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Effects of power and hand–eye coordination on volleyball smash accuracy of vocational students

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ABSTRACT

This study aims investigated the effects of arm muscle power, leg muscle power, and hand–eye coordination on smash accuracy among male volleyball players at SMK Negeri 2 Kerinci. The research employed a quantitative design using path analysis to examine direct, indirect, and simultaneous relationships among variables. The population consisted of 30 male volleyball athletes, with total sampling applied. Arm muscle power was measured using the one-hand medicine ball put test, leg muscle power using the vertical jump test, hand–eye coordination using the ball werfen und fangen test, and smash accuracy through a standardized smash accuracy test. Data were analyzed using path analysis at a significance level of $\alpha = 0.05$. The results showed that arm muscle power, leg muscle power, and hand–eye coordination each had significant direct effects on smash accuracy, with hand–eye coordination contributing the strongest influence. In addition, arm and leg muscle power exerted significant indirect effects on smash accuracy through hand–eye coordination. Simultaneously, all variables explained a substantial proportion of variance in smash accuracy. These findings highlight the importance of integrating physical power and coordination training in volleyball instruction at the school level.

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Introduction

Volleyball is one of the most popular team sports taught in physical education curricula, particularly at the secondary school level, due to its potential to develop students' physical fitness, motor skills, and cooperative abilities (Hayat et al., 2022; Maksum & Indahwati, 2023). Among the fundamental offensive skills in volleyball, the smash plays a decisive role in determining scoring success and competitive performance. However, observations in school-level settings indicate that many athletes still demonstrate low smash accuracy, which limits their effectiveness in both learning and competitive contexts. This issue underscores the need for scientific investigation into the physical and coordinative

factors that influence smash performance in educational contexts (Güldenpenning, Jackson, et al., 2023; Host & Ivašić-Kos, 2022).

Previous studies in sports science have emphasized the importance of muscular power in volleyball performance, particularly arm and leg muscle explosive strength (Ahmad et al., 2023; Meyer et al., 2022). Arm muscle power contributes to ball velocity and force production during overhead striking movements, while leg muscle power supports vertical jump performance and optimal body positioning during aerial actions. Biomechanical analyses indicate that effective smash execution relies on the sequential activation of lower- and upper-body segments through a kinetic chain mechanism. Despite this, most research has focused on elite or university-level athletes, leaving limited empirical evidence concerning vocational high school students who may have different physical and training characteristics (Gredin et al., 2023; Ma et al., 2024).

In addition to physical power, hand–eye coordination has emerged as a critical perceptual–motor component in volleyball skill execution (Hoffmann, 2024; Liu et al., 2023; Xiong & Song, 2024). Coordination enables athletes to perceive ball trajectory accurately, synchronize movement timing, and regulate force application at the moment of contact. Within the context of motor learning, coordination skills are essential for translating physical capacity into technical effectiveness (Astuti, 2017). However, in many studies, coordination is treated as a secondary variable or examined independently, rather than being integrated into comprehensive performance models that account for both physical and perceptual-motor factors.

Methodologically, previous research has primarily employed correlational or simple regression analyses to examine the relationship between physical variables and volleyball skills. While these approaches identify associations, they are limited in explaining complex causal mechanisms or potential mediation effects among variables. Consequently, there is a lack of studies using path analysis to investigate simultaneously both direct and indirect effects of muscle power and hand–eye coordination on smash accuracy, especially in school-based physical education contexts (Mangun & Subarkah, 2024; Rusli & Aprillah, 2025).

A clear research gap exists regarding how arm muscle power and leg muscle power interact with hand–eye coordination to influence smash accuracy among vocational high school volleyball players (Hakim & Abdillah, 2024; Satardi et al., 2023). Specifically, empirical evidence is limited on the mediating role of coordination in enhancing the functional contribution of physical power to technical performance at the student level. Addressing this gap is crucial not only for advancing sports science but also for informing evidence-based training and instructional strategies in school physical education programs.

