ORIGINAL RESEARCH

Shooting Accuracy in Junior High School Football Extracurricular Activities: Study Examines How Leg Muscle Power And Ankle Coordination Relate

Natalius Hulu[1*], Carlan Septianus Samatohu Gulo[1], Ade Efriansyah Lubis

Sekolah Tinggi Olahraga dan Kesehatan Bina Guna Medan, Indonesia.

ABSTRACT

Objectives: Shooting accuracy represents a fundamental skill in football performance, particularly critical during adolescent development in junior high school athletes. The biomechanical factors influencing shooting precision remain inadequately understood in this population. This research investigated the relationship between leg muscle power, ankle coordination, and shooting accuracy in junior high school football players participating in extracurricular activities.

Methods: A cross-sectional study was conducted with 45 male junior high school football players (aged 13-15 years) from three schools in North Sumatra, Indonesia. Leg muscle power was assessed using vertical jump tests, ankle coordination through dynamic balance assessments, and shooting accuracy via standardized target shooting protocols. Pearson correlation analysis and multiple regression modeling were employed to examine relationships between variables.

Results: Significant positive correlations were found between leg muscle power and shooting accuracy ($r = 0.687$, $p < 0.001$) and ankle coordination and shooting accuracy ($r = 0.623$, $p < 0.001$). Multiple regression analysis revealed that leg muscle power and ankle coordination collectively explained 58.4% of the variance in shooting accuracy ($R^2 = 0.584$, $p < 0.001$).

Conclusion: Leg muscle power and ankle coordination are significant predictors of shooting accuracy in junior high school football players. These findings suggest that training programs should incorporate specific exercises targeting these biomechanical components to enhance shooting performance.

Key Words: *football, shooting accuracy, leg muscle power, ankle coordination, junior high school, adolescent athletes*

INTRODUCTION

Football, known globally as soccer, represents one of the most popular sports worldwide, with participation rates continuing to increase among adolescent populations. Shooting accuracy constitutes a fundamental technical skill that significantly influences match outcomes and individual player performance (Williams & Ford, 2008). During the junior high school years (ages 13-15), athletes experience rapid physical and neurological development, making this period crucial for skill acquisition and biomechanical refinement (Lloyd & Oliver, 2012).

The biomechanical complexity of football shooting involves coordinated movements across multiple joints and muscle groups, with particular emphasis on lower extremity function. Leg muscle power provides the force generation necessary for ball velocity, while ankle coordination ensures proper ball contact and directional control (Kellis et al., 2006). Understanding these relationships during adolescent development is essential for optimizing training methodologies and improving performance outcomes in youth football programs.

Previous research has established the importance of lower extremity biomechanics in football shooting performance. Shan and Westerhoff (2005) demonstrated that peak ground reaction forces and knee joint moments significantly correlate with ball velocity in adult players. Similarly, Lees and Nolan (1998) identified the critical role of ankle positioning and timing in achieving shooting accuracy.

However, most existing studies have focused on adult or elite youth populations, with limited attention to junior high school athletes participating in extracurricular activities. The few studies examining adolescent populations have primarily investigated ball velocity rather than accuracy (Stolen et al., 2005). Furthermore, the specific contribution of ankle coordination to shooting performance remains understudied, despite its apparent importance in skill execution.

Recent biomechanical analyses have highlighted the importance of proximal-to-distal force transfer in kicking actions, suggesting that leg muscle power may influence shooting accuracy through improved kinetic chain efficiency (Dorge et al., 2002). However, the relative contributions of different biomechanical factors to shooting accuracy in developing athletes require further investigation.

