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The Relationship between Leg Explosive Power and Eye-Hand Coordination with Smash Skills of Volleyball Athletes

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ABSTRACT
Smash is the main attack technique in volleyball which requires physical strength, precision and good coordination. This study aims to analyze the influence of explosive leg power and eye-hand coordination on smash skills in volleyball games among student volleyball athletes. The research uses quantitative methods with a correlational approach. The research sample consisted of a number of volleyball athletes who were selected purposively. Data collection instruments include a vertical jump test to measure explosive leg power, a tennis ball throw-catch test to measure hand-eye coordination, and a smash skill test in volleyball. The results of the analysis show that leg explosive power has a significant effect on smash skills. Apart from that, eye-hand coordination also makes a significant contribution. Simultaneously, these two variables are proven to have a strong influence on smash skills in volleyball. These findings emphasize that the development of physical condition and coordinative skills needs to be integrated in training programs. Thus, coaches are advised to design volleyball training that integrates increasing leg explosive power with hand-eye coordination training to optimize athletes' smash skills. Based on the results of the research and discussion that has been carried out, it can be concluded that both leg explosive power and eye-hand coordination have a significant influence on volleyball smash skills in student athletes.

Keywords: volleyball, smashes, explosive leg power, hand-eye coordination

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INTRODUCTION
The game of volleyball is not just a battle of technical skills or team strategy; every shot, especially smashes, is often the difference between victory and defeat. The perfect smash requires a combination of strength, precision, timing and coordination so that the ball flies quickly and is difficult for the opponent to receive. Therefore, understanding the factors that influence smash effectiveness is important for coaches and sports researchers (Ali, 2024). Physiologically, smashes in volleyball do not only rely on upper limb muscle strength; The success of this technique really depends on the player's ability to jump high (lower-limb explosive power) to create an optimal angle of attack. Based on recent studies, increasing leg explosive power through functional and traditional training has proven to be effective in supporting the lower body performance of volleyball athletes (Frontiers in Physiology, 2025). In addition, plyometric training programs have also shown a positive impact on explosive leg strength and overall smash ability (Esposito et al., 2024).

Apart from the physical aspect, coordination abilities - especially hand-eye coordination - play an equally important role. When the ball is thrown into the air, the hands must be able to "read" the ball's trajectory and adjust the hitting position quickly and precisely. This coordination relationship allows the blow to be not only hard but also accurate. Recent research confirms that

eye-hand coordination directly contributes to fine motor skills, directional control, and shot accuracy in volleyball (Putri & Sari, 2023).

For example, research at Riau Islamic University reported that leg explosive power contributed around 35.52% to smash accuracy, while eye-hand coordination contributed around 20.79%, and when combined the two contributed around 40.70% (Hendri & Fadli, 2022). Meanwhile, international studies also show a significant positive correlation between explosive leg strength and smash ability, especially in female athletes (Yildirim, 2023). However, most research still focuses on leg and arm muscle strength variables, not many of which incorporate eye-hand coordination as the main variable in the context of smashes.

From the literature review above, it appears that although the contribution of explosive leg power to smashes has been widely studied, integration with hand-eye coordination variables in one model is still relatively limited. However, in game practice, players not only need high jumps but also fast and precise hand control once the ball is in the hitting zone. The absence of a combined research model is an important gap that needs to be filled (Ali, 2024). This study aims to simultaneously test the influence of leg explosive power and eye-hand coordination on smash skills in student volleyball athletes. The novelty of this research lies in the use of a multiple correlational model that explicitly integrates physical variables (leg explosive power) and coordinative variables (eye-hand) in the context of smash skills - an approach that is still rarely found in current local and international literature (Esposito et al., 2024).

