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The Role of Plyometric Training in Optimizing Strength and Agility

Teguh Satria[1]✉, Anjario Ardiyan[2]✉

Program Studi Pendidikan Jasmani, Universitas Cipasung Tasikmalaya, Jawa Barat, Indonesia[12]

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Abstract

This study aims to examine the effectiveness of plyometric training in improving strength and agility, as well as to compare the extent to which plyometric exercises are more effective than conventional training methods. The research employed an experimental approach designed to identify causal relationships between the treatment and the measured outcomes. The study utilized a Pretest Posttest One Group Design, in which measurements were conducted both before and after the intervention. The research sample comprised 20 students actively participating in the volleyball extracurricular program. The research instruments included a leg dynamometer to assess lower-limb muscle strength and a zig-zag test to evaluate participants' agility levels. The findings revealed significant differences between the pretest and posttest results for both dependent variables strength and agility. The obtained significance value of 0.000 ($p < 0.05$) indicates that the implemented training programs, namely the box drill and flog jump exercises, had a substantial impact on enhancing the participants' physical performance. Therefore, it can be concluded that plyometric training has a positive influence and statistical impact on increasing strength and agility. Overall, this study reaffirms that plyometric training is an effective and efficient method for enhancing physical capabilities, making it highly recommended for inclusion in athletic conditioning and performance development programs.

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✉ Correspondence address :
E-mail: teguhsatria@uncip.ac.id ; anjarioardiyan34@gmail.com

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INTRODUCTION

Sports can be understood as a structured form of physical activity that engages movements of the entire body with the fundamental objective of enhancing physical fitness and well-being (Haris et al. 2025). A sedentary lifestyle, or lack of physical activity, has been identified as the fourth leading global risk factor contributing to premature mortality (Artiluhung and Yulianto 2025). Within the sphere of physical education, sports hold a vital function in shaping individuals who possess both high competence and strong character (Risyanto and Yulianto 2025). In contemporary times, sports are no longer confined merely to the pursuit of health and fitness. They have evolved into competitive and professional domains where individuals undergo systematic training processes aimed at achieving excellence and distinction in specific sporting disciplines (Rusandi et al. 2025).

Exercise, as a subset of physical activity, elicits beneficial physiological adaptations within the human body (Mudzakir et al. 2025). It can be characterized as a deliberate and organized effort to enhance athletic capability through the integration of theoretical frameworks, practical applications, methodological procedures, and implementation principles that are scientifically structured and goal-oriented. Emphasizes that effective training must be executed regularly, methodically, and repetitively, with a gradual and progressive increase in workload over time (Yulianto, Marsuna, and Azizah 2025). The incorporation of training load serves as a defining feature of an effective exercise regimen, grounded in the concepts of practice, exercise, and training (Yulianto, Triansyah, and Azizah 2025). Essentially, the training load represents a modifiable motor stimulus, regulated by athletes or coaches, to optimize the performance of various bodily systems (Bedoya, Miltenberger, and Lopez 2015).

Physical attributes such as flexibility, muscular strength, agility, speed, and endurance can be progressively developed through consistent participation in sports activities (Rocamora et al. 2019). The physical condition of an individual is an inherent trait and constitutes a critical foundation for the enhancement of athletic performance (Bompa and Buzzichelli 2021). Strength is described as the capacity of a muscle or group of muscles to exert maximal force during a single contraction or maximal effort (Ali et al. 2016). Muscular strength is generally defined as the capability of a muscle or a group of muscles to exert force in overcoming external resistance or loads (Haqiyah et al. 2017).

In contrast, agility refers to the ability to change direction quickly and efficiently while maintaining speed and control. It constitutes a vital element of physical fitness and plays a crucial role across various sporting disciplines (Muthiarani, Lismadiana, and Yuniana 2021). Agility can also be described as the body's ability to move swiftly while preserving postural stability. Moreover, it encompasses the capacity to adjust body position rapidly and powerfully without compromising balance, thereby supporting efficient and coordinated movement performance (Satria, Subarjah, and Kardjono 2019).

Plyometric training, on the other hand, is characterized as a training method that involves repetitive, high-intensity movements integrating both speed and strength to produce explosive muscular contractions (Satria 2015). This type of exercise is particularly beneficial for individuals who already possess a good physical foundation, especially athletes, as it enhances muscular power, speed, and vertical jump performance (Ramirez-Campillo et al. 2022). Plyometric exercises are structured to maximize muscular output within a short time frame through the utilization of isometric contractions and stretch shortening cycles (Nugraha and Iskandar 2024).

