



TADULAKO JOURNAL SPORT SCIENCES AND PHYSICAL EDUCATION
PHYSICAL EDUCATION, HEALTH, AND RECREATION STUDY PROGRAM
EDUCATION SCIENCE DEPARTMENT
TADULAKO UNIVERSITY, PALU, INDONESIA
<https://jurnalfkipuntad.com/index.php/tjsspe/index>
E-ISSN 2581-0383 | P-ISSN 2337-4594



SQUAT STYLE LONG JUMP IN JUNIOR HIGH SCHOOL EXTRACURRICULAR ACTIVITIES: THE IMPACT OF BOX JUMP AND DEPTH JUMP PLYOMETRIC TRAINING

***Edgar Nofriyanto Palin¹, Hendra Iskandar², Rivalwan³, Kamarudin⁴**

^{1,2,3,4}Tadulako University, Palu, Indonesia.

Correspondence: nofriantoedgar@gmail.com

Article History: Accepted Auguts 2026, Approved September 2026, Published December 2026

ABSTRAK

The development of neuromuscular coordination and leg muscle explosive power during early adolescence is critical to optimizing horizontal-to-vertical force transition in the long jump. However, evaluating appropriate plyometric modalities to maximize adaptations without causing excessive fatigue remains necessary. This quasi-experimental study with a matching-by-subject design compared the effectiveness of Box Jump and Depth Jump training on improving squat-style long jump performance. Thirty early adolescent athletes (24 males, 6 females; aged 12–15 years) were selected via purposive sampling and assigned to a 6-week intervention (3 sessions/week; 35-cm box height). Data were analyzed using paired-samples and independent-samples t-tests. Both groups showed significant performance improvement within themselves ($p < 0,001$). More importantly, gain score analysis found that Depth Jump training produced significantly larger performance improvement than the Box Jump training ($t(28) = -3,500$, $p = 0,002$, $d = 1,28$), with the average of 0,90 m (23,44%) improvement for Depth Jumps vs. 0,61 m (15,84%) for the Box Jumps group. In summary, Depth Jump training is superior in improving leg muscles explosive strength because of the optimized Stretch Shortening Cycle (SSC) and myotatic reflex during the amortization phase. It is suggested that physical education teachers and coaches should apply Depth Jumps training with controlled drop heights to safely enhance reactive strength in young athletes.

Keyword: Box Jump, Depth Jump, Plyometric, Squat Style Long Jump

OPEN ACCESS  Copyright © 2026 by author/s

INTRODUCTION

Achieving maximum jump distances in squat-style long jump depends on the explosiveness of the ATP-PC anaerobic energy system together with the efficient application of biomechanics in approach and takeoff phases (Mursyidin et al., 2026). The technique is dependent on the mechanical relationship of horizontal approach speed and the vertical force exerted at the takeoff plate (Maheswari & Saputra, 2026). On the touch down, there is conversion of horizontal speed to vertical speed in order to attain a proper take-off angle without losing much kinetic

energy from the short ground contact time (Hasani et al., 2026). This is controlled through the neuromuscular function by regulating joint stiffness and stretch-shortening cycle (SSC) in the lower extremities to ensure optimal force transfer during flight (Henjilito et al., 2024). the implementation of a planned physical conditioning program utilizing natural body movement loading has been proven to optimize athlete performance (Hafidz et al., 2021). Such structured physical training is not only useful for the efficiency of body movement, but it is also instrumental in achieving the success of flight phase execution and landing phase control in the sandpit (Maifa et al., 2024). The challenge of coordinating high-speed take-off with accurate landing control is a common neuromuscular challenge experienced by all early adolescent athletes because of the awkwardness experienced during adolescence a period characterized by fast somatic growth that temporarily disrupts motor control and coordination (Janna et al., 2026).

Empirical facts at SMP Negeri 1 Palu reinforce this issue. Test results on the long jump using the squat-style technique revealed an average jump length of 3.81 meters from the sample size of 30 participants with 63.3% of the total number of participants failing to reach the minimum criterion of 4.00 meters. In the process of testing, most students made some basic technical mistakes, such as poor takeoff strength and unsteady landing due to no coordination of body movements. This happened even though the school had very conducive training facilities. This contradiction reveals a problem in terms of methodology whereby good training facilities do not necessarily mean a good performance of correct techniques. The root cause lies in conventional learning approaches that remain product-oriented, failing to facilitate the neuromuscular adaptations and motor pattern re-conditioning required by adolescent students (Wiarto, 2021).

This condition demonstrates that traditional training methods cannot help maximize the student's abilities, and therefore plyometric training must be implemented. From a physiological perspective, plyometrics involve stretch-shortening cycle reflexes in the muscles of the legs (Gusnelia et al., 2022). The efficiency of such an SSC depends on the decrease in the amortization period, the maximization of passive elastic energy release by the musculotendinous system, and the stimulation of the myotatic reflex due to the activation of muscle spindles (Purba et al., 2026). Specific neuromuscular changes occur as a result of such training due to increasing muscle stiffness, fast-twitch motor units, and stretch reflex sensitivity. This method plays a significant role in young athletes; there is sufficient evidence that maximum explosive strength depends on efficient work of SSC performance and a rapid rate of force development (Arief et al., 2024).

