reporting that explosive concentric contraction-based training can increase the rate of force development (RFD), which is crucial in the initial phase of a jump during smashes and blocks (Cormie et al., 2011; Tillaar & Marques, 2013). A t-value greater than the t-table indicates that the squat jump training stimulus is strong enough to produce statistically and practically meaningful performance adaptations.

Meanwhile, the knee tuck jump group also showed a significant increase of 7.71 cm (13.07%). Although the percentage increase was lower than the squat jump, this training emphasizes neuromuscular coordination, movement speed, and the ability to optimally utilize the SSC during the eccentric-concentric phase of the jump. The knee tuck jump demands synchronization between leg muscles, core stability, and mid-air body control, which has been empirically shown to improve jump mechanical efficiency and explosive movement quality (Slimani et al., 2016; Moran et al., 2017). This finding is consistent with studies stating that plyometric training with high amplitude of motion can improve vertical jump performance and neuromuscular responses of volleyball athletes (Stojanović et al., 2017; Chaabene et al., 2019).

The difference in the magnitude of improvement between the two training methods can be explained by the principle of training specificity. Squat jumps emphasize maximal force production from a stable position, while knee tuck jumps emphasize speed, coordination, and body control. In the context of athlete development, these two characteristics are equally important and complementary, given that volleyball performance demands a combination of explosive strength, timing, and movement efficiency (Sheppard et al., 2016; Palao et al., 2018). Therefore, the results of this study reinforce the notion that a variety of plyometric training is necessary to optimize the comprehensive development of leg muscle explosive power.

In addition to improving performance, squat jump and knee tuck jump training also have important implications for injury prevention. Improved leg muscle strength and neuromuscular control contribute to better landing quality, thereby reducing the risk of lower extremity injuries common in volleyball athletes (Hewett et al., 2016; Lloyd et al., 2021). Therefore, these findings are relevant not only for improving performance but also for sustainable and safe athlete development.

Overall, the results of this study align with international literature confirming the effectiveness of plyometric training in increasing leg muscle explosive power. The primary contribution of this study lies in the empirical evidence that two simple,

equipment-free, and easy-to-implement plyometric training forms can still have a significant impact on club-level athletes. This strengthens the scientific basis for developing applicable technical and physical training models, including in the context of developing basic leg serve technique training models in games like Teqball, which also demand leg strength and explosiveness as a foundation for performance.

CONCLUSION

Based on the research results, it can be concluded that plyometric training in the form of Squat Jumps and Knee Tuck Jumps has proven effective in increasing the explosive power of the leg muscles of volleyball athletes at Club Mandala. Empirically, both training methods provided a significant stimulus for improving vertical jump performance, which is a primary indicator of explosive leg ability and plays a crucial role in the execution of smash, block, and serve techniques in volleyball.

Squat Jump training demonstrated a greater increase in explosive power, indicating that this training is effective in developing the ability to produce maximal force quickly through dominant concentric contractions of the leg muscles. This finding confirms that training with a static starting position can increase the neuromuscular capacity required in the initial phase of the jump takeoff. Meanwhile, Knee Tuck Jumps also provided significant increases, albeit at a lower percentage, reflecting their role in improving coordination, movement speed, and the efficiency of the stretch-shortening cycle during explosive activity.

Conceptually, the results of this study strengthen the theory that explosive leg muscle power can be effectively increased through simple, specific, and structured plyometric training. Thus, Squat Jump and Knee Tuck Jump can be recommended as an integral part of the physical conditioning training program for volleyball athletes, especially at the club development level, to support performance improvement as well as sustainable and safe athlete development.

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