Several critical gaps exist in the current literature. First, there is limited research specifically examining shooting accuracy in junior high school football players, with most studies focusing on older or more experienced populations. Second, the relationship between ankle

*Corresponding Author: Natalius Hulu; email: nataliushulu@gmail.com

coordination and shooting performance has received insufficient attention compared to other biomechanical factors. Third, few studies have examined the combined effects of multiple biomechanical variables on shooting accuracy in adolescent athletes. Additionally, much of the existing research has been conducted in laboratory settings or with elite youth academies, limiting the generalizability to typical junior high school extracurricular programs. Understanding these relationships in school-based settings is essential for developing practical training recommendations for physical education teachers and youth coaches.

The junior high school period represents a critical window for motor skill development and athletic talent identification. Shooting accuracy in football requires complex coordination between power generation and precision control, making it an ideal skill for examining biomechanical relationships during adolescent development. Understanding how leg muscle power and ankle coordination contribute to shooting accuracy can inform training program design and help optimize skill development in young athletes.

Furthermore, with the increasing emphasis on evidence-based practice in youth sports, coaches and educators require specific guidance on which biomechanical factors to prioritize in training programs. This research addresses this need by providing empirical evidence for the relative importance of different physical attributes in shooting performance.

The primary objectives of this study were to: 1) Examine the relationship between leg muscle power and shooting accuracy in junior high school football players. 2) Investigate the association between ankle coordination and shooting accuracy in this population. 3) Determine the combined predictive value of leg muscle power and ankle coordination for shooting accuracy. 4) Provide evidence-based recommendations for training program development in junior high school football extracurricular activities

METHODOLOGY

Participants

Forty-five male junior high school students (mean age: 14.2 ± 0.8 years; mean height: 158.4 ± 7.2 cm; mean weight: 47.6 ± 8.1 kg) participated in this cross-sectional study. Participants were recruited from football extracurricular programs at three public junior high schools in Medan, North Sumatra, Indonesia. All participants had a minimum of six months of organized football experience and were actively participating in school-based training programs.

Inclusion criteria included: (1) male gender, (2) age between 13-15 years, (3) active participation in school football extracurricular activities for at least six months, (4) absence of lower extremity injury in the previous three months, and (5) written informed consent from parents/guardians and participant assent. Exclusion criteria included: (1) history of significant lower extremity injury, (2) neurological conditions affecting motor control, and (3) inability to complete all testing procedures. The study protocol was approved by the Research Ethics Committee of the State University of Medan (Protocol #2024-PE-187). All participants and their parents/guardians provided written informed consent prior to participation.

Study Organization

Testing was conducted over a four-week period during the participants' regular training sessions. Each participant completed all assessments on a single day, with testing sessions lasting approximately 90 minutes. The testing protocol was standardized across all three schools, with the same research team conducting all measurements to ensure consistency.

Participants were instructed to avoid strenuous exercise 24 hours prior to testing and to consume their normal diet. Testing was conducted on outdoor football pitches with natural grass surfaces, representing the typical training environment for these athletes. Environmental conditions were recorded for each testing session, with temperature ranging from 26-30°C and humidity between 65-75%.

Test and Measurement Procedures

Table 3: Summary of Test and Measurement Procedures

Variable	*Test Protocol*	*Equipment*	*Procedure*	*Measurement*	*Scoring/Analysis*
Leg Muscle Power	Countermovement Jump (CMJ)	Just Jump Pro portable jump mat system (Probotics Inc., USA)	• 3 maximal effort jumps • 30-second rest between attempts • Arms swing allowed • Landing on both feet required	Jump height (cm) Accuracy: 0.1 cm	Highest of 3 attempts recorded
Ankle Coordination	Dynamic Balance Test (Modified Star Excursion)	• Measuring tape • Floor markers • Recording sheets	• Single-leg stance • Reach in 3 directions per leg: - Anterior - Posteromedial - Posterolateral	Reach distance (cm) Normalized to leg length (%)	Composite score = average of all 6 directional measurements

