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Contribution of leg muscle power and eye-foot coordination to football shooting results in PS UIR athletes

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Contribution of leg muscle power and eye-foot coordination to football shooting results in PS UIR athletes

Research Article

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INDONESIA**Abstract.****Background**

Shooting is one of the fundamental techniques that determine success in football, serving as the primary key to scoring goals and winning matches. Shooting performance is influenced not only by technical skills but also by the player's physical condition. Two physical components that are suspected to have a significant impact are leg muscle power and eye-foot coordination.

Objectives

This study aims to determine the extent of the contribution of leg muscle power and eye-foot coordination to shooting performance among PS UIR athletes.

Methods

The research employed a correlational method with a multiple correlation design. The population consisted of all PS UIR athletes, totaling 22 individuals, all of whom were included as the sample using a total sampling technique. The research instruments included the standing broad jump test to measure leg muscle power, an eye-foot coordination test, and a football shooting test.

Results

The results indicate that: (1) leg muscle power contributed 43.69% to shooting performance ($r = 0.661 > r\text{-table} = 0.423$), (2) eye-foot coordination contributed 32.83% ($r = 0.573 > r\text{-table} = 0.423$), and (3) the combined contribution of both variables reached 50.41% ($r = 0.710 > r\text{-table} = 0.423$).

Conclusion

It is concluded that leg muscle power and eye-foot coordination have a significant influence on shooting performance. These findings provide practical implications for coaches and athletes in designing more targeted and evidence-based training programs to improve shooting effectiveness during matches.

Keywords: leg muscle power, eye-foot coordination, soccer shooting.

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INTRODUCTION

Sports are activities that bring together players who share a passion for a particular sport, despite their different backgrounds, on one field. Sports need to be promoted and popularised as part of efforts to improve the overall quality of Indonesian people. The importance of sports development and promotion is outlined in the Regulation of the Minister of Youth and Sports of the Republic of Indonesia (Peraturan Menteri Pemuda Dan Olahraga Republik Indonesia, 2022) on the National Sports Development Roadmap for the Period 2021-2024, Article 3, Section 1, Paragraph 4, which states: "Sports encompass all aspects related to sports that require regulation, education, training, development, improvement, supervision, and evaluation."

Based on the above regulation, it can be concluded that development in sports activities can be carried out through several stages, starting from introducing sports disciplines, monitoring, guiding, developing talents, and improving performance. All these stages can be implemented to ensure that development in sports activities is achieved in line with the objectives set. This is also supported by Balfasa (Yulianti et al., 2021) in explaining that sports performance can be achieved if the existing coaching system is well-planned and implemented. Sports coaching can be carried out at the regional or provincial level as the frontline in advancing national sports performance. Sports federations in each Province are expected to pay more attention and manage every form of sports activities in a planned, systematic, and professional manner.

One of the most popular sports among students, university students, and the general public is football. Football is one of the most beloved sports by the majority of people and has gained the sympathy of the Indonesian public. Football is also enjoyed by all segments of society, from local,

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national, and international levels, as well as children, adults, and the elderly. The objective of the game is to score goals by manipulating the ball with the feet. Each team consists of eleven main players and is allowed to have substitute players. To achieve good performance in football, mastery of basic techniques is essential.

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Basic technical skills are essential in football; without good basic techniques, a team cannot win a match. Therefore, every player in a team or club must have good basic techniques to support their performance in a game. The basic techniques in football that players must master include passing (passing the ball), dribbling (dribbling the ball), throwing (throwing the ball), heading (heading the ball), and shooting (kicking). In this study, the basic technique to be discussed is shooting. Shooting is a kick towards the goal. This technique is simple but requires accuracy to score a goal. In football, shooting is the most effective way to score a goal. Shooting can be done in various ways, such as using the back of the foot, the tip of the foot, and the inside of the foot.

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In addition to technique, physical condition also influences the outcome of football shooting. In this study, the physical condition factors considered to have a strong influence on the outcome of football shooting are leg muscle power and eye-foot coordination. Lower limb muscle power is one of the most important components in performing shooting in football, as power essentially refers to the muscle's ability to exert maximum force in a very short time. This power influences the kick, resulting in a hard kick and a fast-moving ball. Therefore, lower limb muscle power is essential in performing shooting in football, which predominantly uses the lower body during shooting. In this context, coordination is required in almost all sports, including football. The coordination required of every football player is eye-foot coordination, as the eyes serve as the centre for observing the conditions on the field, while the feet play a role in controlling the ball. Foot movements must be synchronised with the direction of the eyes to easily align visual perception with foot movements.