One of the distinct advantages of plyometric training lies in its reliance on the forces generated through body acceleration against gravitational resistance (Bedoya, Miltenberger, and Lopez 2015). This principle enables plyometric movements to be effectively incorporated into various sports actions such as jumping, sprinting, and throwing more dynamically than traditional resistance training methods (Suhendra, Satria, and Nur, 2020.). Consequently, plyometric exercises are recognized for their dynamic and explosive characteristics, substantially contributing to improvements in overall physical performance and athletic capability (Satria 2018).

Therefore, this study aims to analyze the effectiveness of plyometric training in enhancing both strength and agility. Furthermore, it seeks to compare the relative effectiveness of plyometric training with conventional training methods to identify the most efficient approach for improving physical performance.

The study was conducted on extracurricular volleyball students at State Madrasah Aliyah (religious-based senior high school) 2 Tasikmalaya, a relatively rare subject. Most previous studies have focused on professional athletes or physical education students. The use of two specific plyometric exercises-box drills and frog jumps-in

a single structured program has rarely been the primary combination in previous studies. Research typically examines only one type of exercise. While many studies separate strength and agility variables, this article assesses these two key motor performance variables simultaneously using standardized measurement tools (leg dynamometer and zigzag test). The results are relevant for high school Physical Education teachers and coaches, not just academics or elite athletes, providing practical recommendations for improving student performance.

METHODS

This study adopted a quantitative approach aimed at identifying causal relationships between variables, particularly to evaluate the effectiveness of a specific treatment on measurable outcomes. The research employed a Pretest–Posttest One Group Design, in which participants were assessed twice before (pretest) and after (posttest) the intervention. This design enables researchers to compare participants' conditions prior to and following the treatment, thereby providing a clearer picture of the intervention's impact (Sugiyono 2013).

The plyometric training program applied in this study consisted of two main exercises: the box drill and the frog jump. These activities were conducted three times per week throughout the intervention period. The research sample comprised 20 students actively participating in the volleyball extracurricular program at State Madrasah Aliyah (religious-based senior high school) 2 Tasikmalaya. A total sampling technique was used, meaning that all eligible participants who met the inclusion criteria namely, active volleyball extracurricular members were included in the study.

To assess the study variables, two standardized instruments were utilized. Lower-limb strength was measured using a leg dynamometer, while agility was evaluated through the zig-zag run test. Both instruments were chosen for their established validity and reliability in measuring key aspects of physical performance relevant to this study.

Data analysis was carried out in three main stages. The first stage involved descriptive analysis to provide an overview of the data distribution, including the calculation of the mean (average) and standard deviation, which indicate central tendency and variability within the dataset. When the data were organized into grouped frequency distributions, calculations were performed following grouped distribution formulas (Marsden and Torgerson 2012). The second stage involved variance analysis to determine data variability through the squared value of the standard deviation. Finally, assumption testing was conducted, comprising normality and homogeneity tests to ensure that the dataset met the statistical requirements for further analysis. The homogeneity test, in particular, was essential to verify the consistency of variances across samples, both in small and large groups (Marsden and Torgerson 2012).

RESULTS AND DISCUSSION

Table 1 and **Table 2** summarize the findings of a study involving 20 students who took part in the volleyball extracurricular program at State Madrasah Aliyah (religious-based senior high school) 2 Tasikmalaya. The research evaluated each participant's lower-limb muscle strength and agility levels both before and after the implementation of the box drill and frog jump training programs.

Table 1. Leg Muscle Strength Test (Leg Dynamometer) Pre-Test and Post-Test

Name	Strength Test		D
	Pre-Test	Post-Test	
Subject 1	54	56	1,41
Subject 2	43	45	1,41
Subject 3	37,1	45	5,58
Subject 4	53	52	0,70
Subject 5	44	48	2,82
Subject 6	50	57	4,94
Subject 7	25	26	0,70
Subject 8	23	29	4,24
Subject 9	37,5	40	1,76
Subject 10	33	35	1,41
Subject 11	30,5	40	6,71
Subject 12	24	41	12,02
Subject 13	39	42	2,12
Subject 14	45	47	1,41
Subject 15	45	49	2,82
Subject 16	35	59	16,9
Subject 17	70	77	4,94
Subject 18	48	55	4,94
Subject 19	40	51	7,77
Subject 20	73	77	2,82
Amount	849,1	971	87,61
Average	42,45	48,55	4,38
Std Deviation	13,42	13,10	4,08