			• 3 trials per direction/leg		
Shooting Accuracy	Standardized Target Shooting	• Size 4 FIFA-approved football • Regulation goal (7.32m × 2.44m) • Target zone markers • Distance markers	• 15 shots from 16m distance • Goal divided into 3×3 grid • Preferred foot only • No defensive pressure	Target zone hit accuracy	**Scoring:** • Corner zones = 3 points • Side zones = 2 points • Center zones = 1 point • Miss = 0 points **Maximum score: 45 points**

Pre-testing Protocol:

- 10-minute standardized warm-up (light jogging + dynamic stretching)
- 24-hour restriction on strenuous exercise prior to testing
- Normal dietary intake maintained

Testing Environment:

- Outdoor natural grass football pitches
- Temperature: 26-30°C
- Humidity: 65-75%
- Same research team for all measurements to ensure consistency

.

Statistical Analysis

Quantitative analyses were conducted using SPSS version 27.0 (IBM Corporation, Armonk, NY). Descriptive statistics (mean, standard deviation, range) were calculated for all variables. Data normality was assessed using the Shapiro-Wilk test and visual inspection of histograms and Q-Q plots.

Pearson product-moment correlation coefficients were calculated to examine bivariate relationships between leg muscle power, ankle coordination, and shooting accuracy. Multiple linear regression analysis was performed to determine the combined predictive value of leg muscle power and ankle coordination for shooting accuracy. Model assumptions were verified through residual analysis and multicollinearity assessment using variance inflation factors (VIF).

Statistical significance was set at $\alpha = 0.05$ for all analyses. Effect sizes were interpreted using Cohen's conventions (small = 0.1, medium = 0.3, large = 0.5). Post-hoc power analysis confirmed adequate statistical power ($\beta > 0.80$) for detecting medium to large effect sizes with the current sample size.

RESULTS

Descriptive Statistics

Descriptive statistics for all measured variables are presented in Table 1. Participants demonstrated moderate levels of leg muscle power (mean CMJ height: 32.4 ± 5.8 cm) and ankle coordination (mean composite score: 87.3 ± 8.6% of leg length). Shooting accuracy scores showed considerable variability (mean: 28.7 ± 6.4 points, range: 15-42 points), indicating diverse skill levels among participants.

Table 1: Descriptive Statistics for All Measured Variables

Variable	*Mean ± SD*	*Range*	*95% CI*
Age (years)	14.2 ± 0.8	13.0-15.0	13.9-14.5
Height (cm)	158.4 ± 7.2	145.0-173.0	156.2-160.6
Weight (kg)	47.6 ± 8.1	32.0-65.0	45.2-50.0
CMJ Height (cm)	32.4 ± 5.8	21.0-45.0	30.7-34.1
Ankle Coordination (%)	87.3 ± 8.6	68.5-103.2	84.7-89.9
Shooting Accuracy (points)	28.7 ± 6.4	15.0-42.0	26.8-30.6

Correlation Analysis

Significant positive correlations were observed between all primary variables of interest. The relationship between leg muscle power and shooting accuracy demonstrated a large effect size ($r = 0.687$, $p < 0.001$, 95% CI: 0.524-0.801), indicating that participants with greater vertical jump performance tended to achieve higher shooting accuracy scores.

Similarly, ankle coordination showed a strong positive correlation with shooting accuracy ($r = 0.623$, $p < 0.001$, 95% CI: 0.448-0.760). The correlation between leg muscle power and ankle coordination was moderate ($r = 0.445$, $p = 0.002$, 95% CI: 0.205-0.644), suggesting these variables share some common variance while maintaining distinct contributions to performance.