Numerous studies have shown that the application of plyometric exercise variations helps develop explosive power and speed of leg muscles' movements for achieving maximum jump heights through optimum strength capacity (Mardius et al., 2023). Specifically, Depth Jump training effectively enhances explosive strength and take-off precision (Sinuhaji & Salsabila, 2025). whereas Box Jump training makes a significant contribution to vertical propulsive force (Ramadhan et al., 2024). Nevertheless, from a mechanical point of view, both types of exercises have different biomechanical requirements that need to be considered in relation to athlete maturity levels. The Box Jump training involves the generation of concentric force since legs push up the body towards a higher surface, which significantly reduces landing impact and lengthens the energy transfer duration. Conversely, Depth Jump focuses on a rapid and intense eccentric phase upon landing to trigger a high-velocity stretch-shortening cycle (SSC). This mechanism exposes the body to very short ground contact time (<250 ms) and high peak ground reaction force accumulation (Yanti et al., 2021).

Understanding these biomechanical distinctions is especially important in training early adolescents, whose underdeveloped neuromuscular system and immature osteoarticular structures are not able to handle high peak eccentric loads repeatedly. In this particular case, the high repetition of high-impact eccentric loads will lead to early neuromuscular fatigue and poor motor coordination in early adolescents, which makes low-impact variations such as Box Jump a better physiological choice as a basis for building up the propulsive force. While these two types of exercise training are usually considered separately, there is currently no comparative analysis of how the predominance of concentric exercises in Box Jumping and eccentric exercises in Depth

Jumping affects the performance of the early adolescents who experience growth spurts in the context of LTAD. The purpose of this study is to examine the efficiency of Box Jump and Depth Jump training on the performance of squat-style long jump in early adolescents and, at the same time, reveal the mechanism of movement adaptation.

METHOD

The research design for this study includes experimental research design using the Matching by Subject Design approach in which the research pattern follows a two-group pre-test-post-test research pattern (Permana, 2026). This design was selected because the study focuses on directly testing and comparing the effectiveness of Depth Jump and Box Jump training interventions in enhancing students' long jump performance. The application of this design is grounded in considerations regarding the developmental phase of movement coordination, motor control, and lower-limb muscle explosive power in junior high school students undergoing rapid neuromuscular growth. Within this age range, variations in response to plyometric training loads are highly influenced by baseline physical readiness. Thus, it is necessary to control the initial conditions of the subjects through the use of Ordinal Pairing method in AB-BA design according to the pre-test distance achieved during the squat-style long jump of each subject for ensuring the statistical equality of the variances in terms of capability at the baseline of both the groups (Asmawi et al., 2024). The process provides two groups with equal initial capabilities. From these groups, the subjects are assigned to Experimental Group 1 and Experimental Group 2, receiving Depth Jump training (Tanious & Manolov, 2025).

The study population encompassed all students who engaged in co-curricular activities at SMP Negeri 1 Palu. Thirty subjects consisting of 24 males and 6 females were chosen through a purposeful sampling method using criteria that matched the research objectives (Ramadani et al., 2025). The inclusion criteria were: 1) students actively registered in extracurricular activities at SMP Negeri 1 Palu, 2) age between 12 and 15 years old, 3) physically healthy and free from injury, and 4) willing to undergo the entire series of training programs and measurements. Baseline anthropometric characteristics—including height, weight, Body Mass Index (BMI), and estimated biological maturation status (Peak Height Velocity / PHV)—were measured and recorded prior to testing. Data collection was conducted on the school field to objectively measure physical condition and reflexive explosive power (Nurafiati et al., 2025).

The research procedures were systematically and structurally arranged as illustrated in the research procedure flowchart (Figure 1). All physical testing (pre-test and post-test) required a total duration of two days, directly supervised by a certified testing team in physical conditioning and sports assessment. To ensure that there is no impact from acute fatigue, the pre-test was done two days before the onset of the intervention session. After the completion of six weeks of the training, a recovery period of two days was observed before performing the post-test. In view of the fact that the plyometric intervention involves a very high impact for the subjects aged between 12 and 15 years, this research received approval from an ethics committee as well as informed consent forms signed by the participants' parents or guardians before data collection initiated.

