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The effect of plyometric training (hurddle jumps), body weight training (lunges) and speed on increasing leg muscle explosive power of futsal players: a factorial experimental design

Efecto del entrenamiento pliométrico (salto de vallas), el entrenamiento con peso corporal (estocada) y la velocidad en el aumento de la potencia explosiva de los músculos de las piernas de los jugadores de fútbol sala: Un diseño experimental factorial

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Abstract. Futsal games have high intensity and dynamics that require good skills and physical conditions, one of which is leg muscle explosiveness. By doing plyometric training (hurddle jump), body-weight training (lunges), and paying attention to explosive power factors including speed as a group determinant is believed to affect the explosive power of the player's leg muscles. However, despite recognizing the importance of both training methods in improving leg muscle explosive power, there is still a lack of a thorough understanding of their combined effect on players' leg muscle explosive power during futsal play. This study aims to analyze the differences in the effect of the intervention groups of plyometric training methods and body weight training by considering the level of running speed on explosive power results. Training groups include plyometric training groups and body weight training groups, while speed is categorized as high or low. Using an experimental approach with a 2 x 2 factorial design, this study randomly selected 20 players aged 17.1 ± 0.768 years. Training was conducted in three sessions per week for approximately six weeks. Training focused on fast/explosive movements. Speed data was collected using the 30m acceleration test and the leg muscle explosiveness standing broad jump test. The data were then statistically analyzed using a two-way ANOVA at the 0.05 level of significance. The results showed that both training methods can benefit individuals with high speed ($P<0.05$). However, leg muscle explosive power training with plyometric exercise was more effective on individuals with high speed ($P<0.05$). As for those with low speed, plyometric exercise can provide better results ($P<0.05$). These findings provide valuable insights for futsal coaches and instructors in designing customized training programs to improve leg muscle explosiveness.
Keywords: Plyometric, Body Weight, Speed, Power

Resumen. El juego del fútbol sala tiene una alta intensidad y dinámica que requiere habilidad y una buena condición física, una de las cuales es la agilidad. Se cree que el entrenamiento de la agilidad mediante la realización de variaciones del ejercicio en cono y del ejercicio en escalera, y la atención a los factores de la agilidad, incluido el equilibrio, mediante el entrenamiento de la estabilidad del núcleo y la velocidad como factor determinante del grupo, afectan a la capacidad de agilidad de los jugadores. Sin embargo, a pesar de reconocer la importancia de ambos métodos de entrenamiento en la mejora del rendimiento de la agilidad, existe una falta de comprensión profunda de sus efectos combinados en la agilidad del jugador durante el juego de futsal. Este estudio pretende analizar la diferencia de grupos en el entrenamiento de la agilidad teniendo en cuenta las variaciones en el nivel de velocidad y su impacto en la agilidad de los jugadores de fútbol sala. Los grupos de entrenamiento de agilidad incluyen un grupo de combinación de ejercicios de cono con estabilidad central y un grupo de combinación de ejercicios de escalera con estabilidad central, mientras que la velocidad se categoriza como alta o baja. Utilizando un enfoque experimental con un diseño factorial 2 x 2, este estudio seleccionó aleatoriamente a 20 jugadores de 17,1 ± 0,76 años. El entrenamiento de agilidad se realizó en tres sesiones por semana durante aproximadamente seis semanas. El entrenamiento se centró en los movimientos rápidos/explosivos y el equilibrio. Los datos de velocidad y agilidad se recogieron utilizando la prueba de aceleración de 30 metros y la prueba de agilidad de Illinois. A continuación, se analizaron estadísticamente mediante un ANOVA de dos vías al nivel de significación 0,05. Los resultados mostraron que ambos métodos de entrenamiento pueden beneficiar a los individuos con alta velocidad ($P<0,05$). Sin embargo, el entrenamiento de agilidad con una combinación de ejercicios de escalera y entrenamiento de estabilidad central fue más eficaz en individuos con alta velocidad ($P<0,05$). Mientras que para aquellos con baja velocidad, la combinación de ejercicios de escalera con estabilidad central puede proporcionar mejores resultados ($P<0,05$). Estos resultados proporcionan información valiosa para los entrenadores e instructores de fútbol sala en el diseño de programas de formación personalizados para mejorar la agilidad.
Palabras clave: Ejercicio del cono, Ejercicio de la escalera, Estabilidad del núcleo, Velocidad, Agilidad

