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THE EFFECTIVENESS OF PLYOMETRIC AND AGILITY LADDER ON INCREASING LEG MUSCLE POWER AND REACTION SPEED

Andy Bima Priyanto¹, Haryo Mukti Widodo², Agus Himawan³, Septyaningrum Putri Purwoto⁴, Heni Yuli Handayani⁵

STKIP PGRI Bangkalan^{1,2,3,4,5}

Andybima50@gmail.com¹ haryomukti@stkipgri-bkl.ac.id² heni@stkipgri-bkl.ac.id³
septy@stkipgri-bkl.ac.id⁴ agus@stkipgri-bkl.ac.id⁵

Abstract

Leg muscle power and reaction speed are important components in athlete performance, especially in sports that require explosive movements such as sprinting, jumping, and rapid changes of direction. The purpose of this study was to assess the effectiveness of a combination of plyometric and agility ladder training on increasing leg muscle power and reaction speed, especially in futsal players. Both types of training are theoretically capable of increasing explosive ability and motor response speed. The method used was a quasi-experimental study with a pre-test and post-test design. The results showed that there was a significant increase in both physical variables studied. These findings support the use of combined training as an efficient method for developing the physical condition of futsal athletes.

Keywords: Plyometric; Agility ladder; Leg Muscle Power; Reaction Speed

INTRODUCTION

Athlete performance depends not only on technical skills but also on physical capacities that support explosive and responsive abilities. Two important aspects of this physical capacity are leg muscle power and reaction speed (Irfandi et al., 2023). Leg muscle power is the ability of muscles to produce maximum force in a short time, which is very necessary in activities such as sprinting, jumping, or starting in a match (Asyhari & Nurliani, 2025). This movement is a basic movement used in sports, one of which is futsal. Meanwhile, reaction speed refers to the time it takes an athlete to respond to a stimulus, whether visual, sound, or physical contact, which is often a determinant of success in this sport. The performance of futsal players is largely determined by physical capacities such as explosive power and reaction speed (Barasakti & Faruk, 2019). The fast-paced game of futsal in a tight space requires athletes to have the ability to perform short sprints, sudden changes of direction, and quick reactions to the ball and opponents. Therefore, developing training methods that can improve these two abilities is very important.

Leg muscle power and reaction speed are important components of athletic performance, particularly in futsal, which requires explosive movements such as sprinting, jumping, and rapid changes of direction. Leg muscle power allows an athlete to generate significant force in a short period of time, while reaction speed allows for rapid responses

to visual, auditory, or kinesthetic stimuli (Mahesa & Rezki, 2022). Many training methods for leg muscle power have been developed to optimize these physical components. One popular method is plyometric training. This exercise utilizes the muscle's stretch-shortening cycle to increase explosive muscle ability, particularly in the lower extremities. Movements such as squat jumps, tuck jumps, and bounding have been scientifically proven to stimulate positive neuromuscular adaptations that increase explosive muscle power (Arianda et al., 2021).

⁵ Plyometric training is known as an effective method for increasing muscle explosive power through the stretch-shortening cycle. On the other hand, an agility ladder is a simple tool used to train foot speed, coordination, and neuromuscular response. The combination of these two methods will provide a more comprehensive training stimulus for the nervous and muscular systems. This is because the agility ladder is used as a training aid designed to improve foot speed, agility, coordination, and reaction time (Lestari & Herawati, 2024). Training with this coordination ladder is typically used to improve rapid motor responses and increase the speed of changes of direction. The patterned movements in agility ladder training involve visual and kinesthetic stimuli that stimulate the central nervous system to respond quickly and coordinated.

² The combination of plyometric and agility ladder training can provide a more complex and comprehensive stimulus than either exercise performed separately. This exercise not only trains leg muscle strength and explosiveness but also stimulates rapid reactions through varied and dynamic movement patterns. This is particularly relevant for futsal athletes who are developing physical abilities and motor coordination. Energy is mainly supplied by the aerobic system. However, during high-intensity actions, anaerobic metabolism becomes the dominant energy source. Due to the structure of futsal regulations, players must possess strong aerobic endurance in combination with efficient anaerobic energy systems (Barbero-Alvarez et al., 2015). Furthermore, reaction speed is crucial in futsal because the limited playing space requires players to respond quickly to the opponent's movements and the ball. From a biomechanical perspective, the muscles involved, namely the tendons and minor muscles, automatically generate energy more quickly (Arrasid & Gumilar, 2024). Furthermore, neurophysiological research also shows that neuromuscular function is maximized when the concentric and eccentric phases of the

muscle are subjected to stressors. Explosive plyometric training can improve neural efficiency by enhancing ¹⁰ neuromuscular coordination. Therefore, plyometric training improves neuromuscular performance by increasing the set speed at which muscles can act (Ebben et al., 2010).