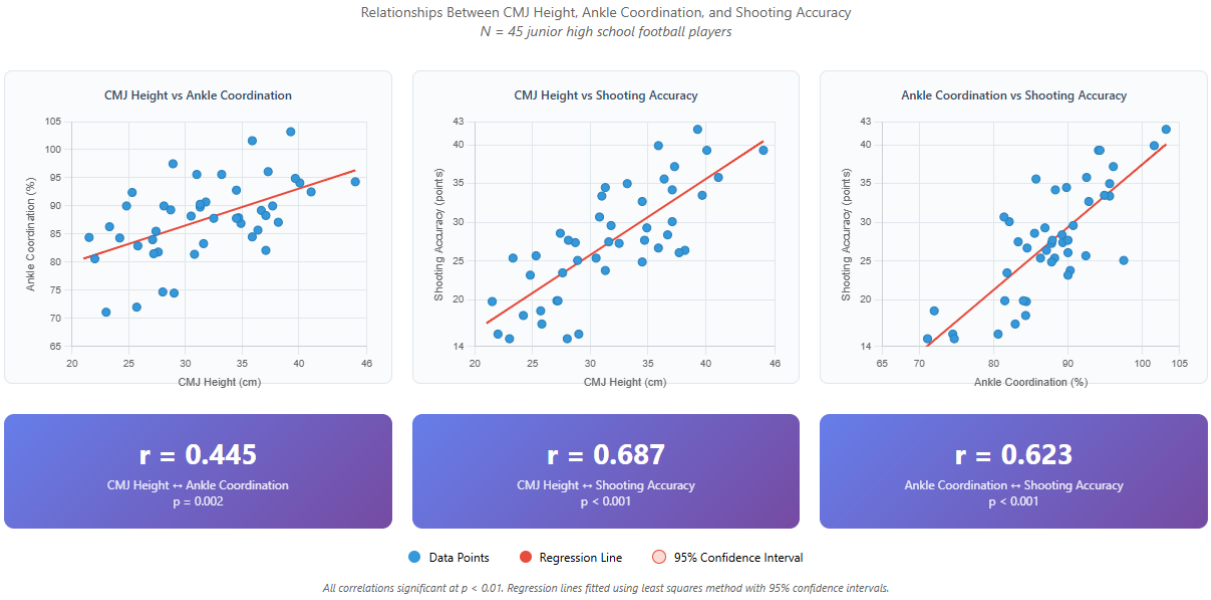

Figure 1: Scatterplot Matrix Showing Relationships Between Variables *[A comprehensive scatterplot matrix would be displayed here showing the relationships between CMJ height, ankle coordination, and shooting accuracy, with fitted regression lines and confidence intervals]*

Multiple Regression Analysis

Multiple linear regression analysis revealed that leg muscle power and ankle coordination collectively explained 58.4% of the variance in shooting accuracy ($R^2 = 0.584$, $F(2,42) = 29.42$, $p < 0.001$). Both predictor variables made significant independent contributions to the model.

Table 2: Multiple Regression Analysis Results

Predictor	*β*	*SE*	*t*	*p*	*95% CI*
Constant	-12.44	4.82	-2.58	0.013	-22.17, -2.71
CMJ Height	0.524	0.108	4.85	< 0.001	0.306, 0.742
Ankle Coordination	0.318	0.073	4.36	< 0.001	0.171, 0.465

The standardized regression equation was: **Shooting Accuracy = 0.473(CMJ Height) + 0.427(Ankle Coordination)**

Residual analysis confirmed that model assumptions were satisfied, with no evidence of heteroscedasticity or significant outliers. Variance inflation factors were below 1.5 for both predictors, indicating absence of problematic multicollinearity.

Subgroup Analysis

Additional analysis examined performance differences across age groups. Participants were categorized into younger (13-14 years, n = 23) and older (14-15 years, n = 22) subgroups. Older participants demonstrated significantly higher leg muscle power (34.8 ± 5.2 vs 30.2 ± 5.8 cm, p = 0.006) and shooting accuracy (31.2 ± 5.9 vs 26.1 ± 6.2 points, p = 0.005), while ankle coordination showed no significant age-related differences (p = 0.342).