Table 2. Agility Test (Zig-Zag Test) Pre-Test and Post-Test

Name	Agility Test		D
	Pre-Test	Post-Test	
Subject 1	10,00	12,10	0,68
Subject 2	10,61	10,99	0,99
Subject 3	11,34	11,66	0,55
Subject 4	11,88	11,52	0,55
Subject 5	11,50	11,53	0,74
Subject 6	12,10	11,18	0,65
Subject 7	10,99	10,06	0,65
Subject 8	11,66	11,16	0,35
Subject 9	11,52	11,20	0,22
Subject 10	11,53	11,30	0,16
Subject 11	11,70	10,87	0,58
Subject 12	11,55	10,86	0,48
Subject 13	10,80	09,65	0,81
Subject 14	11,20	10,67	0,37
Subject 15	11,40	10,22	0,83
Subject 16	10,25	09,87	0,26
Subject 17	10,24	09,81	0,30
Subject 18	10,16	09,65	0,36
Subject 19	09,77	09,03	0,52
Subject 20	10,41	09,61	0,56
Amount	220,61	205,47	10,70
Average	11,03	10,27	0,53
Std Deviation	0,69	0,76	0,22

As shown in the **Table 1** & **Table 2**, there was a clear improvement in the students' physical performance following the intervention. In particular, increases were observed in both muscular strength and agility scores after completing the plyometric exercises. These outcomes provide empirical support for the effectiveness of the box drill and frog jump methods in enhancing key components of athletic performance among student athletes.

Based on the strength test data, there was a clear and statistically meaningful improvement after the four-week training period. The average pretest score of participants was 42.45 kg, which increased to 48.55 kg in the posttest. This result suggests that the plyometric training program produced a measurable enhancement in lower-limb muscle strength among students participating in the volleyball extracurricular activities. The comparison of pre- and post-training averages is illustrated in the diagram below **Table 3.**

Table 3. Results of the Normality Test for the Two Variables

Variabel test		sig	Inf	Status
Agility Test	Pre-Test	0,822	P > 0,05	Normal
	Post-Test	0,833	P > 0,05	Normal
Strength Test	Pre-Test	0,871	P > 0,05	Normal
	Post-Test	0,644	P > 0,05	Normal

Similarly, the agility test results revealed a noticeable improvement following the intervention. The mean pretest completion time was 11.03 seconds, which decreased to 10.27 seconds after the training. The reduction in time reflects an increase in movement efficiency and overall agility performance. These findings indicate that participants became more capable of executing rapid directional changes while maintaining control and stability. Overall, it can be concluded that the four-week plyometric training program, conducted three times per week, effectively enhanced both muscular strength and agility among the participants. The diagram below presents the average agility test results, highlighting the performance gains achieved through the training intervention.

Table 4. Results of the homogeneity test of the data for the two variables

Variabel test		sig	Inf	Status
Agility Test	Pre-Test	0,342	P > 0,05	Homogen
	Post-Test	0,323	P > 0,05	Homogen
Strength Test	Pre-Test	0,321	P > 0,05	Homogen
	Post-Test	0,324	P > 0,05	Homogen

Table 4 indicates that the data obtained for both dependent variables strength and agility exhibit homogeneous variances. This is evidenced by the significance (p) values for all data, which are greater than 0.05, leading to the conclusion that the variances across groups are equal or homogeneous. Furthermore, to assess the effect of the box drill and flog jump training programs, a t-test specifically the paired t-test in SPSS was employed. The results of this statistical analysis are presented in **Table 5.**

Table 5. Results of the Dependent Variable Difference Test

Variabel test		t-hitung	sig	Status
Agility Test	Pre-Test Post-Test	11,554	0,000	Homogen
Strength Test	Pre-Test Post-Test	11,223	0,000	Homogen

Based on the results presented in **Table 5**, there is a significant difference between the pre-treatment and post-treatment conditions for both dependent variables agility and strength within the study group. The obtained significance value of 0.000, or in other words, $P < 0.05$, indicates that the applied treatment had a statistically significant effect. Therefore, it can be concluded that there was a meaningful improvement following the implementation of the box drill and flog jump training programs.

The box drill exercise has been shown to have a positive effect on improving agility and muscular strength. This exercise is performed by running along a square-shaped area with sides measuring 10 yards (1 yard = 91.44 cm). It consists of four different movement variations designed to train both agility and strength in a structured sequence. In the first phase of the exercise, participants performed straight sprints to develop speed and enhance lower-body power. The second phase involved side shuffles, which focused on improving lateral coordination and body stability. During the third phase, participants executed backpedaling movements that targeted the posterior leg muscles and contributed to better balance control. Finally, the fourth component incorporated karaoke or crossover running, designed to increase hip flexibility, movement coordination, and overall agility.

Plyometric training, which emphasizes rapid, dynamic, and explosive movements such as jumping, bounding, and reactive pushing, has consistently been shown to improve muscular strength and agility when performed regularly. As its application in sports continues to grow, numerous studies have documented the effectiveness of plyometric methods in enhancing agility, speed, acceleration, maximal strength, and jump performance (Ramirez-Campillo et al. 2022).