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Recent studies further highlight the multifaceted nature of football performance and development. Abdulsatar, (2025) emphasizes the importance of cardiorespiratory fitness (CRF) and its correlation with maximum oxygen consumption (VO₂ max) among youth players, suggesting that individualized training based on physiological responses is crucial, especially in unique environmental contexts. Meanwhile, Chafidz et al., (2023) demonstrate that speed and agility training significantly enhance dribbling skills in young football players, underscoring the need to integrate physical conditioning with technical skill development. Ebrahim & Hussein, (2025) add that experiential learning strategies can effectively improve players' understanding and execution of fixed offensive plans, including decision-making and movement off the ball, which are vital tactical components.

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Moreover, psychological factors play a role in athlete performance and health awareness Ream & Jung, (2025) reveal that football players often exhibit confirmation bias regarding chronic traumatic encephalopathy (CTE) risks, prioritizing athletic identity over precautionary health measures. This insight suggests that communication and education strategies must consider athletes' identity to effectively address health risks. Finally, governance and technology management also impact football experience and fairness. Sulaiman et al., (2025) find that the introduction of Video Assistant Referee (VAR) technology in the Iraq Stars League has improved perceptions of refereeing fairness, although governance challenges and transparency issues persist. This points to the broader importance of systematic, transparent management in advancing the sport's development.

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Collectively, these insights reinforce that football development requires a holistic approach encompassing physical conditioning, technical skill mastery, cognitive and psychological factors, as well as effective governance and education. Such a comprehensive strategy is essential to nurturing well-rounded athletes capable of achieving high performance sustainably. One of the football clubs in Pekanbaru is PS UIR. PS UIR is a football club at the University of Islam Riau. The chairman of PS UIR is Dr. Ir. H. Rosyadi, M.Si. PS UIR conducts training sessions three times a week on Mondays, Wednesdays, and Saturdays in the afternoon at the football field on Jl. Kaharuddin Nasution, Riau Islamic University campus. PS UIR, as the football activity centre of Riau Islamic University, is trained by a football expert with a National C licence, Mr. Drs. Abrar. PS UIR has achieved notable accomplishments, including winning the 2023 ASKOT Pekanbaru League Championship, finishing as runner-up in the 2019 U21 Menpora Cup, and finishing as runner-up in the 2016 U20 Student League Menpora Cup. However, these achievements have not been sustained, as PS UIR has not achieved any further accomplishments to date.

Burhan, in the journal(Gunadi et al., 2020), stated that leg muscle power plays a significant role in the success of shots on goal. Leg muscle strength is needed to support the legs so that the ball can be kicked powerfully. Strong leg power results in a stronger thrust from the legs, which makes the ball

difficult for the goalkeeper to catch. According to Bompa, as quoted by (Kusuma et al., 2014), kicking the ball on goal requires several requirements, in addition to strength. According to (Cahyono & Sin, 2023), in soccer, leg muscle power is a crucial element. This organ plays a vital role in the game, especially when it comes to shooting accuracy. Shooting, or kicking at a goal, involves moving the ball toward the target using the feet or any part of the feet. Shooting the ball on goal requires leg muscle power to produce a powerful, fast, and targeted shot, or to hit the designated target.

Then, according to (Anas, 2018), physical conditions that support the ability to shoot on goal using the inside of the foot include leg muscle strength. In kicking a goal, strength is used to produce a fast, powerful, and accurate kick. A player who wants to kick hard and wants to determine the direction to be aimed, needs to pay attention to a very important aspect, namely, leg muscle strength. According to (Mielke, 2003), the way to shoot is to approach the ball from a slightly sideways direction, not a straight line. Try to keep your steps short and fast. Place the foot that is not used for kicking or the supporting foot approximately one step beside the ball, with the toe facing the goal. Pull the leg used for kicking behind the body with a bend of approximately 90 degrees.