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Introduction

Futsal is a simplified indoor game version of soccer that is popular in over 100 countries with over 12 million athletes, Where the game of futsal consists of five players: one goalkeeper and four outfielders, commonly named defenders, right or left-wingers, and pivots (Borges et al., 2021; Doğramaci et al., 2015). Futsal is a team game consisting of five members, aiming to score goals into the opponent's goal using all body parts except the hands (Karavelioglu et al., 2016). The futsal game does not require a very large place, where the futsal field is smaller than soccer 40 × 20 and the basic futsal techniques consist of passing, receiving, dribbling, and shooting (Guerra Echevarria & Valencia Sánchez, 2022; Tanyeri & Öncen, 2020).

The effort required for each player depends on several

factors such as playing position, tactical, technical ability, team strategy, and level of competition (Barcelos et al., 2017; Castagna & Barbero Álvarez, 2010). Futsal players make sudden changes of direction, acceleration and stopping jumps, and tackles (Caetano et al., 2015). During matches or training sessions, futsal players usually have high aerobic and sprint capacities, as well as high muscle strength to endure continuous mechanical stress and physiological demands (Barbero-Alvarez et al., 2008). Such efforts cause stress that affects the performance of Futsal players, characterized by high-intensity and dynamic play, which requires skill and good physical condition (Medina et al., 2016; Sekulic et al., 2019).

To achieve maximum performance in achievement sports, coaching and a very long process are needed (Ilham, Agus, Sugiyanto, et al., 2024). Not only the role of coaches and sportsmen to support maximum achievement but such as nutritionists, physical condition experts and physiotherapists also play an important role in this achievement (Sudarko et al., 2022). Coaching starts from the multilateral stage with the introduction of various sports to the special-ization stage of one particular branch that is truly involved and prospective for maximum achievement (Spyrou et al., 2020; Sudarko et al., 2022). The role of the coach is very large in the process, including preparing physical motor skills, techniques, tactics, and mental athletes in getting maximum achievement (Pratama et al., 2024).

There are many advantages of excellent physical condition, namely easy-to-understand environmental skills, reducing the risk of injury, maintaining physical performance, strengthening post-training recovery, and increasing self-confidence (Bompa & Buzzichelli, 2015; Naser et al., 2017). Components of the body's physical condition include strength, speed, endurance, muscle explosiveness, agility, balance, flexibility, and coordination (Gronwald et al., 2020; Ömer, 2020; Ribeiro et al., 2020). In futsal games, the dominant physical condition components that need to be possessed are endurance, strength, explosive power, speed, and agility (Setiawan et al., 2019; Tanyeri & Öncen, 2020). The influence of thedominant physical components will affect the basic techniques in futsal games, one of which is a good explosive power component that is the key to successful tactics and strategies (Prastyo, 2017). Explosive power is the ability to exert great muscle strength in a very short time (Hurst et al., 2017). The explosive power of the leg muscles will determine how high someone can jump, how far someone can kick, and for the start when running (Mlk et al., 2017). In the game of futsal, changes in direction are multi-faceted and continuous, characterized by dynamic actions associated with running forward and backward and lateral movements (Borges et al., 2021; Vicente-vila, 2016). These actions occur when the intensity of movement changes, along with jumping, kicking, and tackling movements to avoid injury. In addition, the game of futsal requires technical skills and tactical awareness where implementation and performance depend largely on the player's position, and the league to which the player belongs (Alvarez et al., 2020).

Physical elements, especially explosive power in leg strength, are needed in futsal games to support performance when practicing or competing in order to provide maximum results (Kaimusik et al., 2023). Efforts to prepare these abilities have been prepared by the coach with various forms of training applied. The methods used to increase explosive power include providing plyometric exercises and body weight training (Patoz et al., 2023; Pujowigoro et al., 2023). Plyometrics training aims to increase the storage and release of elastic energy of musculotendinous units by focusing on short time and high leg stiffness during the eccentric-concentric contraction cycle (L. G. Pereira et al., 2023). Plyometrics links movement speed and strength by producing explosive movements (Bakti et al., 2024; Raharjo et al., 2024). Plyometrics uses exercises such as various types of jumps, skipping, and hopping to increase the efficiency of the muscle eccentric-concentric cycle (Barrio et al., 2023). Body weight training exercises aim to develop power production by focusing on concentric contractions (Yendrizal et al., 2023). Body weight training exercises are characterized by basic movements using their own body weight or a tool to push and pull the body against gravity (Nunes & Orsatti, 2018). The pull of gravity during exercise increases the load on the body optimally, thus progressively exerting stress during exercise (Welis et al., 2024a). Exercising using one's own body is a strength training alternative that can be done almost anywhere and at any time, while using external weights can improve physical fitness such as muscle strength, muscle hypertrophy, coordination, and power (Welis et al., 2024b). Several parts of the workout should be considered, including the strength and volume of the activity, the order of the activity, the number of repetitions, the sets, the speed of progression, the rest time between sets, and the type of activity.