The novelty of this study lies in its integrative analytical approach, which simultaneously examines the direct, indirect, and combined effects of arm muscle power, leg muscle power, and hand–eye coordination on smash accuracy using path analysis (Aman et al., 2023). By focusing on vocational high school athletes within an educational context, this study provides new insights into the multifactorial determinants of volleyball performance and offers practical implications for designing holistic, coordination-based training programs that can enhance both motor skill development and learning outcomes in school physical education (Al-Wajedi et al., 2025; Setiawan & Makorohim, 2024).

Method

This study employed a quantitative research design using a path analysis approach to examine the direct and indirect effects of arm muscle power, leg muscle power, and hand–eye coordination on smash accuracy. The population consisted of all 30 male volleyball players at SMK Negeri 2 Kerinci, with total sampling applied due to the limited population size. Arm muscle power was measured using the one-hand medicine ball put test, leg muscle power using the vertical jump test, hand–eye coordination using the ball werfen und fangen test, and smash accuracy using a standardized smash accuracy test. Prior to hypothesis testing, assumption tests for normality and linearity were conducted. Data were analyzed using path analysis through structural model testing at a significance level of $\alpha = 0.05$ to determine both individual and simultaneous effects among variables.

Results and Discussions

Descriptive Statistics of Research Variables

Descriptive statistics were conducted to describe the characteristics of each research variable, including arm muscle power, leg muscle power, hand–eye coordination, and smash accuracy.

Normality and Linearity Assumptions

Prior to hypothesis testing, assumption testing was conducted. Normality testing using the Kolmogorov–Smirnov test showed that all variables were normally distributed ($p > 0.05$). Linearity testing indicated linear relationships between independent variables and smash accuracy, fulfilling the requirements for path analysis.

Path Analysis Results

Path analysis was employed to examine both direct and indirect effects among variables. The structural model consisted of arm muscle power (X1), leg muscle power (X2), and hand–eye coordination (X3) as exogenous variables, with smash accuracy (Y) as the endogenous variable.

Direct Effects

Table 1. Direct Effects of Independent Variables on Smash Accuracy

Path	Path Coefficient (ρ)	Contribution (%)	Sig.
X1 to Y	0.313	9.80	< 0.05
X2 to Y	0.403	16.24	< 0.05
X3 to Y	0.755	57.00	< 0.05

The results indicate that arm muscle power, leg muscle power, and hand–eye coordination have significant direct effects on smash accuracy. Among these variables, hand–eye coordination contributed the largest direct effect.

Indirect Effects through Hand–Eye Coordination

Table 2. Indirect Effects of Muscle Power on Smash Accuracy via Hand–Eye Coordination

Indirect Path	Indirect Effect Value	Contribution (%)
X1, X3, to Y	0.7196	71.96
X2, X3, to Y	0.3493	34.93

These findings show that both arm and leg muscle power influence smash accuracy indirectly through hand–eye coordination, with arm muscle power demonstrating a stronger mediated effect.

Simultaneous Effect of Independent Variables

Table 3. Simultaneous Effect of X1, X2, and X3 on Smash Accuracy

Model	R	R^2	Adjusted R^2	Contribution (%)
X1, X2, X3 to Y	—	0.827	—	68.39

The coefficient of determination ($R^2 = 0.827$) indicates that arm muscle power, leg muscle power, and hand–eye coordination jointly explain 68.39% of the variance in smash accuracy. The remaining variance is influenced by other factors not examined in this study.

The results demonstrate that hand–eye coordination plays a dominant role in determining smash accuracy, both directly and as a mediating variable. Muscle explosive power of the arms and legs contributes significantly, particularly when mediated through coordination ability.