According to (Emral, 2017), the main indicators of coordination are accuracy and economical movement. Coordination is the result of the combination of muscle, bone, and joint performance and quality in producing an effective and efficient movement. The components of movement, which consist of energy, muscle contraction, nerves, bones, and joints, constitute neuromuscular coordination. According to (Afrinaldi et al., 2021), eye-foot coordination in football is also important in determining the accuracy of a kicked ball. Good eye-foot coordination in football is expected to improve the accuracy of shots on goal, resulting in goals. According to (Putra & Riduwan, 2019), in football, eye-foot coordination occurs when actively coordinating the roles of the feet and eyes in performing a series of technical movements in football, especially during shooting. The coordination that plays a very important role is eye-foot coordination. Furthermore, (Kurniawan & Alficandra, 2023) state that in football, eye-foot coordination is an absolute necessity in playing the game.

Meanwhile, according to (Susanto & Kamarudin, 2022), a footballer's eye-foot coordination enables them to kick the ball well and quickly, as the player can combine several movement elements and perform an efficient ball kick. The kick must be executed correctly so that the ball travels as intended by the kicker (Henjilito et al., 2022). According to (Hasrion et al., 2020), one of the fundamental techniques that significantly influence scoring is the basic technique of shooting the ball into the goal. According to (Adityatama, 2017), the accuracy of shooting the ball into the football goal is one of the basic techniques in football, but is quite difficult to learn, especially for players who are not yet skilled. When performing a shot, the following aspects need to be considered: the approach, the accuracy of the steps, the contact between the foot and the ball, the timing of releasing the ball, the follow-through movement, the goalkeeper's position, and the accuracy of the shot (Zainuddin et al., 2022).

Furthermore, (Charles & Rook, 2012) explain that one way to train shooting ability is for each player to advance one by one while passing the ball towards the centre of the field, then running to catch up with the ball. (Peng & Tang, 2022) mentions that a good shooting kick in football heavily relies on strong leg muscle power. According to (Anas, 2018), physical conditions that support shooting ability towards the goal using the inner part of the foot include leg muscle strength. (Luxbacher, 2013) explains the common mistakes made when shooting are: 1) the shot goes over the goal line. 2) The shot lacks power. 3) The shot goes wide of the goal. 4) The player fails to kick the ball with the instep. Based on observations conducted on PS UIR players, it was found that the shooting ability of some PS UIR players towards the goal is still relatively weak. This is evident from the low speed of the ball when it is kicked towards the goal, which is caused by the lack of strength in the kick, making it easy for the opposing goalkeeper to anticipate. The low shooting accuracy also results in a low number of goals scored by PS UIR in matches. Based on these problems, it is necessary to conduct research to investigate the influence of leg muscle power and eye-foot coordination on the shooting ability of PS UIR players.

METHOD

Participants

The population in this study consisted of 22 football players from PS UIR. To ensure data homogeneity and representativeness, the total sampling technique was used, where the entire population was included as the sample. Thus, the number of participants in this study was 22 individuals, all of whom are active players of the PS UIR football team.

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Research Design

This study employed a multiple correlation research design, which is a statistical approach used to examine the relationship between two or more independent variables and one dependent variable (Arikunto, 2014). The independent variables in this study were leg muscle power (X1) and eye-foot coordination (X2), while the dependent variable was football shooting performance (Y). Data were collected using performance-based tests for each variable: a standing broad jump test for leg muscle power, an eye-foot coordination test, and a football shooting test to measure shooting accuracy and power. Additional data collection techniques included observation, literature review, and measurement.

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Data Analysis

The data analysis in this study involved several statistical methods. First, the Pearson product-moment correlation formula was used to calculate the relationship between X1 (leg muscle power) and Y (shooting performance), and also between X2 (eye-foot coordination) and Y. To determine the combined relationship between both independent variables (X1 and X2) and the dependent variable (Y), a multiple correlation formula was used. Additionally, the F-test (F-calculated formula) was applied to assess the partial or simultaneous significance of the correlations. The coefficient of determination (R^2) was then used to determine the percentage contribution of leg muscle power and eye-foot coordination to football shooting performance.

