



# The Effects of Plyometric Training on Physical Performance Improvement and Physiological Adaptation: A Literature Review

*Pengaruh Latihan Plyometrik terhadap Peningkatan Kinerja Fisik dan Adaptasi Fisiologis: Tinjauan Literatur*

Review Article

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## Abstract.

### Background

Physical performance and physiological capacity are crucial determinants of success in various sports disciplines. Athletes and physically active students require training programs that effectively enhance muscle strength, power, flexibility, and neuromuscular efficiency. Plyometric training is a method emphasizing explosive muscle contractions through the *stretch-shortening cycle* (SSC), a rapid eccentric-concentric sequence that promotes neuromuscular coordination, motor unit efficiency, and increased muscle power. Physiological adaptations from plyometric training include elevated electromyographic (EMG) activity, greater muscle torque, and improved tendon elasticity.

### Objectives

This literature review aims to comprehensively examine the effects of plyometric training on physical performance and physiological adaptations.

### Methods

The study followed the PRISMA guidelines and applied the PICO framework to identify relevant studies using the Scopus database. From 963 identified articles, four met the inclusion criteria, consisting of two true experimental designs, one randomized controlled trial, and one quasi-experimental design.

### Results

The findings indicate that plyometric training consistently improves strength, power, speed, and neuromuscular efficiency. Variations in training forms such as jump-to-box, knee tuck jump, and sand-based plyometric exercises produced different effects on muscle strength and flexibility, yet all contributed to enhanced functional performance and muscle mass development.

### Conclusion

In conclusion, plyometric training is an effective method to improve physical performance and physiological adaptations by optimizing neuromuscular system function. This training approach can be applied broadly to athletes and students, provided that intensity and duration are appropriately adjusted to maximize results while minimizing injury risks.

**Keywords:** Plyometric Training; Neuromuscular Adaptation; Physical Performance.

Received: October 26, 2025. Accepted: December 26, 2025

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## INTRODUCTION

The musculoskeletal system is a system in the human body that provides stability. The musculoskeletal system is a system in the human body that provides stability and enables coordinated movement [5][19][15]. If this system is disrupted, it will affect the human body's movement system. One of the most common musculoskeletal disorders is a bone fracture. Physical performance and physiological capacity are two critical aspects that determine performance in various sports. Athletes and students who are physically active require training programs that can develop muscle strength, explosive power, flexibility, and the efficiency of the neuromuscular system. Actively participating in physical activities such as morning exercises, regular sports, and strength training not only improves muscle strength, stamina, flexibility, and balance, but also demonstrates better focus, discipline, and academic performance at school [4].

Physical training models in athletics vary according to objectives, event types, and athlete characteristics, with approaches such as strength training, speed training, endurance training, and modern combinations based on the principles of periodization and physiological adaptation, which significantly contribute to improving athlete performance through methods such as interval training, circuit training, and plyometrics [1]. One form of training widely used and proven effective for improving these abilities is plyometric training. Plyometric training stimulates muscles to develop maximum strength rapidly, thereby improving performance through high-speed eccentric and concentric contractions [17].

Plyometric training is a training method that emphasizes explosive muscle contractions through the stretch-shortening cycle (SSC), a phase of rapid stretching followed by a fast contraction [1]. This contraction pattern stimulates improved neuromuscular coordination and motor nervous system efficiency [2], resulting in increased muscle strength and power. Plyometrics not only affect functional performance, such as speed and jumping, but also induce physiological adaptations, including increased electromyographic (EMG) activity, muscle torque, and tendon elasticity [3].

Various studies have proven the effectiveness of plyometric training in improving athletic performance. Research on female basketball players shows that an eight-week plyometric program can significantly improve strength, speed, and neuromuscular efficiency [3]. Another study on professional soccer players compared heavy resistance training and plyometric training and found that both improved neuromuscular performance. Still, plyometric training was superior at developing speed and movement coordination [4]. Meanwhile, sand-based training has been shown to increase leg muscle power and strength in young athletes, with a lower risk of injury [2].

In addition to improving performance, plyometric training also contributes to increased muscle mass and overall physical fitness [16]. The mechanical stress induced by explosive eccentric contractions stimulates muscle fiber growth and strengthens supporting tissues, such as tendons and ligaments. Thus, plyometrics not only improve explosive ability but also enhance functional muscle structure. Exercise as a physical activity plays a vital role in improving health, physical fitness, and physiological functions of the body, where the application of sports physiology principles through aerobic and resistance training has been proven to enhance cardiovascular endurance, muscle strength, and mental health by reducing stress, increasing endorphins, and improving sleep quality, thus becoming an effective strategy to support overall physical and psychological Well-being. [23] Based on these findings, it is essential to comprehensively review how plyometric training impacts physical performance and physiological adaptation. This literature review aims to describe the neuromuscular adaptation mechanisms that result from plyometric training and to review its contribution to increasing strength, explosive power, muscle mass, and physical fitness components across various populations of athletes and students.