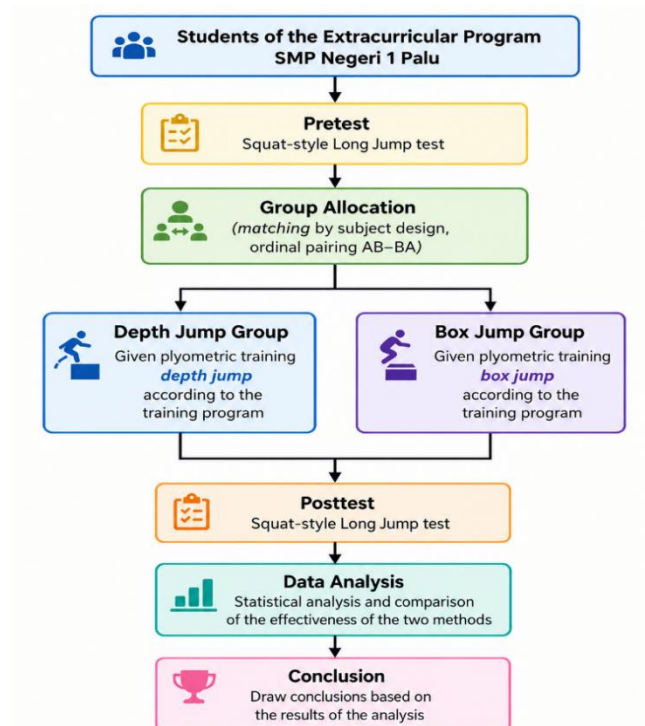


Figure 1, Research Procedure Flowchart

The plyometric training intervention program was conducted over a period of 6 weeks, with an intensity of 3 sessions weekly (Monday, Wednesday, and Friday) to ensure an adequate recovery period of at least 48 hours between each training session. The plyometric training dosage and protocol for both experimental groups was set to be equal and standardized in regard to the frequency of training, number of sets, repetitions, rest time, and box height. That way, the internal validity of the experiment was ensured, so that any variations in performance would depend only on the difference in biomechanics of the Box Jump and Depth Jump exercises. Progression was performed through the control of training volume. The box height was fixed at 35 cm; it was used as the target height for Box Jumps and as a drop height for Depth Jumps. The training periodization protocol is described in Table 1.

Week	Day / Session	Sets	Repetitions	Rest
1	Monday, Wednesday, Friday	3	10	40 seconds
2	Monday, Wednesday, Friday	3	10	40 seconds
3	Monday, Wednesday, Friday	5	10	40 seconds
4	Monday, Wednesday, Friday	5	10	40 seconds
5	Monday, Wednesday, Friday	5	10	40 seconds
6	Monday, Wednesday, Friday	4	10	40 seconds

Table 1, Training design

Data collection involved the use of the squat-style long jump test to assess horizontal explosive power and jump distance. The device was chosen because it is an objective physical performance test with measurement methods that are well suited for the physical attributes of teenagers. Before conducting tests on the subjects, a standardized warm-up period of 15 minutes - involving sub maximal dynamic stretching exercises, lower-extremity activation drills, and gradually increasing jumping practice - was carried out in order to maximize neuromuscular readiness without using passive static stretching, which could lead to decreased force production. Jump distance was determined from the outer edge of the take-off board to the closest point on

the sandpit marked using a standardized fiberglass measuring tape. In order to reduce errors that may result from the elasticity of the tape, the tape was drawn continuously at standardized tension. To reduce experimenter's bias and parallax error, measurements were conducted in a single-blinded test setting by certified independent testers unaware of group assignments. Furthermore, each jump performance was independently verified by two assessors to ensure measurement precision, validity, and reliability during both pre-test and post-test administrations.

The test procedure began with the assembly of all participants for an orientation session that covered the technical rules and procedures associated with the squat style long jump test. After the orientation, the subjects were made to conduct a warm up session lasting 10 to 15 minutes before conducting the test. The participants were then called one by one to conduct two test attempts during pre and post-test occasions. The assessment criteria used to measure performance was the longest jump distance from the take-off line to the nearest body impression left in the sandpit relative to the take-off line. Stepping on or over the take-off line resulted in an invalid trial scored as 0 (zero). Of the two attempts provided, the highest score was recorded as the primary explosive jump performance outcome.

Data collected from pre-test and post-test were analyzed using descriptive and inferential statistics through the use of IBM SPSS software. Descriptive analysis was used in order to get an overall idea about the data in terms of mean, standard deviation, maximum scores, and minimum scores in each treatment group. Later on, the test of analysis assumptions was carried out that consisted of normality testing through the Shapiro-Wilk test in order to check data distribution and homogeneity testing through Levene's test in order to verify variance equality in each group. In case if the data satisfied normality and homogeneity assumptions, performance improvement in each group was determined by means of the Paired Sample t-Test while relative effectiveness of plyometric depth jump and box jump training was evaluated through the use of Independent Sample t-Test. Otherwise, analysis was performed using non-parametric tests: Wilcoxon Signed Rank Test and Mann-Whitney U Test.