RESULTS AND DISCUSSION

Results

Based on descriptive data from the standing broad jump test results for 22 respondents, a minimum score of 157 cm and a maximum score of 237 cm was obtained, with an average (mean) of 189.91 cm. The standard deviation (STDV) of 23.38 indicates a moderate variation or distribution of scores among test participants. The median score of 182 cm indicates that half of the participants scored below or equal to 182 cm, while the mode score of 178 cm indicates that this score was the most frequently occurring score. Overall, the distribution of this data tends to be slightly spread out, indicating that most participants have standing broad jump abilities that are close to the average. Based on the frequency distribution of the standing broad jump results for the 22 participants, the majority of participants fell within the 173–188 cm range, representing 8 participants (36.36%), the largest group. It was suggested that 5 people (22.73%) were in the 157–172 cm interval, and 3 people (13.64%) were in the 189–204 cm, 205–220 cm, and 221–237 cm intervals. This indicates that most participants have standing long jump abilities that are classified as medium, with a few participants in the very high or very low categories. The fairly even distribution of frequencies in the three upper groups also reflects the existence of performance variations between individuals, although they remain in the medium interval. For more details, please see the following table:

Table 1. Frequency Distribution of Leg Muscle Power (X1) in PS UIR Athletes

No	Interval	Absolute Frequency	Relative Frequency
1	157	172	22,73%
2	173	188	36,36%
3	189	204	13,64%
4	205	220	13,64%
5	221	237	13,64%
Amount		22	100%

After analyzing the data through descriptive data distribution, the results of the study showed a significant contribution between muscle strength and shooting performance in PS UIR athletes, with a correlation coefficient (r) of 0.661 and a determination coefficient (R^2) of 43.69%. The calculated r value, which is greater than the table r ($0.661 > 0.423$), indicates that the relationship between the two variables is real and statistically significant. This means that the higher an athlete's muscle strength, the better their shooting performance they can achieve. Muscle strength and fitness are crucial components of physical condition in soccer, particularly in performing basic shooting techniques. Strong legs generate a significant propulsive force on the ball, allowing it to travel at optimal speed and distance toward the target. In this context, the results of the study support the theory that muscle strength directly influences the power and accuracy of shots on goal.

The 43.69% contribution indicates that nearly half of the PS UIR athletes' shooting performance is influenced by muscle strength and fitness. This demonstrates the importance of physical training focused on leg muscles, such as through plyometric exercises, squats, leg presses, and short sprints. These training programs need to be systematically incorporated into athletes' daily training routines to improve their shooting effectiveness in matches. However, there are still 56.31% of other factors influencing shooting results that were not examined in this study. These factors could include shooting technique, coordination, mental focus, confidence, or field and equipment conditions. Therefore, while the strength of the surrounding muscles contributes significantly, coaches and athletes still need to develop other technical and psychological aspects to achieve optimal shooting performance.

44 The Contribution of Eye-Foot Coordination to Soccer Shooting Results in PS UIR Athletes

Based on descriptive data from the eye-foot coordination test results for 22 participants, a minimum score of 2 and a maximum score of 12 were obtained, with an average (mean) of 6.14. The standard deviation (STDV) of 2.96 indicates significant variation in eye-foot coordination ability among participants. The median score of 5 indicates that half of the participants scored at or below 5, while the mode score of 3 indicates that this score was the most frequent. Overall, these results indicate that most participants still have low to moderate levels of eye-foot coordination, and there are significant differences between participants.

The frequency distribution of the eye-foot coordination test for 22 participants shows that the majority of participants fell within the 4-5 range, with 7 participants (31.82%), making up the largest group. This was followed by the 2-3 and 8-9 ranges, with 5 participants each (22.73%). Meanwhile, only two participants (9.09%) were in the 6-7 and 10-11 ranges, and only one (4.55%) reached the highest 12-13 range. This distribution pattern indicates that participants' eye-foot coordination abilities tended to be concentrated in the low to moderate categories, with only a small proportion having very high abilities. This underscores the importance of training that focuses on improving coordination abilities to achieve optimal performance in sports like soccer. For more details, see the following table:

Table 2. Frequency Distribution of Eye-Foot Coordination (X2) in PS UIR Athletes

No	Interval	Absolute Frequency	Relative Frequency
1	2	3	22,73%
2	4	5	31,82%
3	6	7	9,09%
4	8	9	22,73%
5	10	11	9,09%
6	12	13	4,55%
Amount		22	100%

After analyzing the data through descriptive data distribution, the results of this study indicate that eye-foot coordination significantly contributes to soccer shooting results in PS UIR athletes, with a calculated r value of 0.573, which is greater than the r table value of 0.423, and a coefficient of determination (R^2) of 32.83%. This means that almost one-third of the variation in shooting results can be explained by the athlete's eye-foot coordination ability. This finding suggests that the better the coordination between vision and foot movement, the more effective the athlete's shooting results will be. Eye-foot coordination is the ability to align what the eyes see with foot movements precisely and quickly. In the context of soccer shooting, this coordination is crucial because athletes must be able to accurately control the position of the ball, the viewing angle, and the timing and power of their kicks. Weaknesses in this coordination will result in off-target shots, lack power, or are easily blocked by the opponent. Therefore, eye-foot coordination is a motor aspect that directly influences the success of shooting technique.