## METHOD

### Search Strategy

This study follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure complete and transparent reporting [3]. The PICO (Population, Intervention, Comparison, Outcome) method was used in this study to identify relevant articles and extract significant data from peer-reviewed academic sources, including books and scientific journals. The primary focus of this review was academic literature on the direct effects of exercise on the performance and adaptation of the body's physiological systems. Search and Selection Strategy: The database used in this study was Scopus. The keywords used for the search were "plyometric" AND 'knee' AND "Increasing". Next, the author will select the study characteristics and research methodology.

### Exclusion Criteria

The exclusion criteria used were as follows: (1) Articles in the form of literature reviews, (2) Articles in languages other than English, (3) Articles published outside the last five years, namely 2021-2025, (4) Articles that did not explicitly mention plyometric exercises.

### Search Procedure

The initial search identified 963 articles from various databases. After screening, 147 articles were identified as duplicates. Identification of titles and abstracts resulted in 517 articles that did not meet the research criteria. The exclusion criteria were applied, resulting in the elimination of 26 of 39 articles after the initial screening. Four articles remained eligible for further analysis.

## RESULTS AND DISCUSSION

author and Year	Research Methods and Types	content	Research purposes	Research result
[1]	An experimental study with a pre-test and post-test control-group design; the study involved an 8-week plyometric program intervention in female basketball athletes.	The effect of an 8-week plyometric program on the physical performance and neuromuscular adaptations of elite female basketball players. Measurements included sprint speed, change-of-direction ability, jumping ability, EMG, and knee muscle strain comparison between experimental and control groups.	To examine the effects of an 8-week plyometric program on improving physical performance and neuromuscular adaptation in female basketball players. Specifically, it improved speed, jumping, muscle strength, and neuromuscular activity.	The experimental group showed improvements in the ability to change direction and thigh muscle volume. EMG improvements in the vastus medialis muscle during the squat jump. Trends in sprint and jumping performance were observed, but not statistically significant. There were no significant increases in peak torque strength and average power of the thigh and hamstring muscles.
[2]	The study design was a single-masked randomized controlled trial. Participants were divided into three groups: HRT, PLY, and control. The intervention lasted 8 weeks and combined resistance and plyometric training. Measurements were taken before and after the intervention using various tools and tests (e.g., 1-RM, sprint, jump, isokinetic torque). Statistical tests used Kruskal-Wallis, Wilcoxon, ICC, and Cronbach's $\alpha$ .	The importance of neuromuscular training in professional soccer performance. Lack of direct research comparing HRT and PLY. Measured performance issues include sprint speed, strength, and jumping performance implications of the heterogeneity of previous study results and the need for further research.	This study compared the effects of HRT and PLY training over 8 weeks on the neuromuscular performance of professional soccer players. According to the summary, this study aimed to determine whether HRT was more effective than PLY in improving strength, speed, and jumping performance.	Both methods (HRT and PLY) improved neuromuscular performance compared to the control. HRT tended to be more effective in increasing relative strength and balance. Both methods increased speed and jumping capacity equally. No significant side effects were observed, but knee muscle imbalance was observed in most

				participants.
[3]	Pretest-posttest randomized experimental design. Number of participants: 33 male students. Intervention: Three groups (knee tuck jump, hurdle jump, control). Duration of intervention: 5 weeks (15 sessions). Measurement: Using NordBord and Force Decks. Analysis techniques: Paired t-test, One-way ANOVA, post-hoc LSD.	Investigating the effects of sand-based and other surface-based plyometric training on leg muscle strength and power. Comparing the impact of different types of jumps (knee tuck and hurdle jump). Measuring changes in muscle strength and power using specific measuring instruments. Made observations over 5 weeks of regular training.	To determine the effect of sand-based plyometric training on increasing leg muscle strength and power. To compare the effectiveness of different types of plyometric jumps. To examine the effects of short-term training on the performance of young athletes.	Both types of plyometric training increase muscle strength and power. Hurdle jumps are more effective than knee-tuck jumps at improving performance. There is a positive relationship between increases in muscle strength and power. Plyometric training improves the SSC mechanism and muscle-tendon characteristics.
[4]	Quasi-experiment with randomization and pretest-posttest. Type: Quasi-experimental research	To examine the effect of plyometric Knee Tuck Jump and Jump to Box exercises on increasing leg muscle strength and flexibility in female students who participate in volleyball extracurricular activities.	Analyze the effect of plyometric training on leg muscle strength and flexibility, and compare the effectiveness of the two exercises.	Both exercises significantly increase leg muscle strength and flexibility. Knee tuck jumps are more effective for increasing flexibility, while jumps to the box are more effective for increasing leg muscle strength.