The combination of strength and movement speed is a major factor in producing explosive power. In addition, the combination of speed and strength is a very important physical biomotor in various sports. Without a good element of both, a person cannot produce maximum explosive power. The element of speed is always based on a basic concept, namely: the ratio between time and distance, so speed is always related to reaction time, frequency of motion per unit time, and speed over a certain distance (Silvia et al., 2024; Yoslanda et al., 2024). Speed shows the ability of muscles to overcome the load with a very fast contraction, muscle strength and muscle contraction are the main characteristics of explosive power. Increased explosive power output results in meaningful speed, which can confirm the casual relationship between the variables (Loturco et al., 2018). Linear velocity athletes must quickly overcome inertia, directing large forces against the ground to effectively accelerate the body forward (L. A. Pereira et al., 2018). Eight weeks of plyometric training added to the standard athletics program was highly likely to improve the lower

limbs speed and explosive strength in young athletes. Our findings highlight the potential value of combined training methods in a conditioning program aimed at maximizing power performance in youth (Fischetti et al., 2018). Provides the fact that plyometric training is better than circuit training in terms of high and low foot-eye-hand coordination on the explosive power of sickle attacks (Sudirman et al., 2024). In addition, weight training can help improve the explosive power of athletes when it involves speed control (Miftachurochmah et al., 2023). Our results suggest that especially free-weight training has benefits in improving leg and triceps strength and subjective perception in older adults, the free-weights group exhibited significant differences for the percentage increase over a period of 26 weeks compared to the machine group (Schott et al., 2019).

This could be the basis that the use of appropriate training methods and setting exercise doses is important. This is reinforced by several studies that the key to successful training is the suitability of exercise doses, because physical exercise can be analogous to medicine so it must be in accordance with the dose. Therefore, this study aims to analyze the differences in the effect of intervention groups of plyometric training methods and body weight training by considering the level of running speed on explosive power results. Futsal players must have good physical and mental fitness so that when training and matches become effective and achieve maximum results. The results of this study are useful for coaches, physical education teachers, practitioners, and athletes to train explosive power in sports, especially futsal. Therefore, coaches can consider player speed to train explosive power.

Table 1.
The two-way factorial ANOVA design.

Speed (B)	Explosive power training (A)	
	Hurdle jumps A1 (plyometric)	Lunges A2 (weight training)
High (B1)	A1B1	A2B1
Low (B2)	A1B2	A2B2
Total	A1	A2

Materials and Methods

Study design

This research is an experimental research with two-way ANOVA factorial design. Explosive power training (A) consists of two forms of treatment, namely hurdle drill as a plyometric (A1) and lunges as a weight training (A2). Meanwhile, Speed (B) consisted of high speed (B1) and low speed (B2). The classification of these variables is illustrated in Table 1. In summary, this study included four treatments: Explosive power with hurdle jumps high and low speed (A1B1 and A1B2) and Explosive power training with lunges high and low speed (A2B1 and A2B2).

After the sample category using the 30-meter sprint measurement, the average and standard deviation are obtained as follows A1B1= 3,92 ± 0,13, A2B1= 3,96 ± 0,12, A1B2= 4,88 ± 0,18, dan A2B2= 5,08 ± 0,55.

Participants

The study population consisted of Vamos Academy Padang Futsal Players. From a total sample of 38 players, grouping is taken from a sample that has a high speed of 27% and a low speed sample of 27% of the data that has been ranked. The number of samples 27% x 38 = 10.26 and rounded to 10 thus getting 10 players who have high speed and 10 players who have low speed (Miller, 1996). After the speed data is collected, further analysis is carried out using the ordinal pairing technique to identify the experimental group. After random recruitment, the total number of participants who participated in this study was 20 futsal players who had signed informed consent as a condition of conducting the study. The age of the participants was 17.1 ± 0.768 years. Meanwhile, body weight was 61 ± 5.94, height was 166.89 ± 4.27 cm and BMI was 22.03 ± 2.58.