The findings of this study indicate that arm muscle power has a significant direct effect on smash accuracy among male vocational high school volleyball players. This result confirms that explosive strength of the upper limbs is essential for generating ball velocity and directional control during the smash movement. Biomechanically, adequate arm muscle power allows athletes to perform rapid acceleration and optimal force transfer at ball contact, directly contributing to improved accuracy (Nisa'Urizka Fayogi et al., 2025; Zahedi et al., 2025). From an educational perspective, these results highlight the importance of incorporating structured upper-body explosive power training, such as

medicine ball throws or resistance exercises, into school-based volleyball learning programs to enhance both skill execution and strength development (Guntur et al., 2022; Hikmawati et al., 2023).

Leg muscle power was also found to have a significant direct effect on smash accuracy. This finding supports the notion that effective smash performance originates from the lower extremities through a kinetic chain mechanism. Explosive leg power enhances vertical jump height and mid-air stability, allowing athletes to strike the ball at a higher contact point and maintain spatial control (Desrtiana, 2025). In physical education settings, this underscores the pedagogical value of lower-body plyometric exercises, such as jump squats or box jumps, as foundational training for developing technically effective volleyball skills among students (Maulana & Soenyoto, 2025; Wibowo, 2025).

Hand–eye coordination emerged as the most dominant variable influencing smash accuracy, exhibiting the strongest direct contribution (Asdi & Rifki, 2020). This finding indicates that perceptual motor coordination is a critical determinant of successful smash execution, particularly in timing, ball tracking, and precision of contact. The strong influence of coordination demonstrates that technical skill execution in volleyball depends not only on physical power but also on neuromuscular control and perceptual processing. Consequently, volleyball instruction should incorporate coordination-based drills such as target hitting, reaction ball exercises, and tracking drills to improve students' motor control and decision-making during dynamic game situations (Nugroho et al., 2023; Xie & Zhang, 2025).

The mediation analysis revealed that arm and leg muscle power exert substantial indirect effects on smash accuracy through hand–eye coordination (Güldenpenning, Weigelt, et al., 2023; Hoffmann, 2024; Liu et al., 2023). These results suggest that physical power alone is insufficient to optimize smash accuracy unless integrated with coordination abilities. In other words, explosive strength is most effective when athletes possess the perceptual-motor skills to regulate force application accurately. This finding aligns with contemporary motor learning theories, which emphasize the functional integration of physical and perceptual-motor components in skill acquisition and performance optimization.

The simultaneous influence of arm muscle power, leg muscle power, and hand–eye coordination indicates that smash accuracy is a multifactorial performance outcome (Gredin et al., 2023). The high coefficient of determination reflects the strong explanatory power of the model, confirming that physical and coordination components jointly determine volleyball smash performance. For physical education teachers and coaches, these findings imply that effective instructional strategies should adopt a holistic approach, combining strength development, coordination enhancement, and technical practice. However, the generalization of these findings should consider the sample size and specific context of vocational high school athletes, emphasizing the need to adapt training programs to student-level capabilities.

Conclusions

This study concludes that arm muscle power, leg muscle power, and hand–eye coordination have significant direct and indirect effects on smash accuracy among male vocational high school volleyball players, with hand–eye coordination emerging as the most influential factor. These findings indicate that smash accuracy is determined by the integrated contribution of physical power and perceptual–motor coordination, emphasizing the importance of holistic training and instructional approaches in physical education to improve volleyball skill performance.

References

Ahmad, W., Munsif, M., Ullah, H., Ullah, M., Alsuwailem, A. A., Jilani Saudagar, A. K., Muhammad, K., & Sajjad, M. (2023). Optimized deep learning-based cricket activity focused network and medium scale benchmark. *Alexandria Engineering Journal*, *73*, 771–779. https://doi.org/10.1016/j.aej.2023.04.062

Al-Wajedi, M. Q. A., Zahedi, H., & Badami, R. (2025). The Effect of Visual Training on the Psychomotor

Performance of Male Volleyball Players under Environmental Evaluation Conditions. *International Journal of Education and Cognitive Sciences*, *6*(3), 1–7.