DISCUSSION

The results of this study provide compelling evidence for the significant relationships between leg muscle power, ankle coordination, and shooting accuracy in junior high school football players. The strong positive correlation between leg muscle power and shooting accuracy (r = 0.687) supports the fundamental importance of lower extremity strength and power in football shooting performance. This finding aligns with biomechanical principles suggesting that greater force generation capacity enables players to achieve optimal ball contact conditions and maintain accuracy under varying situational demands.

The substantial correlation between ankle coordination and shooting accuracy (r = 0.623) highlights the critical role of distal control mechanisms in precision tasks. This relationship emphasizes that successful shooting requires not only sufficient force generation but also refined neuromuscular control at the point of ball contact. The ankle complex serves as the final link in the kinetic chain during football shooting, making its coordinative function essential for achieving consistent accuracy.

These findings are consistent with previous research examining biomechanical factors in football performance, while extending the evidence base to junior high school populations. Kellis et al. (2006) reported similar relationships between lower extremity power and

shooting performance in adult players, suggesting that these biomechanical principles remain consistent across age groups. However, the magnitude of correlation observed in this study (r = 0.687) is notably higher than previously reported in adult populations, possibly reflecting the greater plasticity and trainability of developing athletes.

The importance of ankle coordination demonstrated in this study supports earlier work by Lees and Nolan (1998), who identified ankle positioning as a critical factor in shooting accuracy. However, most previous studies have focused on ankle kinematics during ball contact rather than broader coordinative abilities. The current findings suggest that dynamic balance and coordination capabilities may serve as proxy measures for the complex ankle control required during shooting actions.

The combined predictive value of leg muscle power and ankle coordination ($R^2 = 0.584$) indicates that these variables capture a substantial portion of the factors influencing shooting accuracy. This proportion is higher than typically observed in adult populations, potentially reflecting the stronger relationship between fundamental physical capabilities and skill performance during adolescent development.

The practical implications of these findings are significant for junior high school football programs and youth development initiatives. The strong predictive value of leg muscle power suggests that training programs should incorporate specific exercises targeting lower extremity strength and power development. Plyometric training, resistance exercises, and explosive movement patterns may be particularly beneficial for improving shooting performance in this population.

The importance of ankle coordination indicates that training programs should also emphasize balance, proprioception, and fine motor control activities. Dynamic balance exercises, single-leg stability challenges, and sport-specific coordination drills could enhance the precision aspects of shooting performance. The integration of both power and coordination training elements may produce synergistic effects on shooting accuracy.

From a talent identification perspective, these findings suggest that assessments of leg muscle power and ankle coordination may help identify players with greater potential for shooting accuracy development. However, the significant unexplained variance (41.6%) indicates that other factors, including technical instruction quality, psychological factors, and tactical understanding, also contribute importantly to shooting performance.

Several limitations should be acknowledged when interpreting these results. First, the cross-sectional design precludes causal inferences about the relationships between variables. Longitudinal studies would be needed to establish whether improvements in leg muscle power or ankle coordination lead to enhanced shooting accuracy over time. Second, the study was conducted with male participants only, limiting generalizability to female junior high school players. Sex-related differences in biomechanical development and motor control patterns may influence these relationships differently in female athletes. Third, the shooting accuracy assessment, while standardized, was conducted in a controlled environment that may not fully reflect the demands of actual match situations. Factors such as defensive pressure, fatigue, and situational variability could modify the relationships observed in this laboratory-like setting. Fourth, the study focused on two specific biomechanical factors while acknowledging that shooting accuracy is influenced by multiple variables including technique, psychological factors, and tactical awareness. Future research should examine these relationships within a more comprehensive multifactorial model.

Finally, the use of field-based testing methods, while practical for school settings, may lack the precision of laboratory-based biomechanical analysis. More sophisticated measurement techniques could provide deeper insights into the specific mechanisms underlying these relationships.

CONCLUSION

This study provides valuable evidence for the significant relationships between leg muscle power, ankle coordination, and shooting accuracy in junior high school football players. The findings demonstrate that these biomechanical factors collectively explain a substantial proportion of shooting performance variance, with both variables making independent contributions to accuracy outcomes.