The 32.83% contribution also confirms that exercises focused on developing coordination deserve greater attention in soccer training programs. Exercises such as juggling, bouncing, small ball drills, and visual reaction games to the ball's movement can help improve athletes' eye-foot coordination. These exercises not only improve accuracy and precision but also improve reaction time when shooting under pressure. However, 67.17% of the time, other factors influence shooting results beyond eye-foot coordination. These factors can include leg muscle power, basic technique, concentration, decision-making, and the playing environment. Therefore, to achieve optimal shooting

results, athletes must train comprehensively and synergize all physical, technical, and mental components that support successful shooting in soccer.

Contribution of Leg Muscle Power and Eye-Foot Coordination to Soccer Shooting Results in PS UIR Athletes

Based on descriptive data from the soccer shooting test results of 22 participants, a maximum score of 15 and a minimum score of 5 were obtained, with an average (mean) of 10.73. The median score of 11 indicates that half of the participants scored at or above that number, while the mode score of 14 was the most frequently occurring score. The standard deviation (STDEV) of 2.99 indicates a moderate spread of scores from the mean. Overall, these data indicate that most participants have quite good shooting ability, with a tendency for performance to be above the average, despite differences in skill level among participants. Based on descriptive data from the soccer shooting test results of 22 participants, a maximum score of 15 and a minimum score of 5 were obtained, with an average (mean) of 10.73. The median score of 11 indicates that half of the participants scored at or above that number, while the mode score of 14 was the most frequently occurring score. The standard deviation (STDEV) of 2.99 indicates a moderate spread of values from the mean. Overall, this data indicates that most participants have fairly good shooting skills, with a tendency for performance to be above average, although there are differences in skill level among participants. For more details, see the following table:

Tabel 3. Frequency Distribution of Soccer Shooting Results (Y) in PS UIR Athletes

No	Interval	Absolute Frequency	Relative Frequency
1	5	6	9,09%
2	7	8	13,64%
3	9	10	22,73%
4	11	12	22,73%
5	13	15	31,82%
Amount		22	100%

Discussion

After analyzing the data through descriptive data distribution, the results of this study indicate a significant simultaneous contribution of leg muscle power and eye-foot coordination to soccer shooting results in PS UIR athletes. This is evidenced by the calculated r value of 0.710, which is greater than the r table of 0.423, and the coefficient of determination (R^2) value of 50.41%. This means that more than half (50.41%) of the variation in shooting results can be explained by the combination of these two independent variables. In other words, athletes with good leg muscle strength and trained eye-foot coordination tend to have superior shooting abilities. This dual contribution illustrates the synergistic relationship between physical strength and coordination skills. Leg muscle power plays a crucial role in providing power to kicks, while eye-foot coordination helps direct the ball precisely to the intended target. These two abilities complement each other: without strength, a kick can be weak, and without coordination, a kick can be off target. Therefore, effective shooting requires both aspects to work optimally and simultaneously.

In practice on the field, soccer athletes with strong leg muscles can produce kicks with high speed and propulsion. However, this strength must be balanced with good foot-eye coordination to ensure the ball is not only fast but also accurate. Poor coordination can lead to poor timing or an inaccurate contact point with the ball, resulting in an ineffective kick. The results of this study align with theories in sports coaching that emphasize the importance of synergy between strength and coordination in soccer skills. Furthermore, the 50.41% contribution indicates that other factors still influence an athlete's shooting performance by 49.59%. These factors can stem from the shooting technique used, decision-making ability under pressure from opponents, psychological factors such as self-confidence and concentration, and external conditions such as field conditions and weather. Therefore, athlete coaching should not only focus on physical aspects and coordination but also encompass technical and mental aspects comprehensively.