Procedure

Distribution of treatment groups

For the first step, we obtained all permits and prepare the necessary equipment and infrastructure this research. Participants will undergo a pre-test. However, before carrying out the pre-test, they had already done it asked to sign a research consent form. A 30 meter sprint test was carried out to determine groups using a two-way ANOVA design. This test was carried out before providing explosive power training using plyometric training methods with hurdle jumps and weight training with lunges.

The 30 meter sprint test was carried out on 20 men futsal players, and speed is classified based on maximum and minimum results. After the result It is known that later the sample is paired with the A-B-B-A technique The test classifies participants into two groups. That the higher group (27%, n = 10) was considered high speed, while the lower group (27%, n = 10) classified as having low speed (Kettlety et al., 2023). The researchers classified the participants into upper and lower groups to make participants' speeds significantly different (high and low). Then, in the next step, the treatment group is placed into explosive power training methods with hurdle jumps and lunges under the direction of the trainer. This placement is done by drawing randomly based on groups, whether they have a high or low speed level. The detailed process can be seen in Figure 1 and Table 2. As seen in Figure 1 and Table 2, there are 4 treatments groups, each group consisting of 5 participants.

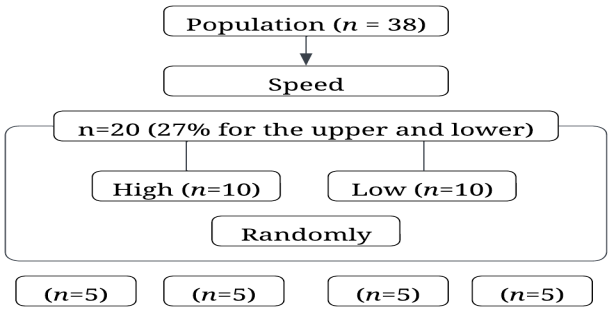

Figure 1. The flow of treatment group assignment in the research

Table 2.
The sample size for each treatment group.

Speed (B)	Explosive Power Training (A)				Total (n)
	Hurdle jumps (A1) Plyometric methods	n	Lunges (A2) Weigh training methods	n	
High (B1)	A1B1	5	A2B1	5	10
Low (B2)	A1B2	5	A2B2	5	10
Total	A1	10	A2	10	20

Treatment for Explosive Power Training

This study uses an explosive power training method with a plyometric training method, namely hurdle jumps and a weight training method, namely Lunges. The explosive power training was given for ± 6 weeks, three times a week. The exercise begins with a 10-minute warm-up (static and dynamic), followed by training on the futsal field (using the hurdle jumps and lunges method). The exercise ended with a rest period. Routine technical exercises performed by participants are always done as maintenance.

Explosive power training was conducted for ± 6 weeks, 3 times per week. The increase in training load was done constantly because it remembers the principles of explosive power training, which is done explosively. The training dose was increased every week until the third consecutive week. In accordance with the principles of training, the principles of overload, progressive and individualized were applied. In some weeks, for example the fourth week, the training dose is equal to the training dose of the second week, and the dose is equal to the dose of the fourth week. This means there is a decrease in training load. This aims to prepare or recover from efforts to increase the training dose. The increase in training dose of this model was continued until week 6, before a posttest was held.

In accordance with the training method provided by the researcher, namely looking at the difference between plyometric training and weight training on explosive power. Participants will be divided into 4 groups with high and low speed categories and with 2 training methods. As we know, plyometrics and weight training can be a very effective way to improve your overall fitness. Plyometrics improves speed, strength and agility, while weight training helps build strength and muscle mass. Plyometrics involves explosive movements that utilize muscle stretch-shortening cycles and adding weights to these exercises can increase their intensity and effectiveness.