RESULTS

Baseline anthropometric characteristics including body height, weight, BMI, sitting height, leg length, and biological maturation status (PHV)—were measured prior to testing (Table 2),

Variable	Mean $\pm$ SD	Min – Max
Age (Years)	13,10 $\pm$ 0,80	12,00 – 14,00
Height (cm)	156,63 $\pm$ 9,14	139,00 – 169,00
Weight (kg)	48,40 $\pm$ 7,02	34,00 – 59,00
Body Mass Index (kg/m ²)	19,59 $\pm$ 1,57	17,60 – 20,66
Sitting Height (cm)	81,50 $\pm$ 4,35	73,00 – 87,00
Leg Length (cm)	75,13 $\pm$ 4,82	66,00 – 82,00

Table 2, Subject Baseline Anthropometric Characteristics (N = 30)

This research involved comparing the efficacy of the Depth Jump training (n=15) and the Box Jump training (n=15) methods on the improvement of the long jump skill using the squat technique by extracurricular students of SMP Negeri 1 Palu. A numerical summary of the data for the Box Jump training participants is shown in Table 3.

	Minimum Value	Maximum Value	Total Distance	SD	Mean Average	Mean Increase	Percentage Increase
(Pre-test)	3,21	4,47	57,69	0,41	3,85		
(Post-test)	4,14	4,94	66,89	0,25	4,46	0,61	15,84%

Table 3, Box Jump Training Group

Based on Table 3, the Box jump training group recorded a pre-test mean of 3.85 meters (SD = 0,41), with a minimum value of 3,21 meters, a maximum value of 4,47 meters, and a total distance of 57,69 meters. In the post-test, the mean increased to 4,46 meters (SD = 0,25), with a where the minimum was 4.14 meters, the maximum was 4.94 meters, and the total distance was 66.89 meters. The overall Box Jump training program had a mean improvement of 0.61 meters, which is 15.84% improvement. Furthermore, a summary of the pre-test and post-test measurement results for the Depth jump training group is presented in Table 4,

	Minimum Value	Maximum Value	Total Distance	SD	Mean Average	Mean Increase	Percentage Increase
(Pre-test)	3,17	4,40	57,56	0,41	3,84		
(Post-test)	4,21	5,56	73,33	0,35	4,74	0,90	23,44%

Table 4, Depth Jump Training Group

Based on Table 4, the Depth Jump training group recorded a pre-test mean of 3,84 meters, with a minimum value of 3,17 meters, a maximum value of 4,40 meters, and a total distance of 57,56 meters. In the post-test, the average distance covered by the subjects increased to 4,74 meters with a minimum of 4,21 meters and a maximum of 5,56 meters. In general, the Depth Jump training produced a mean gain of 0,90 meters, that is equal to a 23,44% improvement. The visual representation of the performance improvement of the two treatment groups can be seen in Figure 2.

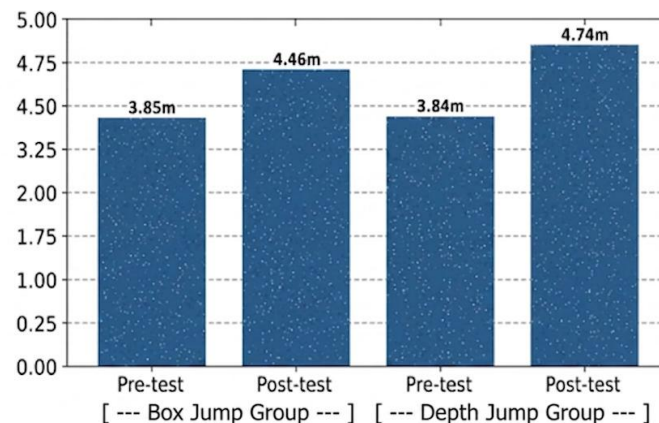


Figure 2, Comparison Graph of Pre-test and Post-test Average Achievements for Box Jump and Depth Jump Groups

Before the application of the hypothesis testing process, the data was subjected to preconditions' tests such as tests for normality and homogeneity of variance. The results of the test of the distribution of the data for normality via Shapiro-Wilk are presented in Table 5 below.

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
Pre-test box	0,152	15	,200*	0,935	15	0,326
Pre-test depth	0,153	15	,200*	0,930	15	0,271
Post - test box	0,159	15	,200*	0,919	15	0,186
Post - test depth	0,208	15	0,081*	0,927	15	0,244

Table 5, Results of Data Distribution Normality Test (Shapiro-Wilk)

Based on Table 5, all research variables have significance (p -value) greater than 0,05. In the Box Jump group, p -values of 0,326 for the pre-test and 0,186 for the post-test were obtained.

In the Depth Jump group, p -values of 0,271 for the pre-test and 0,244 for the post-test were obtained based on the Shapiro-Wilk test. These results indicate that the data for both groups, including the pre-test and post-test measurements, are normally distributed. Furthermore, the results of the homogeneity of variance test for the pre-test data are presented in Table 6,

Variable	Mean	Df1	Df2	Sig
Pre-test box	3,8587	1	28	0,772
Pre-test depth	3,8247	1	28	

Table 6, Homogeneity Test Results

Based on Table 6, the pre-test significance value was 0,772 ($p > 0,05$), proving that the data variance is homogeneous. As all parametric assumptions were met, the hypotheses were tested using parametric tests.

The first hypothesis testing regarding the effect of box jump training was analyzed using a paired-samples t -test, with the results presented in Table 7.