Aman, M. S., Gusril, G., Hasnah, D., & Arrasyih, F. (2023). Analysis of the Serve and Smash Abilities of Volleyball Athletes in the 2022 Proliga Final. *INTERNATIONAL JOURNAL OF SPORT SCIENCE, HEALTH AND TOURISM*, *1*(2), 83–91.

Asdi, F., & Rifki, M. S. (2020). Pengaruh Daya Ledak Otot Tungkai, Koordinasi Mata Tangan dan Konsentrasi terhadap Kemampuan Block Bolavoli. *Sporta Saintika*, *5*(2), 176–190. https://doi.org/10.24036/sporta.v5i2.142

Astuti, Y. (2017). The Power Contribution Of Arm Muscle Strength And Eyes-Hand Coordination To Volleyball Set Up Passing Skills. *JPI (Jurnal Pendidikan Indonesia)*, *6*(2), 163–171.

Desrtiana, D. (2025). Relationship between arm length, arm muscle strength and eye-hand coordination on the results of the upper service in the Garuda Jaya Sumatra volleyball team. *Retos*, *68*, 1518–1529.

Gredin, N. V., Broadbent, D. P., Thomas, J. L., & Williams, A. M. (2023). The role of action tendencies in expert anticipation. *Asian Journal of Sport and Exercise Psychology*, *3*(1), 30–38. https://doi.org/10.1016/j.ajsep.2023.02.001

Güldenpenning, I., Jackson, R. C., & Cañal-Bruland, R. (2023). The science of deceptive human movement. *Human Movement Science*, *92*, 103147. https://doi.org/10.1016/j.humov.2023.103147

Güldenpenning, I., Weigelt, M., Böer, N. T., & Kunde, W. (2023). Producing deceptive actions in sports: The costs of generating head fakes in basketball. *Human Movement Science*, *87*, 103045. https://doi.org/10.1016/j.humov.2022.103045

Guntur, G., Shahril, M. I., Suhadi, S., Kriswanto, E. S., & Nadzalan, A. M. (2022). The influence of jumping performance and coordination on the spike ability of young volleyball athletes. *Pedagogy of Physical Culture and Sports*, *26*(6), 374–380.

Hakim, H., & Abdillah, A. (2024). Smash Techniques in Volleyball Games (Correlation Study of Explosive Power and Coordination). *Cakra Journal of Sports and Health*, *1*(1), 17–23.

Hayat, Z., Sharma, S., & Minhaj, T. M. (2022). Efficacy of caffeine on athletic performance: A systematic review and meta-analysis. *Science & Sports*, *37*(5), 333–353. https://doi.org/10.1016/j.scispo.2021.07.011

Hikmawati, H., Hartati, H., & Usra, M. (2023). The Impact of Hanging Ball Training Method on Volleyball Under Passing and Hands Eye Coordination. *AL-ISHLAH: Jurnal Pendidikan*, *15*(4), 4527–4536.

Hoffmann, M. (2024). 2 - How to accomplish brain fitness: The five brain rules. In M. Hoffmann (Ed.), *Executive Brain Vitality* (pp. 13–120). Academic Press. https://doi.org/10.1016/B978-0-443-29839-4.00002-0

Host, K., & Ivašić-Kos, M. (2022). An overview of Human Action Recognition in sports based on Computer Vision. *Heliyon*, *8*(6), e09633. https://doi.org/10.1016/j.heliyon.2022.e09633

Liu, J., Huang, G., Hyyppä, J., Li, J., Gong, X., & Jiang, X. (2023). A survey on location and motion tracking technologies, methodologies and applications in precision sports. *Expert Systems with Applications*, *229*, 120492. https://doi.org/10.1016/j.eswa.2023.120492

Ma, S., Geok Soh, K., Binti Japar, S., Xu, S., & Guo, Z. (2024). Maximizing the performance of badminton athletes through core strength training: Unlocking their full potential using machine learning (ML) modeling. *Heliyon*, *10*(15), e35145. https://doi.org/10.1016/j.heliyon.2024.e35145