The explosive power training method using plyometric training in the form of hurdle jumps aims to increase leg muscle power which functions to increase stamina, coordination, agility, and speed. In this procedure, the body position is straight, the head is upright, and both arms are behind the body. Swing the arms forward and up to cover the ears at the same time as jingling, heels high away from the floor. Hold the raised arms and jingling feet for 2 or 3 seconds. The knees bend as the arms begin the upward movement, but are still at the bottom. Add a jump at the end of the movement when the arms are raised up. Practice adding the jump over a block, small goal post or piece of foam. How to step on the start. Use a small block between 20-30 cm high. Stand up tall with arms straight beside the ears on the block, legs straight, push up to the jingjit position and remain stretched. Return to perfect stance, body upright. Do it with intensive movements.

After that, weight training using lunges. Lunges are a type of exercise to train the quadriceps muscles by squatting and standing on one leg. Steps Stand up straight with your feet hip-width apart. Step your right foot forward, then bend your right knee to form a 90-degree angle while the back leg is bent to form a 45° angle parallel to our body. Reposition your left leg as if you were kneeling with your heel slightly raised off the floor. Make sure your left knee does not touch the floor. Return to the starting position. Repeat both methods of exercise with 6 - 10 repetitions at an intensity of 80%-90% of your rep max.

Both forms of explosive power training are very basic and aim to increase the explosive power of futsal players, especially explosive power in footwork. The training is done periodically for approximately 6 weeks. In addition, these exercises use the same terrain and distance on the field when performing the same movements. Therefore, they need to be compared to see how effective they are. Also, the exercises are performed in almost the same way, i.e. starting with a warm-up, basic exercises with a similar progression dose increase, and then followed by a cool-down. On the other hand, the fundamental difference between the two explosive power exercises is that significant differences between the training methods may occur due to different movement forms and different training demands. Plyometrics not only improves strength and speed, but also helps to build muscle. The added resistance of the load forces the muscles to work harder, thus increasing muscle growth and strength. Weight training is a strength training method applied by athletes by using their own body weight in a way that is opposite to gravity. This can increase their muscle mass and mobility and become balanced and healthy with strength training. Despite being in training areas and fitness rooms for hours on end, targets can be achieved with bodyweight exercises in simple areas. Keep in mind that many successful athletes also allocate a lot of space for bodyweight training.

Instrument

This study used several instruments to collect data. For example, speed was measured using 30m acceleration (Bompa & Buzzichelli, 2015). Then, to measure explosive

power using a standing broad jump (Ilham, Agus, Tomoliyus, et al., 2024). They are required to do 3 trials, and record the data. After that, the researcher took 1 trial that was considered the best of the 3 trials. data collection using a stopwatch, meter, and cone as a barrier.

Statistical Analysis

Descriptive analysis was used to characterize data from each treatment group. Normality test was analyzed based on standardized residual values, homogeneity was analyzed using Levene's test. Then, a two-way factorial ANOVA test was used to analyze the difference in effects. This study also conducted Tukey's further test to analyze significantly different groups or better results in one's explosive power with an alpha significance value of 0,05. All data in this study were analyzed using the IBM SPSS statistical program version 25.

Results

The study found that the mean and standard deviation of pre-test and post-test leg explosive power increased as follows: A1B1 (231,4 ± 4,88 to 236,4 ± 9,22), A1B2 (213,8 ± 3,37 to 225,4 ± 5,16), A2B1 (230,4 ± 5,85 to 232,2 ± 5,31), and A2B2 (216 ± 3,74 to 220,2 ± 3,87). The highest percentage occurred in group A1B2, with a rate of 5,15% (11.6), assessing this group first. This was followed by the A1B1 group, with an increase of 2,12% (5) and ranked second. After that, the A2B2 group showed the third highest percentage of 1.91% (4,2). Finally, the A2B1 group showed an increase of 0,78% (1,8) as the fourth place. For more details, please refer to Table 3.

Table 3.
The mean differences, standard deviations, and percentage improvements in pretest and posttest scores of leg explosive power for each treatment group

Explosive Power Training Metode	Explosive power exercise speed level of each group (n-=5)	Pre Test	Post Test	Differences	%
		$\bar{x}$ ± SD	$\bar{x}$ ± SD		
Plyometric Training (Hurdle Jump)	High (A1B1)	231,4 ± 4,88	236,4 ± 9,22	5	2,12
	Low (A1B2)	213,8 ± 3,37	225,4 ± 5,16	11,6	5,15
Weight Training (Lunges)	High (A2B1)	230,4 ± 5,85	232,2 ± 5,31	1,8	0,78
	Low (A2B2)	216 ± 3,74	220,2 ± 3,87	4,2	1,91