Variable	Mean	t-test For Equality of means		
		t-statistic	t-table	Sig
Pre-test	3,85	9,087	2,145	0,000
Post-test	4,46			0,000

Table 7, Hypothesis Testing Results for box Jump Training

Based on Table 7, a t -statistic value of 9,087 was obtained at 14 degrees of freedom ($df = 14$) with a significance value of $p = 0,000$ ($p < 0,05$). These results indicate a significant effect of Box Jump training on squat-style long jump performance. The second hypothesis testing regarding the effect of Depth jump training is presented in Table 8.

Variable	Mean	t-test For Equality of means		
		t-statistic	t-table	Sig
Pre-test	3,84	12,092	2,145	0,000
Post-test	4,74			0,000

Table 8, Hypothesis Testing Results for Depth Jump Training

Based on Table 8, a t -statistic value of 12,092 was obtained at 14 degrees of freedom ($df = 14$) with a significance value of $p = 0,000$. These results confirm that Depth Jump training has a significant effect on improving squat-style long jump performance. Testing of the third hypothesis, conducted to compare the difference in gain score effectiveness between the two groups, was analyzed using an independent-samples t -test, as summarized in Table 9,

Group	Mean	%	t-test For Equality of means		
			t-statistic	t-table	Sig
Box jump	0,61	15,84%	-3,500	2,048	0,02
Depth jump	0,90	23,44%			

Table 9, Gain Score Difference Test Results

Based on Table 9, the mean gain score difference test yielded a t -statistic value of -3,500 at $df = 28$ with a significance value of $p = 0,002$. From the statistical findings above, there is a statistically significant difference in effectiveness of the two training programs; the Depth Jump had a greater mean increase (0,90 meters / 23,44%) than the Box Jump (0,61 meters / 15,84%).

DISCUSSION

These findings demonstrate a significant improvement in squat-style long jump performance following Box Jump and Depth Jump plyometric training in adolescent students. These results can be attributed to functional changes that have been brought about by optimal recruitment of motor units. In teenagers, plyometric training leads to an increase in the frequency of action potentials in motor neurons, synchronization of motor units, and the recruitment of fast-twitch muscles. Plyometric training therefore increases power output in these athletes without muscle hypertrophy. Also, this type of training improves kinetic chain efficiency. Energy flow is through triple extension which includes plantar flexion of the ankle joint, knee extension, and hip extension. This proximal-to-distal transfer maximizes ground reaction force (GRF) to optimize propulsion during the take-off phase.

The difference between the mean improvement suggests that the Depth Jump training played a more significant role compared to the Box Jump training in improving long jump performance among early adolescents. Biologically speaking, early adolescents possess less passive tendon stiffness and sub-optimal motor unit synchronicity in contrast to adults, limiting their innate capability to harness elastic energy in rapid stretch-shortening cycle (SSC) exercises. Exercises such as the Box Jump fail to offer adequate eccentric muscle loading that would induce mechanical adaptations on the tendon level. On the other hand, Depth Jump training involves an eccentric pre-load mechanism that provides mechanical tension to promote long term adaptation in terms of improved passive tendon stiffness and Rate of Force Development (RFD). This high-intensity eccentric stimulus trains neuromuscular coordination to absorb and optimize ground reaction forces (GRFs), thereby improving SSC efficiency and converting landing forces into explosive horizontal propulsion more effectively.

The findings of this study are reinforced by research demonstrating that Depth Jump training yields greater improvements in lower-limb explosive power compared to Box Jump training (Athifah et al., 2026). These results align with findings from a systematic review and meta-analysis proving that stretch-shortening cycle (SSC)-based plyometric interventions are highly effective in enhancing physical performance in growing populations (Santos et al., 2024). Neurophysiologically, the superior effectiveness of the Depth Jump is associated with the efficiency of amortization phase duration. In the case of Box Jumps, the movement does not contain any eccentric deceleration and consists only of pure upward concentric propulsion. In this case, the lack of eccentric pre-stretching increases the coupling time between eccentric and concentric actions, which makes it less efficient in using the stretch reflex. On the contrary, Depth Jump training contains specific eccentric loading that allows for efficient reduction of the amortization phase duration. While the early adolescents do not have the mature enough tendon stiffness, such eccentric training helps to train proper neuromuscular control over GRF absorption and converting it efficiently into a more explosive propulsive force.

On the other hand, these findings are consistent with research demonstrating that repeated plyometric interventions significantly enhance lower-limb propulsive capacity (Insanistyo et al., 2024). Specifically, ground contact time efficiency is a primary mechanical determinant in maximizing kinetic energy transfer during take-off (Anwar, 2025). The important role of Depth Jump exercise can be explained by optimizing the mechanism of the Stretch Shorten Cycle, which involves quick eccentric landing (pre-stretch) immediately followed by concentric contraction. This SSC mechanism is often disturbed among young adolescent participants due to the failure to perform a transition from landing to take-off.