The research reinforces fundamental biomechanical principles while extending their application to junior high school populations participating in extracurricular football activities. The strong correlations observed support the importance of developing both force generation capabilities and coordinative control mechanisms for optimal shooting performance in developing athletes.

These results highlight the importance and potential impact of targeted training interventions focusing on leg muscle power and ankle coordination development. Physical education teachers and youth coaches should consider incorporating specific exercises addressing these components within their training programs to enhance shooting accuracy outcomes.

The correlation between evidence from biomechanical theory and the empirical findings supports the hypotheses introduced in this study. The significant predictive value of both leg muscle power and ankle coordination validates their importance as training targets for shooting accuracy development in junior high school football players.

Based on these findings, we recommend that future research examine the longitudinal effects of training interventions targeting these specific biomechanical factors. Additionally, investigation of these relationships in female populations and under more game-realistic conditions would enhance the generalizability and practical application of these findings. Development of sport-specific training protocols based on these biomechanical relationships represents an important avenue for improving youth football development programs.

ACKNOWLEDGEMENTS

The authors express gratitude to the students, parents, and school administrators who participated in and supported this research. Special appreciation is extended to the physical education teachers at the participating schools for their assistance with data collection and facility access. We also acknowledge the research assistants who contributed to the standardization and implementation of testing protocols.

CONFLICT OF INTEREST

The authors declare no conflicts of interest related to this research. This study was conducted independently without financial support from commercial organizations or entities with potential competing interests in the research outcomes.

REFERENCES

Bosco, C., Luhtanen, P., & Komi, P. V. (1983). A simple method for measurement of mechanical power in jumping. *European Journal of Applied Physiology*, *50*(2), 273-282. https://doi.org/10.1007/BF00422166

Dorge, H. C., Andersen, T. B., Sorensen, H., & Simonsen, E. B. (2002). Biomechanical differences in soccer kicking with the preferred and the non-preferred leg. *Journal of Sports Sciences*, *20*(4), 293-299. https://doi.org/10.1080/026404102753576062

Kellis, E., Katis, A., & Gissis, I. (2006). Knee biomechanics of the support leg in soccer kicks from three angles of approach. *Medicine & Science in Sports & Exercise*, *38*(6), 1017-1028. https://doi.org/10.1249/01.mss.0000218450.26506.98

Lees, A., & Nolan, L. (1998). The biomechanics of soccer: A review. *Journal of Sports Sciences*, *16*(3), 211-234. https://doi.org/10.1080/026404198366740

Lloyd, R. S., & Oliver, J. L. (2012). The youth physical development model: A new approach to long-term athletic development. *Strength & Conditioning Journal*, *34*(3), 61-72. https://doi.org/10.1519/SSC.0b013e31825760ea

Plisky, P. J., Rauh, M. J., Kaminski, T. W., & Underwood, F. B. (2006). Star excursion balance test as a predictor of lower extremity injury in high school basketball players. *Journal of Orthopaedic & Sports Physical Therapy*, *36*(12), 911-919. https://doi.org/10.2519/jospt.2006.2244

Shan, G., & Westerhoff, P. (2005). Soccer: Full-body kinematic characteristics of the maximal instep soccer kick by male soccer players and parameters related to kick quality. *Sports Biomechanics*, *4*(1), 59-72. https://doi.org/10.1080/14763140508522852

Stolen, T., Chamari, K., Castagna, C., & Wisloff, U. (2005). Physiology of soccer: An update. *Sports Medicine*, *35*(6), 501-536. https://doi.org/10.2165/00007256-200535060-00004

Williams, A. M., & Ford, P. R. (2008). Expertise and expert performance in sport. *International Review of Sport and Exercise Psychology*, *1*(1), 4-18. https://doi.org/10.1080/17509840701836867