The results of this study also reported that the average leg explosive power scores of groups A1 and A2 were 230,90 ± 9,78 and 226,20 ± 8. For groups B1 and B2, the averages were 234,30 ± 8,23 and 222,80 ± 5,53. The average explosive power scores of groups A1B1 and A2B1 were 236,40 ± 10,31 and 232,20 ± 5,93. Meanwhile, A1B2 and A2B2 were 225,40 ± 5,77 and 220,20 ± 4,32. Table 3 shows that the A1B1 group had the highest average increase compared to the other treatment groups. The data are presented in Table 4 and Figure 2. While Table 5 shows the results of the normality and homogeneity test of the data which shows that the data are normal and homogeneous (P > 0.05). Figure 3 describes the normality plot and detrended plot.

Table 4.
The results of the leg explosive power of each treatment group

Group	*n*	Min	Max	*M* ± *SD*
A1	10	216	248	230,90 ± 9,78
A2	10	215	239	226,20 ± 8
B1	10	220	248	234,30 ± 8,23
B2	10	215	231	222,80 ± 5,53
A1B1	5	220	248	236,40 ± 10,31
A2B1	5	225	239	232,20 ± 5,93
A1B2	5	216	231	225,40 ± 5,77
A2B2	5	215	225	220,20 ± 4,32

Legend: The dependent variable is leg explosive power, the unit is seconds, "A1" is plyometric training (hurdle jumps) ,"A2" is weight training (lunges), "B1" is high speed, "B2" is low speed, "A1B1" is plyometric training (hurdle jumps) with high speed, "A2B1" is weight training (lunges) with high speed, "A1B2" is plyometric training (hurdle jumps) with low speed, "A2B2" is weight training (lunges) with low speed.

Table 5.
Normality and homogeneity testing

Normality test			Homogeneity test		
Shapiro-Wilk			Levene's		
Statistic	df	p	df1	df2	P
0.964	20	0.634	3	16	0.634

Legend: Data is normally distributed and homogeneous (P>0.05).

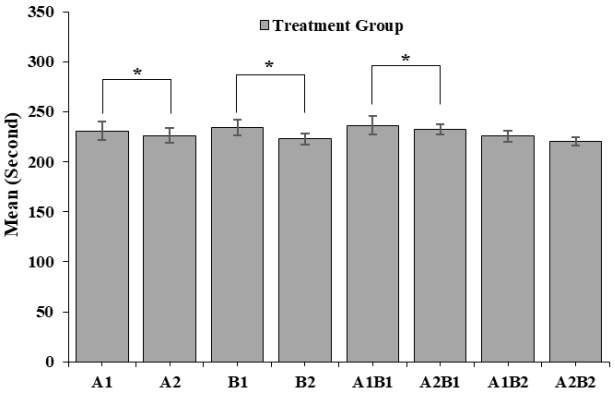

Figure 2. The average leg explosive power of each treatment group (*p<0.05) compared to each group. The data are presented with mean and standard deviation scores of leg explosive power.

Table 6 below presents the results of the two-way ANOVA test. The table shows that the explosive power results of groups A1 and A2 (P<0.05) and groups B1 and B2 (P<0.05) are significantly different. Figure 4 adds that there is a significant interaction between groups A and B (P<0.05). To determine which treatment group had a better effect on explosive power, a follow-up test was performed using the Tukey test.

As presented in Table 7, Tukey's further test analysis showed that group A1 was better than group A2 (P<0.05) in improving explosive power. This is evidenced by the average of 230,90 > 226,20. Likewise, the speed results in group B1 were better than group B2 (P < 0.05), as shown by an average of 234,30 > 222,80. Then, the explosive

power results in group A1B1 were significantly different from group A2B1 ($P < 0.05$), as evidenced by an average of 236,40 > 232,20. Furthermore, the explosive power results in the A1B1 group were the highest and much better than the A2B1 group ($P < 0.05$).