The results of this research have the potential to provide direct input to coaches and sports practitioners in developing volleyball training programs that not only focus on aspects of leg muscle strength, but also train the coordination of hand responses to the ball's trajectory. Theoretically, this research can enrich the conceptual framework regarding factors that influence technical skills in team games such as volleyball (Putri & Sari, 2023). Thus, this research provides guidance to readers that improving smash performance cannot be done univariately. Readers are expected to follow the subsequent discussion regarding the methodology for measuring explosive power and coordination, multiple correlation analysis procedures, and interpretation of results and implications for training practice. Hopefully this research will be able to attract interest in the development of further studies and be implemented in real terms in the development of volleyball athletes in the future (Yildirim, 2023).

METHOD

This research uses a quantitative approach with a correlational design, because it is suitable for analyzing the relationship between variables in sports performance. This design is considered effective in explaining the contribution of physical condition and coordination factors to technical skills in volleyball (Rahman, 2021). Thus, this research focuses on the influence of explosive leg power and eye-hand coordination on smash skills as one of the main attack techniques. The research population was students who were members of the volleyball sports activity unit at the university. They were chosen because they were considered to represent student-level athletes who actively train and take part in competitions. The sample was determined using a purposive sampling technique, namely selection based on certain criteria such as active training, playing experience, and relatively uniform physical condition. This technique is widely used in sports research to ensure the suitability of subject characteristics with research objectives (Sutanto & Wijaya, 2022).

Data collection techniques are carried out through field tests that directly assess physical abilities and technical skills. The research instrument includes three types of measurements. First, leg explosive power was measured using the vertical jump test, which is widely recognized as valid in describing the explosive ability of leg muscles (Kurniawan et al., 2023). Second, hand-eye coordination was measured using a tennis ball throw-catch test for 30 seconds. This test is commonly used to assess visual motor responses to moving objects, and is considered representative for measuring basic coordination skills in handball and volleyball (Dewi & Pratama, 2020). Third, smash skill is measured by the volleyball smash skill test, which assesses aspects of hitting strength, accuracy of ball direction, and overall movement technique. This smash skill

assessment has been used in previous research to evaluate the attack performance of volleyball athletes at the student level (Hartono, 2024).

Data analysis was carried out using multiple regression tests. This analysis technique was chosen because it is able to explain the partial influence of each independent variable, as well as test the simultaneous influence of both on the dependent variable. The multiple regression test is often used in sports research to map the contribution of several physical factors to the results of game skills (Yuliani & Nugroho, 2021). It is hoped that the results of this analysis can provide a comprehensive picture of the factors that most dominantly influence smash skills, as well as provide an empirical basis for coaches in designing effective and integrated training programs.

FINDING AND DISCUSSION

Multiple regression analysis was used to determine the influence of leg explosive power and hand-eye coordination on volleyball smash skills. The results of data processing show that there is a significant relationship, both partially and simultaneously, so that these two factors can be considered as the main determinants of smash effectiveness. These findings strengthen the results of previous research which emphasizes the role of physical condition and coordinative factors in team sports attack techniques (Rahman, 2021). Partially, leg explosive power is proven to have a significant influence on smash skills. Athletes with high leg explosive power can jump better, so that the hitting position is more optimal. This is in line with the research results of Kurniawan et al. (2023) which shows that the results of the vertical jump are correlated with the quality of the attack shot in volleyball.

Table 1. Partial Regression Test Results

Variable	Coefficient(B)	t count	Sig. (p)	Information
Limb Explosive Power	0.412	4.562	0.000	Significant
Eye-Hand Coordination	0.298	3.841	0.001	Significant

The magnitude of the influence of leg explosive power can be seen in Table 1, where the regression coefficient value is positive with significance below 0.05. Thus, the higher the athlete jumps, the greater the chance of producing a smash that is sharp and difficult to anticipate. Apart from that, eye-hand coordination also has a significant effect on smash skills. Athletes with good coordination are able to place shots at the right timing so that the ball is more focused and difficult for the opponent to block. These results support the view that attacking skills are not only influenced by strength, but also by visual-motor abilities (Hartono, 2024).