A key finding in this study was the significant improvement in lower-limb muscle strength among participants who completed the plyometric training program. This enhancement was measured using a leg dynamometer, which quantifies the amount of force generated during muscle contractions. The posttest results indicated that participants were capable of producing greater force and handling higher resistance compared to the pretest. This outcome supports the notion that plyometric training effectively stimulates neuromuscular activation, enabling more powerful and efficient muscle contractions. Such adaptations are particularly advantageous for sports that demand explosive actions such as jumping, sprinting, and throwing making plyometric training an essential method for athletes in disciplines like volleyball, basketball, and athletics (Erfan 2020).

Beyond its effect on muscular strength, plyometric training also demonstrated a substantial improvement in agility performance. This was evident from the zig-zag run test, in which participants completed the course in shorter times and with more coordinated movements after the intervention. These results align with previous research suggesting that plyometric exercises enhance the body's ability to generate rapid and forceful movements by optimizing the stretch shortening cycle (SSC). The SSC is a physiological process where muscles transition quickly from an eccentric (stretching) phase to a concentric (shortening) phase. The rapid eccentric action triggers a stretch reflex that amplifies the subsequent concentric contraction, resulting in greater movement speed and force output. In essence, the faster the muscle is stretched, the more powerful its contraction becomes, which directly contributes to improved agility and explosive performance (Muthiarani, Lismadiana, and Yuniana 2021).

Plyometric training not only focuses on the development of strength and agility but also plays a crucial role in improving muscular stability and neuromuscular adaptation. This form of training induces physiological changes that enable muscles to respond more rapidly and efficiently to external stimuli. In essence, plyometric exercises enhance coordination between the nervous system and muscle fibers, thereby improving reaction time, movement accuracy, and overall motor control (Ramirez-Campillo et al. 2022).

The training program implemented in this study consisted of six core movement patterns: jump squats, jump lunges, tuck jumps, lateral barrier hops, small-to-lateral bounds, and skater jumps. Each movement targeted different muscle groups to strengthen the lower limbs and improve body coordination. The combination of these exercises was designed to develop explosive power, dynamic balance, and rapid reaction ability key physical attributes that directly contribute to better performance in sports and other physical activities.

Physiological adaptations that occur during plyometric training are central to improving overall performance. Through consistent and structured repetition, muscles and connective tissues become more elastic, allowing energy to be stored and released more efficiently during dynamic movements. Additionally, plyometric

exercises contribute to tendon strengthening and thickening, reinforcing structural stability while reducing the likelihood of injury caused by repetitive mechanical stress. As a result, participants who regularly engage in such training exhibit not only enhanced strength and agility but also greater readiness to meet the physical demands of intense activity.

This study further suggests that plyometric training positively influences other aspects of physical fitness, including muscular endurance and core stability. Regular participation in these exercises strengthens the body's stabilizing muscles, which are essential for maintaining balance and posture during movement. Such benefits extend beyond athletic contexts, as improved strength and balance can also enhance general fitness and reduce the risk of injury in daily life.

Beyond its physiological advantages, plyometric training was also found to have a positive psychological impact on participants. Observations and feedback revealed increases in self-confidence and motivation following noticeable gains in strength and agility. These psychological benefits are crucial for maintaining long-term training consistency and achieving peak performance. When individuals feel stronger, more agile, and more capable, they tend to develop a sustained commitment to physical activity and overall well-being.

Overall, the findings of this research highlight the integral role of plyometric training in physical fitness and performance development programs. The significant improvements observed in both strength and agility provide compelling evidence that this training method is effective, efficient, and adaptable to a variety of physical needs. Incorporating plyometric exercises into regular training routines whether for athletic or recreational purposes can yield substantial benefits for power, endurance, and body stability. Thus, plyometric training holds value not only for professional athletes but also for the general population seeking to enhance their quality of life through improved and sustainable physical fitness.

CONCLUSION

Based on the findings and discussion presented previously, it can be concluded that the box drill and flog jump training programs contribute to improved physical performance, particularly in the areas of muscular strength and agility. The results showed that box drill training effectively increased agility and lower limb strength, while flog jump training also produced positive, measurable improvements in both performance aspects.

Furthermore, the analysis revealed differences in the magnitude of improvements produced by each training method, indicating that both training methods have unique characteristics and varying degrees of effectiveness, depending on the specific physical attributes targeted. This implies that the choice of training method should align with the desired performance goals, whether emphasizing the development of agility, muscular strength, or a combination of the two.

In conclusion, this study provides empirical evidence supporting the effectiveness of plyometric-based training such as box drills and flog jumps in improving key physical components relevant to volleyball performance. While both methods have been shown to be beneficial, their effects may vary depending on the participants' initial physical condition and the dominant movement patterns involved in each exercise.

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