This condition is caused by low tendon stiffness and immature neuromuscular control at this age, resulting in passive elastic energy being dissipated as heat due to prolonged ground contact time. The Depth Jump training modality directly helps address the failure in the transition of adolescent athletes through eccentric loading, which leads to the onset of the stretch reflex and reduction of the amortization period. This mechanical modification enables the adolescent athlete

to utilize the impact forces and move quickly into maximal power production from the take-off board of the squat-style long jump.

Motorically, regular plyometric training improves neuromuscular coordination and motor unit synchronization to accelerate the formation of motor programs for take-off (Ramirez-Campillo et al., 2022), aligning with (Tafuy et al., 2025) regarding the automatization of movement patterns. This adaptation can be seen from the results obtained quantitatively, where the gain score for the Depth Jump was 0,90 m (23,44%), whereas for the Box Jump group, it was 0,61 m (15,84%), with an average difference of 0,29 m. On a physiological level, the advantage of the Depth Jump is explained by the mechanical stress in the drop-landing that activates the muscle spindles and spinal reflex pathway efficiency. Plyometric loads optimize spinal motoneuron signaling—shortening the amortization phase—while regulating agonist-antagonist muscle co-activation (quadriceps-hamstrings). This optimization maintains dynamic knee joint stability and stiffness while preventing excessive internal resistance, thereby maximizing propulsion against the take-off board, stabilizing motor programs, and increasing jump distance.

The differentiating factor in the efficacy of these two training strategies is due to biological and neuromuscular properties of 12-15 years old students who are going through the circumpubertal stage near Peak Height Velocity (PHV). Based on the Long-Term Athlete Development (LTAD) stages in accordance with Lloyd & Oliver, this particular age bracket is categorized in the “Training to Train” phase. In this period, because of the combination of high neural plasticity and the production of anabolic hormones, the neuromuscular system is very sensitive to plyometric loading. While limb growth near PHV can negatively affect motor skill performance, the Depth Jump strategy utilizes this period of neural adaptability for effective eccentric force absorption and concentric force production for stabilization of take-off technique.

Depth Jump training proves to provide higher effectiveness because it requires precise kinetic chain integration, ranging from landing, knee and ankle joint stabilization, to rapid forward-upward take-off. The high eccentric load in this exercise provides optimal stimulation to accelerate neuromuscular maturation and increase stretch-shortening cycle (SSC) efficiency. Conversely, the Box Jump has lower landing complexity and focuses solely on initial acceleration, thereby offering insufficient biomechanical challenges to maximize jumping performance improvements. The main contribution of this study is the discovery of adaptation threshold and qualification for plyometric training in junior high school extracurricular athletes. While the training curriculum is generally carried out using the plyometric approach in a general way, the outcomes obtained from this study indicate that the complexity of landing loads is a more efficient adaptive process. From a theoretical perspective, this study fills the research gap in terms of the biomechanics of early adolescents at the regional level (SMP Negeri 1 Palu). The results obtained clearly indicate that the use of reactive strength approaches involving eccentric loads (Depth Jump) is more efficient than explosive power approaches involving concentric loads (Box Jump).
Limitations:

This study has several limitations that must be considered when interpreting the results:

1. Sample Scope: The limited sample size and selection of students belonging to an extracurricular group of just one school limit the applicability of results to the larger population of young athletes.
2. Measurement Indicators: Performance evaluation was measured solely based on final jump landing distance without assessing other biomechanical indicators such as knee joint speed, ground reaction force, and contact time.
3. Biological Variable Controls: Growth variables such as biological maturation, body mass index, and physical activity apart from extracurricular sessions were not controlled even though they could affect motor adaptation in students.

Practical Implications:

The implications of the current research demonstrate the possibility for coaches and physical education instructors to achieve the highest possible biological adaptation to eccentric

stimuli in young athletes. On a practical basis, training methods for secondary school students can incorporate the Depth Jump technique to improve reactive explosive strength a precise landing control, rather than relying solely on Box Jump exercises.

For future research, it is recommended to:

1. Involve larger and more diverse samples from multiple schools and integrate a control group.
2. Utilize advanced performance analysis technology, such as wearable sensors, high-speed video cameras, and force plates, to objectively record force dynamics and angular kinematics.
3. The study of the long-term effects of training in order to measure the sustainability of jumping ability adaptations after the end of the experiment period.

CONCLUSION

Based on the results of the data analysis, both Depth Jump and Box Jump plyometric exercises significantly contributed to improving squat style long jump in junior high school jumpers (early adolescents). Nevertheless, Depth Jump exercise yielded a significantly higher improvement in performance (23,44% / 0,90 m) than Box Jump exercise (15,84% / 0,61 m). The results suggest that in early adolescents aged 12–15 years, the measured eccentric load in Depth Jump is more efficient in stimulating the adaptation of muscles in the lower limbs to the explosive strength of SSC mechanism than the concentric-dominant propulsion in Box Jump.