These findings also provide important implications for coaches in developing training programs. As supported by (Jatra et al., 2024), training programs that integrate physical, technical, mental, and emotional components have been proven to enhance athletic skill development more effectively than traditional methods. This reinforces the idea that coaching should not only address isolated abilities but also promote synergy among different performance factors. Coaches must ensure that leg muscle power and coordination training are conducted simultaneously and continuously. Some forms of training that can be implemented include plyometric exercises for leg strength, as well as juggling, reaction ball, and

cone dribbling exercises for foot-eye coordination. With comprehensive coaching, athletes' shooting results can be significantly improved. Overall, the results of this study reinforce the view that shooting in soccer is not just a matter of strength, but also an integrated coordination skill. The combination of leg muscle power and foot-eye coordination contributes significantly to an athlete's success in scoring goals. Therefore, a holistic, scientifically based training approach like this is crucial for optimally developing an athlete's potential, especially when facing competitive competition at the collegiate and professional levels.

This research is relevant to the research conducted by (Yulianti, 2017) entitled "The Relationship Between Leg Muscle Power, Flexibility, and Eye-Foot Coordination with Shooting Accuracy in Male Players Aged 13-14 Years of Mars SSB Club, Surakarta" which shows that there is a significant relationship between leg muscle power, flexibility, and eye-foot coordination with shooting ability. The results of statistical analysis show that leg muscle power has a correlation of $r = 0.437$, eye-foot coordination $r = 0.418$, and a simultaneous contribution of $R^2 = 0.489$ or 48.9%. This research is very relevant because it supports the findings in PS UIR athletes, where leg muscle power contributed 43.69% and eye-foot coordination 32.83% to shooting results, and a joint contribution of 50.41%. Thus, in both young players and students, the power and coordination components are proven to significantly influence shooting accuracy.

Furthermore, a study by Juliarta et al. (2022) entitled "The Relationship Between Leg Muscle Strength and Eye-Foot Coordination with Soccer Shooting Ability in SSB Negaroa U-15" provides a stronger picture of the influence of these two variables on shooting. With a correlation of $r = 0.910$ for leg muscle strength and $r = 0.930$ for eye-foot coordination, and a simultaneous correlation of $r = 0.940$, this study shows that both variables together contribute 88% to shooting ability. While this figure is higher than the results of the PS UIR study, this is understandable considering that the study subjects were adolescent athletes in a phase of rapid motor development. However, these results still reinforce the conclusion that leg strength and eye-foot coordination are two key factors that cannot be ignored in improving shooting accuracy. Furthermore, a study (Pratama, 2023) conducted on IRETA FC athletes entitled "Correlation of Leg Muscle Explosive Power and Eye-Foot Coordination on Shooting Accuracy" also showed a significant contribution from these two variables. This study found that simultaneously, leg muscle explosive power and eye-foot coordination had a 66.1% influence on shooting accuracy, as obtained from correlation tests and multiple linear regression. This finding is between the results of previous studies and PS UIR, which showed that although there were variations from one group to another, the pattern of relationships between leg power and coordination with shooting results remained consistent and significant. This study further strengthens the theoretical basis that the success of soccer kicks is greatly influenced by specific physical conditions such as muscle strength and visual-motor coordination.

CONCLUSION

Eye-foot coordination is essential for every soccer player, as the eyes guide spatial awareness on the field, while the feet are responsible for ball control and execution. This study aimed to examine the contribution of leg muscle explosive power and eye-foot coordination to shooting performance in PS UIR athletes. Based on the findings, both variables were shown to significantly influence shooting outcomes. The explosive power of the leg muscles helps generate force and distance in shooting, while eye-foot coordination improves accuracy and timing. The research contributes valuable insights into the physical components that support technical skills in football, particularly shooting. These findings can be applied by coaches and trainers in developing targeted training programs that emphasize muscle power and coordination to improve shooting performance in players. For future research, it is recommended to explore additional variables that may affect shooting performance, such as mastery of basic techniques, mental focus, reaction time, or core muscle strength. Further studies could also include athletes from various age groups or competitive levels to broaden the understanding and applicability of the findings in different football training contexts.

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AUTHOR CONTRIBUTION STATEMENT

YAS designed the study, collected data, and performed statistical analysis. RJ provided input and revised the draft.

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