However, research on the effectiveness of combined plyometric and agility ladder training on improving leg muscle power and reaction speed is still relatively limited. Therefore, this study is crucial as a scientific effort to evaluate the effectiveness of this combined training program and ¹ contribute to the development of more efficient and measurable physical training methods. ⁵ This study aims to test the effectiveness of combined ⁶ plyometric and agility ladder training on improving leg muscle power and reaction speed. The results are expected to serve as a reference in developing more optimal physical training programs.

METHOD

This study used ⁷ a quantitative approach with a quasi-experimental design. The research design used a pre-test and post-test with a control group. The purpose of this design was to ⁶ evaluate the effectiveness of a combined plyometric and agility ladder training program on leg muscle strength and visual reaction speed in high school futsal players.

² Research Subjects

The subjects in this study were 20 ⁸ high school futsal players who actively participated in a regular training program. Subjects were selected using a purposive sampling method based on the following criteria: Actively participating in futsal training for at least the past 3 months, No injuries during the study, Willingness to participate in the entire training program and measurements.

⁴ The subjects were then randomly divided into two groups: The experimental group (n = 10) received the combined training treatment, The control group (n = 10) continued with regular school training without any additional special training.

Training Design

The experimental group underwent the combined training program for 6 weeks, with a frequency of 3 times a week, and each training session lasted 60 minutes. The training session included: (1) Warm-up: Dynamic stretching and light jogging (10 minutes), (2)

Main session: Plyometric exercises: squat jumps, tuck jumps, and split jumps (30 minutes), Agility ladder exercises: one-in-one-out, lateral shuffles, and zigzag carioca (15 minutes), (3) Cool-down: Static stretching and muscle relaxation (5 minutes). Meanwhile, the control group continued to follow regular school training, which did not involve a combination of plyometric and agility ladder exercises.

Research Instruments

The instruments used for the measurements were as follows (Riyad Fadhli et al., 2023): (1) Vertical Jump Test to measure leg muscle explosive power, using a standard vertical measuring board. (2) Digital Reaction Timer Test to measure visual reaction speed, using a special digital stopwatch designed to measure response to visual stimuli.

Data Collection Procedure

Data collection was conducted twice: at the pre-test (before treatment) and post-test (after 6 weeks of treatment). All measurements were conducted under standardized conditions, at the same time and location to reduce external bias.

Data Analysis

Data analysis was performed using the following steps: (1) Normality test using the Kolmogorov-Smirnov test to ensure normal data distribution. (2) Homogeneity test using Levene's test to check for equality of variance between groups.

T-test

Paired sample t-test was used to determine differences in pre-test and post-test scores within the same group. Independent sample t-test was used to determine differences in results between the experimental and control groups on the post-test. All analyses were conducted using statistical software with a significance level set at $p < 0.05$.

RESULT AND DISCUSSION

The following are the results of statistical analysis using the Kolmogorov-Smirnov normality test, Levene's Test homogeneity test, and paired sample t-test for each variable: leg muscle strength (power) and visual reaction speed. The data below represents the results of research conducted over six weeks. This test is conducted to determine whether the data are normally distributed. A significance value (p) > 0.05 indicates that the data are normally distributed.

Table 1. Normality Test

Variable	Group	Sig. (p)	Description
Power Pre-test	Experiment	0.200	Normal
Power Post-test	Experiment	0.179	Normal
Reaction Speed Pre	Experiment	0.168	Normal
Reaction Speed Post	Experiment	0.146	Normal
Power Pre-test	Control	0.192	Normal
Power Post-test	Control	0.185	Normal
Reaction Speed Pre	Control	0.173	Normal
Reaction Speed Post	Control	0.158	Normal

Table 2. Homogeneity Test

This test is used to determine whether the variances of the two groups are homogeneous (equal). A significance value ($p > 0.05$) indicates homogeneity.