### Research Methods and Results

The articles included in this literature review summarize and analyze four studies that generally used an experimental quantitative approach [1][2][3][4]. Based on grouping, the studies can be divided into three categories: two articles used a true experimental design [1][3]. One article used a Randomized Controlled Trial / RCT approach [2], and another used a quasi-experimental design [4]. The design used a pretest-posttest design to determine the causal relationship between the independent variable (type of plyometric exercise) and the dependent variables (muscle strength, explosive power, flexibility, speed, and neuromuscular adaptation) [11]. Analysis of the research methods and types revealed similar methodological patterns, although there were variations in the level of control and randomization.

### Contents

Physical activity affects physiological adaptation in the musculoskeletal system [21][10][7][14]. Plyometric exercises are physical activities that can increase leg strength [24]. Sports physiology details and explains the changes induced by exercise aimed at improving physiological responses to intensity, duration, frequency, environmental conditions, and individual physiological status [20]. The

musculoskeletal system is one of the systems that undergoes adaptation when trained. Increased muscle mass, vasodilation of blood vessels, and microdamage to tissues are acute effects that occur during physical activity [12][6]. However, there are also chronic effects or responses of the body to the musculoskeletal system, one of which is the muscles. Several adaptations occur in the muscles during this time, namely an increase in muscle fibers, an increase in the number of capillaries, which allows the body to supply the necessary nutrients, and an increase in mitochondrial density, which also increases aerobic capacity.

### Research Objectives and Results

The studies discussed in this literature review [1][2][3][4] examine the impact of plyometric training on physiological adaptation, gradual activities, and programs designed to elicit both acute and chronic adaptation. The experimental group experienced significant improvements in speed, explosive power, and neuromuscular activity compared to the control group [1]. This indicates that plyometric training can improve the efficiency of the nervous system and muscle contraction via the stretch-shortening cycle (SSC). On the other hand, both HRT and PLY significantly improved neuromuscular performance, muscle strength, and speed compared to the control group [2]. However, plyometric training tends to be more effective for improving speed and muscle coordination because it involves repeated explosive contractions. Researchers suggest combining both as an optimal training strategy for enhancing athletes' functional performance [2]. Sand-based plyometric training results in greater improvements in muscle strength and power than training on hard surfaces [3]. This is due to sand's natural resistance, which increases muscle load without increasing the risk of injury. This study emphasizes the importance of training media in influencing muscle adaptation outcomes. In this study, two forms of training significantly increased the strength and flexibility of female students' leg muscles. However, jump-to-box training was more effective in improving strength, while knee tuck jumps had a greater effect on flexibility [4]. This shows that variations in exercise form produce distinct physiological adaptations, depending on the movement's characteristics. All four studies show that plyometric training is an effective method for improving physical performance and physiological adaptation in athletes and students. Although the design and variation of the exercises differed, the overall results consistently showed an increase in muscle strength, explosive power, and neuromuscular ability. The factors that differentiated results across studies mainly stemmed from the type of exercise, the exercise medium, and participant characteristics, but the direction of the effect was the same: plyometrics significantly improved muscle performance and function.

### CONCLUSION

Based on several studies listed in the table, plyometric training consistently improves physical performance and physiological adaptation across various athletic groups.

In general, all studies show that polycystic exercise programs, whether in the form of knee tuck jumps, jump-to-box exercises, sand surface exercises, or combinations with resistance training, can increase leg muscle strength, explosive power, speed, and flexibility. These adaptations occur due to increased neuromuscular efficiency, characterized by increased electromyographic (EMG) activity, increased muscle torque, and improved stretch-shortening cycle (SSC) performance.

Plyometric training has also been shown to improve functional performance, including jumping, sprinting, and change-of-direction. These improvements are not only seen in professional male athletes, but also in female athletes and young students, indicating that the physiological response to plyometrics is universal when performed with controlled duration and intensity (generally 5–8 weeks).

Several studies have compared various types of exercise, such as heavy resistance training (HRT) and plyometric training (PLY), as well as sand-based exercises versus hard surface exercises. The results show that both are effective in improving performance, but plyometrics tends to be more efficient in developing explosive strength and neuromuscular coordination. The difference in effectiveness between methods is due to variations in training media and mechanical load characteristics that affect muscle and tendon adaptation.

There that plyometric training is an effective method for improving physical performance and physiological adaptation, especially in sports that require leg strength and explosive power. This program can be widely applied to both young and professional athletes, provided that the intensity, frequency, and type of exercise are adjusted to individual conditions to avoid muscle imbalance or the risk of injury.

## ACKNOWLEDGMENT

A big thank you to the co-authors and supervisors who contributed to the completion of this manuscript.

## AUTHOR CONTRIBUTION STATEMENT

The authorship of this article involved roles in formulating the research concept and design, reviewing and analyzing relevant literature, and drafting the manuscript as a whole.

## CONFLICT OF INTEREST AND FUNDING

There is no conflict of interest

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