Maksum, A., & Indahwati, N. (2023). Personality traits, environment, and career stages of top athletes: An evidence from outstanding badminton players of Indonesia. *Heliyon*, *9*(3), e13779. https://doi.org/10.1016/j.heliyon.2023.e13779

Mangun, F. A., & Subarkah, A. (2024). The Effect Of Hand-Eye Coordination And Confidence On Badminton Smash Shot. *Gladi: Jurnal Ilmu Keolahragaan*, *15*(02), 187–198.

Maulana, A. I., & Soenyoto, T. (2025). Relationship Between Height and Smash Accuracy in Volleyball for Students at SMK Negeri 1 Bancak. *COMPETITOR: Jurnal Pendidikan Kepelatihan Olahraga*, *17*(3), 2376–2380.

Meyer, J., Smeeton, N. J., Fasold, F., Schul, K., Schön, T., & Klatt, S. (2022). Shot deception in basketball: Gaze and anticipation strategy in defence. *Human Movement Science*, *84*, 102975. https://doi.org/10.1016/j.humov.2022.102975

Nisa'Urizka Fayogi, E. R. S., Hartanto, A., Yachsie, B., Ayudi, A. R., Arianto, A. C., & Nurdin, U. (2025). *Study*

of the Correlation between Arm Muscle Power, Arm Length, Hand-Eye Coordination, and Concentration on Gate-In Results in Woodball. Retrieved.

Nugroho, D., Hidayatullah, M. F., Doewes, M., & Purnama, S. K. (2023). Does Grip Strength, Performance, and Hand-Eye Coordination Affect Tennis Drive Skills? *International Conference on Learning and Advanced Education (ICOLAE 2022)*, 4–11.

Rusli, M., & Aprillah, A. H. (2025). Hand-Eye Coordination As a Predictor of Smash Ability in Volleyball. *Indonesian Journal of Sport and Tourism*, *7*(2), 18–26.

Sanopa, D. F. T., Rosani, M., & Akhbar, M. T. (n.d.). *The Influence of Kinesthetics and Learning Motivation on Volleyball Smash Results in Students of SMP Negeri 1 Buay Madang*.

Satardi, R. N., Kristina, P. C., & Handayani, W. (2023). The influence of training methods and eye-hand coordination against the results of volleyball's top serve skills. *Journal of Social Work and Science Education*, *4*(3), 996–1010.

Setiawan, H., & Makorohim, M. F. (2024). Contribution of Arm Muscle Strength and Hand Eye Coordination to the Lower Service Results of the Mts S Muaro Sijunjung Volleyball Extracurricular Team. *Eduvest-Journal of Universal Studies*, *4*(10), 9699–9714.

Wibowo, A. T. (2025). Arm Length and Hand–Eye Coordination Correlates of Underhand Passing at SMA Negeri 1 Sanggau. *Musamus Journal of Physical Education and Sport (MJPES)*, *1*(4), 86–95.

Xie, B., & Zhang, F. (2025). Intelligent Volleyball action recognition integrating attention mechanism and multi-scale spatiotemporal separation algorithm. *Systems and Soft Computing*, *7*, 200374. https://doi.org/10.1016/j.sasc.2025.200374

Xiong, Q., & Song, D.-L. (2024). Neuromechanical proficiency in elite performance decision-making: An event-related potential (ERP) analysis. *SLAS Technology*, *29*(5), 100171. https://doi.org/10.1016/j.slast.2024.100171

Zahedi, H., Elioudeh, Y., Mohsen, A., & Meshkati, Z. (2025). Comparison of the Effects of a Training Period with Sports Vision, Specialized, and Combined Approaches on Certain Skill Components and Mood in Young Iraqi Volleyball Players under Psychological Pressure. *International Journal of Sport Studies for Health*, *8*(1).