Variabel	Sig. (p)
Power Pre-test	0.427
Power Post-test	0.388
Reaction Speed Pre	0.472
Reaction Speed Post	0.397

Table 3. Average Pre and Post-test of Leg Muscle Power and Reaction Speed

Group	Power Pre-test (cm)	Power Post-test (cm)	Pre-test Reaction Speed (ms)	Post-test Reaction Speed (ms)
Experiment	41.3 ± 3.2	47.8 ± 2.9	320.5 ± 15.6	290.1 ± 12.3
Control	40.7 ± 2.8	42.1 ± 3.1	318.9 ± 14.7	312.4 ± 13.5

Pre-test results showed that both groups had relatively equal initial scores. After the intervention, the experimental group showed significant improvements in leg muscle power and reaction speed compared to the control group. Statistical analysis using the t-test showed a p-value < 0.05 for both variables.

This improvement indicates that the combined exercises provide a synergistic effect: plyometrics enhance muscle force output, while the agility ladder improves coordination and reflex reactions (Huang et al., 2023). This is relevant to the needs of futsal players who must make quick decisions and move in limited spaces. The results of the improvement in the experimental group can theoretically be explained by the role of plyometric training in improving the neuromuscular system's ability to generate explosive power. Exercises such as squat jumps and tuck jumps strengthen leg muscles, particularly the quadriceps, hamstrings, and gastrocnemius, which play a crucial role in jumping and sprinting activities. This increase in power is also supported by the stretch-shortening cycle phenomenon, which is the muscle's ability to produce greater contractions after being stretched rapidly.

Plyometrics can significantly increase leg muscle power because the training principle

involves explosive muscle contractions that begin with a rapid stretching movement (eccentric) followed by an active contraction (concentric), known as the stretch-shortening cycle (SSC) (Tomalka et al., 2021). This SSC mechanism optimizes force production in a short period of time, maximizing muscle elasticity and neuromuscular efficiency (Seiberl et al., 2021). Furthermore, plyometric training can increase motor unit activation and the efficiency of nerve impulse transmission to the muscle, resulting in stronger and faster muscle contractions.

Physiological and neuromuscular adaptations that occur during athletic training play a crucial role in improving performance in sports like futsal, particularly in the vertical jump and initial acceleration. These two aspects are key components in various game situations, such as pressing, short sprints, and aerial duels. One training approach that has proven effective in developing these components is plyometric training. This exercise involves rapid cycles of muscle stretching and shortening, aiming to increase explosive strength and the efficiency of muscle elastic energy use. According to (Apriantono et al., 2023), systematically structured plyometric training can increase muscle explosive power, improve jumping ability, and accelerate motor responses, all of which are essential in the context of futsal.

On the other hand, training using an agility ladder or coordination ladder provides a more dominant stimulus to the central and peripheral nervous systems. This exercise is designed to improve neuromotor coordination, balance, and speed of movement patterns through the repetition of rapid, directed movements on the ladder (Padrón-Cabo et al., 2020). This activity trains athletes to respond efficiently to visual and tactile stimuli, thereby improving reaction speed and agility in dynamic game situations. The use of ladder drills can also strengthen neural connections between the brain and muscles, ultimately resulting in more precise and efficient movements in a short time, which is essential in the fast-paced and high-pressure game of futsal.

The combination of plyometric and agility ladder training forms a holistic and complementary training program. Plyometric training focuses on increasing dynamic and explosive muscle strength, while agility ladder training emphasizes the development of coordination, reactivity, and speed (Lestari & Herawati, 2024). The integration of these two types of training not only improves a player's physical capacity but also contributes to

improved technical and tactical abilities in matches. Therefore, a training approach that combines these two methods can create more optimal adaptation, thus supporting the overall performance of futsal athletes, both physiologically and neurologically (Albalad-Aiguabella et al., 2025).

Plyometrics significantly increases muscle explosive power, and agility training has a positive impact on response speed and change of direction ability (Nurkomaria et al., 2021). Thus, the improvements observed in the experimental group in this study can be scientifically justified. Furthermore, the context of futsal, played in confined spaces at high intensity, demands a combination of speed, strength, and reaction time for players. Therefore, this training program has proven highly suitable and applicable for improving the performance of futsal athletes (Tanyeri & Öncen, 2020). Furthermore, the success of performance improvement is also influenced by the structured and progressive design of the training program. This program combines training intensity and volume tailored to the athlete's ability level, allowing for gradual and controlled physical adaptation. Systematic training arrangements, including movement variations, load progression, and appropriate rest periods, encourage increased effectiveness of the training stimulus. This strengthens the transfer of training results to specific performance in futsal, which demands quick responses and explosive abilities in dynamic game situations.

CONCLUSION

A combination of plyometric and agility ladder ⁴ training has been shown to be effective in improving leg muscle power and reaction speed in futsal players. These results recommend that coaches integrate both methods into their physical training programs to support optimal performance on the field.

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