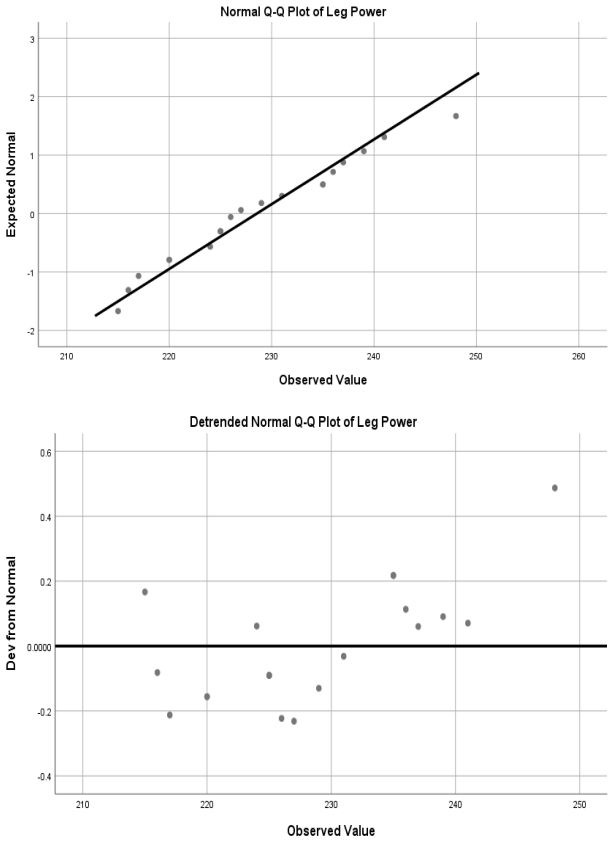

Figure 3. Graph of normality plot and Graph of detrended normality plot

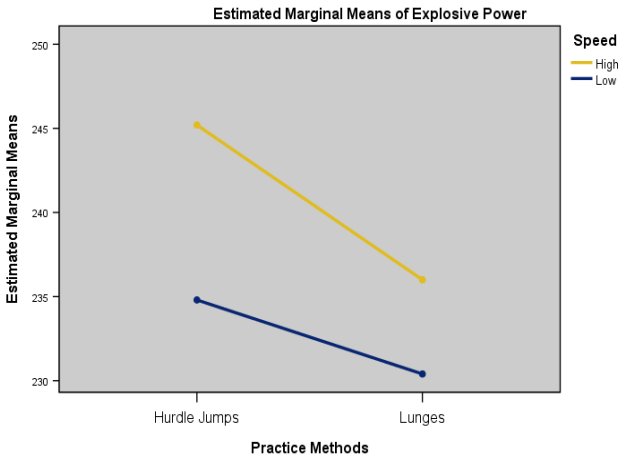

Figure 4. The interaction between explosive power training and speed

Table 6.
Two-way factorial ANOVA

Source	Type III Sum if Squares	*df*	Mean Square	*F*	*P*
Leg Explosive Power Training(A)	213,2	1	231,2	52,249	0.000
Speed (B)	320	1	320	72,316	0.000
Explosive Power Training (A) * Speed (B)	28,8	1	28,8	6,508	0.021

Legend: The dependent variable in this study was leg explosive power. A significant difference was observed between groups A1 and A2 in terms of "explosive power training (plyometric and weight training" ($P<0.05$), indicating its impact on leg explosive power. It was found that there was a significant difference recorded between groups B1 and B2 regarding "speed" ($P<0.05$). Furthermore, the interaction between the "leg explosive power training" and "speed" groups (A and B) had a significant effect on explosive power ($P<0.05$).

Table 7.
Tukey's test

Compare Groups	*P*	Conclusion
A1 and A2	0.000	Significant
B1 and B2	0.001	Significant
A1B1 and A2B1	0.000	Significant
A1B2 and A2B2	0.003	Significant

Legend: The dependent variable is explosive power. The difference is significant ($P < 0.05$).