On the other hand, Depth Jump training offers an immensely significant functional contribution towards optimizing the fast Stretch-Shortening Cycle (SSC) mechanism and eccentric load adaptations through amortization stage (box drop landing). Practical considerations of the current study highlight the significance of introducing training programs that focus on eccentric strength development among physical education teachers and sport coaches. Depth Jump training should be implemented as the top priority technique in order to enhance significantly the muscle power and performance in squat style long jump exercises of the lower limb muscles. Yet, in order to utilize Depth Jump technique effectively and safely among early adolescents, it is suggested for coaches to adjust quantitatively the drop box height and ensure athletes possess stable landing control prior to increasing training intensity.

BIBLIOGRAPHY

- Anwar, N. I. A. (2025). Tinjauan Literatur: Adaptasi Fisiologis terhadap Model Latihan pada Cabang Olahraga Daya Tahan dan Kekuatan. *Jurnal Dunia Pendidikan*, 5(6), 2678–2688. <https://doi.org/10.55081/jurdip.v5i6.4097>
- Arief, M. Q. A., Izzuddin, D. A., & Wijaya, H. H. (2024). Efektifitas Gerakan Vertical Jump terhadap Daya Ledak Atlet SSB Kancil Mas Karawang. *Indonesian Journal of Kinanthropology (IJOK)*, 4(2), 43–47. <https://doi.org/10.26740/ijok.v4n2.p43-47>
- Asmawi, M., Dewi, P. C. P., Or, M., & Pradityana, K. (2024). *Metodologi penelitian dalam pendidikan dan olahraga*. PT. Media Penerbit Indonesia.
- Athifah, Z. S., Iskandar, M. I., & Haprabu, E. S. (2026). Perbedaan Pengaruh Latihan Plyometric Box Jump dan Depth Jump terhadap Peningkatan Power Otot Tungkai Atlet Bolavoli. *SPRINTER: Jurnal Ilmu Olahraga*, 7(2), 754–762. <https://doi.org/10.46838/spr.v7i2.1182>
- Gusnelia, S., Hermanzoni, H., Umar, U., & Setiawan, Y. (2022). Pengaruh Latihan Pliometrik Terhadap Peningkatan Daya Ledak Otot Tungkai Atlet Taekwondo Dojang Kodim 03/04 Agam Bukittinggi. *Jurnal Patriot*, 4(1), 81–94. <https://doi.org/10.24036/patriot.v4i1.793>

- Hafidz, I. A., Syafei, M. M., & Afrinaldi, R. (2021). Survei pengetahuan siswa terhadap pembelajaran atletik nomor lompat jauh di SMAN 1 Rengasdengklok. *Jurnal Literasi Olahraga*, 2(2), 104–109. <https://doi.org/10.35706/jlo.v2i2.4637>
- Hasani, A. B. N., Mubarak, M. F., & Pinem, S. (2026). PENGARUH LATIHAN VERTICAL JUMP TERHADAP PENINGKATAN POWER OTOT QUADRICEPS PADA ATLET LOMPAT JAUH. *Jurnal Ilmiah Spirit*, 26(2), 251–262. <https://doi.org/10.36728/v26i2.6559>
- Henjilito, R., Widianoro, D., Makorohim, M. F., Zikri, I., & Maulana, I. (2024). Penerapan Teknik Dasar Lompat Jauh Melalui Psikologi. *Journal Of Human And Education (JAHE)*, 4(1), 57–62. <https://doi.org/10.31004/jh.v4i1.538>
- Insanistyo, B., Alamsyah, Y., Nopiyanto, Y. E., & Prabowo, A. (2024). Latihan Pliometrik Depth Jump Terhadap Power Otot Tungkai Pada Peserta Ekstrakurikuler Bola Voli. *STAMINA*, 7(1), 37–43. <https://doi.org/10.24036/jst.v7i1.1244>
- Janna, M., Al Mufarid, A. M. R., & Alfarizi, M. R. (2026). STUDI PENDAHULUAN ANALISIS KINEMATIK LATIHAN INTI SEBAGAI BASELINE BIOMEKANIKA ANAK PRA-REMAJA. *Jambura Journal of Sports Coaching*, 8(2), 166–178. <https://doi.org/10.37311/jjsc.v8i2.40183>
- Maheswari, D. L., & Saputra, S. A. (2026). Penggunaan Media Pendaratan Modifikasi untuk Mendukung Pembelajaran Lompat Jauh Siswa Kelas VIII A di SMPN 9 Malang. *Jurnal Terapan Pendidikan Dasar Dan Menengah*, 6(2), 295–300. <https://doi.org/10.28926/jtpdm.v6i2.1919>
- Maifa, S., Segarani, B. G. G., Halimatussa’diah, H., Rokyi, L. S., Akmal, L., Kurniawan, M. H., Jayadi, M. K., & Apriliana, M. (2024). Analisis power otot tungkai dan kecepatan lari terhadap kemampuan lompat jauh. *Jurnal Porkes*, 7(1), 595–605. <https://doi.org/10.29408/porkes.v7i1.25973>
- Mardius, A., Astuti, Y., & Kibadra, K. (2023). Korelasi Antara Daya Ledak Otot Ekstremitas dan Hasil Tolak Peluru Gaya O’Brein. *Jurnal Pelita Ilmu Pendidikan (JPIP)*, 1(2), 37–43. <https://doi.org/10.69688/jpip.v1i2.13>
- Mursyidin, A., Nur, A., Astriananta, F., Febriansyah, I., Iksan, M., & Sulpadli, M. (2026). ANALISIS BIOMEKANIKA GERAKAN LOMPAT JAUH SEBAGAI UPAYA MENINGKATKAN HASIL BELAJAR PJOK KELAS VI (ENAM) SD NENGRI 207 LEMO LEMO. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, 12(02), 234–244. <https://doi.org/10.36989/didaktik.v12i02.16294>
- Nurafiati, S., Anwar, N. I. A., Hanafi, S., & Latuheru, R. V. (2025). Pelatihan Pengukuran Komponen Fisik untuk Meningkatkan Performa Lompat Jauh di SMA Hang Tuah Makassar. *Jurnal Bina Pengabdian Kepada Masyarakat*, 5(2), 247–258. <https://doi.org/10.55081/jbpkm.v5i2.4126>
- Permana, R. (2026). Riset Eksperimen dalam Keolahragaan. *Tangguh Denara Jaya Publisher*.
- Purba, A. J. A. W., Nainggolan, A. P., & Barus, J. B. N. B. (2026). Pengaruh Latihan Plyometric terhadap Kemampuan Lompat Jauh Gaya Jongkok di Kelas X SMA Negeri 1 Tiganderket. *Lencana: Jurnal Inovasi Ilmu Pendidikan*, 4(3), 79–91. <https://doi.org/10.55606/lencana.v4i3.6223>