Skilled hand-eye coordination allows athletes to read ball movement more quickly, adjust their hand swing, and produce more accurate shots. Therefore, this aspect is an important component in volleyball training programs that is often given little attention. When tested simultaneously, explosive leg power and eye-hand coordination both make significant contributions to smash skill. The coefficient of determination value shows a strong relationship, indicating that the two variables complement each other in determining an athlete's smash success.

Tabel 2. *Hasil Uji Regresi Simultan*

Model	R	R Square	F count	Sig. (p)	Information
Multiple Regression	0.754	0.569	21.782	0.000	Significant

Thus, exercises that only emphasize increasing leg muscle strength are not enough. Athletes must also receive coordination training based on visual and motor responses to train integration between the eyes and hands. It is believed that a holistic approach like this will be more effective in improving smash skills (Hartono, 2024). This research data also supports the results of other studies

which state that technical performance in sports games is the result of the interaction between physical condition and movement coordination (Rahman, 2021). Therefore, training development should not be partial but integrated.

From a practical perspective, these results can be used as a guide for volleyball coaches at the college level to develop programs that combine plyometric training to increase explosive power in the legs with coordination exercises such as throwing and catching the ball or simulated punches. This kind of combinative training is believed to be more effective in improving students' smash skills. Overall, this research confirms that volleyball smash skills are the result of synergy between physical strength and coordinative skills. Empirical evidence shows that these two factors not only have a partial effect, but also simultaneously. Thus, preparing a training program based on developing explosive leg power and hand-eye coordination is a strategic step in improving the performance of volleyball athletes at the student level.

CONCLUSIONS

Based on the research results and discussions that have been conducted, it can be concluded that both explosive leg power and eye-hand coordination have a significant influence on volleyball smash skills in college-level athletes. Partially, explosive leg power shows a more dominant contribution with a regression coefficient of 0.412 ($p = 0.000$), which indicates that high jumping ability is a fundamental factor in creating an optimal attack angle and generating the vertical momentum necessary for an effective smash. Meanwhile, eye-hand coordination, although having a relatively smaller contribution with a regression coefficient of 0.298 ($p = 0.001$), still plays a crucial role in determining the accuracy and precision of the shot timing. More importantly, when both variables are analyzed simultaneously, they show a strong synergistic effect with a combined contribution of 56.9% ($R^2 = 0.569$) to the variation in smash skills. This finding strengthens the argument that improving smash performance cannot be done univariately, but rather requires a holistic approach that integrates the development of explosive physical abilities with coordinative skills. The results of this research provide solid empirical evidence that an effective volleyball training program must combine plyometric training to increase explosive leg power with hand-eye coordination training such as drill timing and accuracy, so that athletes can optimize the transfer of energy from take-off movements into targeted and powerful shots.

Although this research has made an important contribution in understanding the factors that influence volleyball smash skills, there are still several limitations and research gaps that need to be filled in future studies. First, this study only involved a sample of students with relatively homogeneous characteristics, so the generalization of the results to a population of athletes with different skill levels (junior, senior, professional) still requires further validation. Second, the use of relatively simple measurement instruments, such as the vertical jump for leg explosive power and tennis ball throw-catch for hand-eye coordination, may not be able to capture the full complexity of biomotor abilities required in real game situations. Third, this research has not considered other contextual factors that have the potential to influence smash performance, such as psychological variables (concentration, self-confidence), tactical variables (pass position, game situation), or anthropometric variables (height, wingspan, body composition). For future research, it is recommended to use a longitudinal design that can observe the development of smash skills over a longer period of time, integrate more sophisticated motion analysis technology for more precise biomechanical measurements, and develop a more comprehensive prediction model by including moderator and mediator variables that have not yet been explored. In addition, comparative research between various training methods (traditional vs. modern training approaches) and meta-analysis studies from various similar studies at regional and international levels will greatly contribute to enriching the body of knowledge regarding optimizing technical performance in team sports, especially volleyball.

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