Discussion

The findings of this study showed a significant effect of training methods on the explosive power of futsal players. This finding shows the effect that explosive power given with plyometric training is better than body weight training. Plyometrics uses exercises such as various types of jumps, skipping, and hopping to increase the efficiency of the muscle eccentric-concentric cycle. Jump training is usually associated with plyometric training and, in particular, with exercises that emphasize the musculotendinous unit (Ramirez-Campillo et al., 2018). Plyometric exercises given to players can make a good contribution to the player because when jumping the load is heavier (Norambuena et al., 2021; Peña et al., 2022; Yendrizal et al., 2024), so the muscle fibers work heavier and contract very strongly so that it can increase power (Sabillah et al., 2022). Plyometric training is a combination of strength and speed to create energy in jumps, as well as muscle elasticity which causes muscles to adjust, so that muscle coordination is better and can make strength more explosive (Booth & Orr, 2016). This corroborates previous research on the fact that plyometric training methods using the stretch-shortening cycle (SSC) (Coelho Bortoleto et al., 2024; Costa Nascimento et al., 2024; Cuenca-Soto et al., 2024; Flores Ferro et al., 2024), where muscles are stretched rapidly before concentric contractions, align more closely with actual movement patterns (sprinting and jumping) in competitive sports (Ramirez-Campillo et al., 2020). SSC training patterns offer more benefits in comparison to non-SSC training patterns (Bafirman et al., 2024; González Orb et al., 2024; Maldybayev et al., 2024), which can result in various structural adaptations (fiber type fiber composition and musculotendinous stiffness) and neuromuscular adaptations (motor unit recruitment, joint contraction, and reflex control) (Radnor et al., 2018; Wang et al., 2024). The findings are in line with previous research, Plyometric is a training method used by athletes that can be observed and plyometric training can also be tried on all types of exercise to increase strength, energy, and efficient explosives for children and young people (Elsayed, 2012; Indika et al., 2023; Rahayu et al., 2024).

The results also revealed an interaction between training method and speed on leg muscle explosive power. Plyometric training and body weight training with high speed were not significant. However, there was an increase in the group that had high speed. The leg muscle explosive power given with Plyometric Exercise has a good improvement compared to body weight exercise for high speed ability. At low speed also gives the same results where, the results of leg muscle explosiveness given with Plyometric Exercise have a good increase compared to body weight exercise. Power can be influenced by strength and speed, both the speed of nerve stimulation and the speed of muscle contraction (Sari, Bafirman, et al., 2023; Sari, Kurniawan, et al., 2023; Selviani et al., 2024). Muscle explosive energy produced by leg muscle strength affects horizontal to vertical momentum transfer (Loturco et al., 2018; Sari et al., 2024). This is influenced by the thrust energy resulting from the change in momentum because the jumping feature is a precision movement that must be attempted by concentrating muscle explosive energy (Anggun Permata Sari et al., 2024; Putra et al., 2021). Athletes who have strong leg muscle power are able to run more optimally (Kurniawan et al., 2024; Lockie et al., 2018). A person who has high leg muscle power will easily develop his running speed, both in his reaction speed (at the start) (Espinoza-Salinas et al., 2023; Firmansyah et al., 2024; Prieto González et al., 2020), acceleration of motion (in the first few meters), basic speed (as maximum speed) and at his speed stamina (speed endurance) when compared to someone who has low leg muscle power (L. A. Pereira et al., 2018).

In summary, this study shows the effect that the explosive power in leg muscles given with plyometric exercise is better than that with body weight exercise. High and low speed also affected leg muscle explosiveness. Based on the findings that showed an interaction between training method and speed. This study highlights the significant contribution of training method and speed on leg muscle explosiveness of futsal players. Both factors play an important role in improving players' performance on the field. Running, jumping and throwing are key components of athletic motor skill competencies that are essential for success in most sports. Athletes need to develop leg muscle strength by performing speed and acceleration movements then with specific movements in sports. Therefore, coaches certainly need to look at and consider the needs of the sport when training. The combined effect is greater than the sum of the individual effects, thus emphasizing the importance of incorporating power, strength, and speed training into the training routines of futsal players. This combination is expected to improve their performance in the sport specifically futsal. The findings provide valuable insights for coaches and athletes looking to improve their leg muscle explosiveness and overall competitive performance. The implications of the results of this study for players are how high one can jump, how far one can kick, and for the start when running, and most importantly can avoid collisions that cause injury. Then it can be taken into consideration for futsal coaches and practitioners in making the right training program to increase leg muscle explosiveness.

Conclusions

This study concluded that the significant effect between plyometric training (hurddle jump) is better than body weight training (LUNGES) on the explosive power of leg muscles of futsal players. This study also shows that high or low speed has a significant effect on leg muscle explosiveness in futsal games. In addition, there is a significant interaction between training methods and speed (high and low) on leg muscle explosiveness. The results of this study can be a guideline for futsal coaches and players in designing more effective training programs to improve leg muscle explosiveness in futsal games.

Conflicts of interest

The authors report that there is no potential conflict of interest.

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