- Ramadani, U. P., Muthmainnah, R., Ulhilma, N., Wazabirah, A., Hidayatullah, R., & Harmonedi, H. (2025). Strategi Penentuan Populasi dan Sampel dalam Penelitian Pendidikan: Antara Validitas dan Representativitas. *QOSIM: Jurnal Pendidikan Sosial & Humaniora*, 3(2), 574–585. <https://doi.org/10.61104/jq.v3i2.1021>
- Ramadhan, R. T., Risma, R., & Nurzaman, M. (2024). Pengaruh Latihan Box Jump dan Naik Turun Tangga Terhadap Power Otot Tungkai. *Jurnal Keolahragaan*, 10(3), 197–205. <https://doi.org/10.25157/jkor.v10i3.20430>
- Ramirez-Campillo, R., Perez-Castilla, A., Thapa, R. K., Afonso, J., Clemente, F. M., Colado, J. C., de Villarreal, E. S., & Chaabene, H. (2022). Effects of plyometric jump training on measures of physical fitness and sport-specific performance of water sports athletes: a systematic review with meta-analysis. *Sports Medicine-Open*, 8(1), 108. <https://doi.org/10.17605/OSF.IO/NWHS3>
- Santos, S. C. R., Oliveira, A. R., Costa, R. A., Nascimento, K. S. B., Alvares, P. D., Medeiros, F. B., Assumpção, C. O., Ramos, G. P., Banja, T., & Veneroso, C. E. (2024). Stretch-shortening cycle utilization in female and male soccer players: A systematic review. *The Journal of Strength & Conditioning Research*, 38(10), e600–e625. <https://doi.org/10.1519/JSC.0000000000004904>
- Sinuhaji, S., & Salsabila, A. (2025). The Comparison of the Effect of Plyometric Depth Jump Exercise and Plyometric Box Jump Exercise on the Improvement of Leg Muscle Strength in Diamond Volleyball Athletes of Medan in 2024. *JURNAL KEPERAWATAN DAN FISIOTERAPI (JKF)*, 7(2), 236–244. <https://doi.org/10.35451/jkf.v7i2.2639>
- Tafuy, A. Y., Nubatonis, S., Dawi, F. K., Seran, Y. A. M., Indu, N. A. Y., Liunokas, O., & Lassi, A. (2025). Latihan Plyometrik untuk Meningkatkan Lompatan Smash Tim Voli Putra Institut Pendidikan Soe. *ABDI UNISAP: Jurnal Pengabdian Kepada Masyarakat*, 3(2), 238–242. <https://doi.org/10.59632/abdiunisap.v3i2.485>
- Tanious, R., & Manolov, R. (2025). Visual analysis of single-case experimental designs data: Beyond time-series graphs. *Single Case in the Social Sciences*, 2(1), 43–64. <https://doi.org/10.15763/issn.1936-9298.2025.2.1.43-64>
- Wiarto, G. (2021). *Dasar-dasar kepelatihan olahraga*. Guepedia.
- Yanti, F. J., Sugihartono, T., & Nopiyanto, Y. E. (2021). Pengaruh Latihan Depth Jump dan Jump to Box Terhadap Power Otot Tungkai Pada Siswa MA Muslim Cendikia Bengkulu tengah. *SPORT GYMNASTICS: Jurnal Ilmiah Pendidikan Jasmani*, 2(1), 24–33. <https://doi.org/10.33369/gymnastics.v2i1.14725>