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The Influence of Explosive Power, Flexibility and Self-Confidence on the Smash Skills of Badminton Athletes at High School

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ABSTRACT

The smash skill in badminton is a complex technique influenced by various physical and psychological factors. However, the specific interaction between leg muscle explosiveness, wrist flexibility, and students' self-confidence levels in school sports programs still requires further analysis through a path analysis approach. This study aims to analyze the influence of leg muscle explosiveness, wrist flexibility, and self-confidence on badminton smash skills in high school students participating in sports programs. This study used a quantitative correlational method. The research sample consisted of 30 student athletes selected using a total sampling technique. The instruments used included a badminton smash skill test, a vertical jump test, wrist flexibility measurements with a protractor, and a Likert scale questionnaire for self-confidence. Data analysis was performed using descriptive statistics and path analysis through SPSS software. The results of the hypothesis test showed that leg muscle explosiveness (sig = 0.001) and self-confidence (sig = 0.000) significantly influenced smash skills. Wrist flexibility also made a significant positive contribution (sig = 0.000). Interestingly, explosive power (sig = 0.236) and flexibility (sig = 0.078) did not directly influence self-confidence, but rather indirectly through smash skill mastery. This study contributes to the development of physical education curricula and sports training programs at the high school level. These findings emphasize that to achieve optimal technique mastery, coaches and teachers must simultaneously integrate the development of physical motor skills and psychological factors.

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1. INTRODUCTION

Badminton is a competitive sport that integrates technical complexity, in-depth strategy, and excellent physical condition (Rajab et al., 2025; Sukardi et al., 2025). As a highly popular sport in Indonesia, badminton training at the high school level is no longer viewed simply as a recreational activity but rather as a platform for the systematic development of athletic talent (Adirahma et al., 2024; Wang et al., 2025). A

student athlete's success in winning matches depends heavily on their ability to master attacking techniques, with the effectiveness of their shot being the primary determinant of dominating the game on the court (Edmizal et al., 2024; Yane et al., 2021).

Within the hierarchy of badminton techniques, the smash occupies a crucial position as the primary offensive instrument for shutting down opponents and quickly gaining points (Dong et al., 2024; Li et al., 2017; Touptiolo et al., 2025). This shot demands precise motor coordination, high speed, and sharp accuracy. According to Li et al. (2023), the smash is not simply a powerful shot but rather the result of complex body mechanics. For high school athletes, mastery of the smash technique is an indicator of technical skill maturity that will lay a crucial foundation for a more professional athletic career (Dewi, 2021).

Biomechanically, the success of a sharp and powerful smash is heavily influenced by the explosive power of the leg muscles (Lin et al., 2025; Pratama, 2020). This physical component enables student athletes to perform an optimal vertical jump to reach the highest point of contact (impact point). With a high reach, the shuttlecock's angle of impact will be steeper and more difficult for opponents to return. Therefore, explosive power is a key asset in creating destructive attacking momentum in the fast-paced game (Chandra et al., 2023; Tang, 2023).

In addition to explosive power, wrist flexibility plays a vital role in determining the final direction and speed of the shot (Abiwan et al., 2024). Good flexibility provides a whipping effect that adds propulsion to the shuttlecock while allowing for unpredictable variations in ball placement (Purnama et al., 2024). Without adequate flexibility, the smash movement tends to be stiff and easy to read, preventing other physical potential from being fully channelled into the racket (Akkase, 2025).

However, mastery of physical and technical aspects alone is insufficient without strong mental preparedness. In the high-pressure environment of school-level competition, self-confidence is the catalyst that determines whether a student can execute a smash boldly or hesitate (Hidayat et al., 2023). High self-confidence allows psychomotor aspects to function automatically without anxiety, allowing physical potential in the form of explosive power and flexibility to be maximally maximized when attacking during critical match moments (Akbari et al., 2018; Amir, 2015).

The uniqueness of this research lies in its integrative approach, linking physical variables (explosive power and flexibility) with psychological variables (self-confidence) in a single analytical model for high school athletes. To date, many previous studies have tended to focus only partially on one aspect. This study seeks to fill this gap in the literature by examining how physical and mental attributes interact to support smashing skills in students, considering that adolescence is a crucial transition period where synchronization between physical and mental development is at its peak.

Building upon this urgency, it is crucial to conduct an in-depth analysis of the extent to which each of these factors contributes to the performance of student athletes. The results of this study are expected to provide theoretical contributions to

sports pedagogy and practical guidance for school coaches in developing comprehensive training programs. Therefore, this study aims to investigate the influence of explosive power, wrist flexibility, and self-confidence on smash skills in badminton athletes at the high school level.

2. METHOD

This study used a quantitative approach with a correlational design to investigate the relationship and contribution of independent variables to the dependent variable. This design was chosen to examine in depth how independent variables, including explosive power, flexibility, and self-confidence, influence the dependent variable, smashing skills, in high school badminton athletes. Through this approach, the relationships between variables can be systematically mapped to provide an objective picture of the determinants of athlete performance.

The analytical model applied in this study is path analysis, which functions to examine patterns of causal relationships and influences, both direct and indirect. The use of path analysis allows researchers to see how physical and psychological variables interact with each other to influence the final outcome of technical skills. This conceptual framework serves as the primary reference in ensuring that each hypothesis is tested with high statistical rigor and is relevant to the dynamics of on-field performance.

The population and sample in this study focused on high school badminton athletes who met certain competency criteria to ensure data validity. The sampling technique was systematic to ensure that the data obtained was representative of the physical and mental conditions of athletes in a competitive sports environment. All data collection procedures were conducted under strict supervision to minimize bias and ensure that athletes were in optimal condition at the time of data collection.

The research instruments used included validated physical tests and psychological measurements. To measure explosive power and flexibility, standard badminton field tests with high reliability were used, while self-confidence was measured using a psychological scale adapted for the sport context. For smashing skills, a direct performance test was conducted, assessing parameters such as strength, accuracy, and execution technique to obtain comprehensive descriptive data.

All collected data was then processed using descriptive and inferential statistical analysis techniques. The results are presented in tables and figures, carefully centered on the page for easy reader interpretation. This visual presentation is supported by analytical narrative within the manuscript that directly references the data findings, providing a strong argumentative flow regarding the influence of explosive power, flexibility, and self-confidence on athletes' smashing skills.

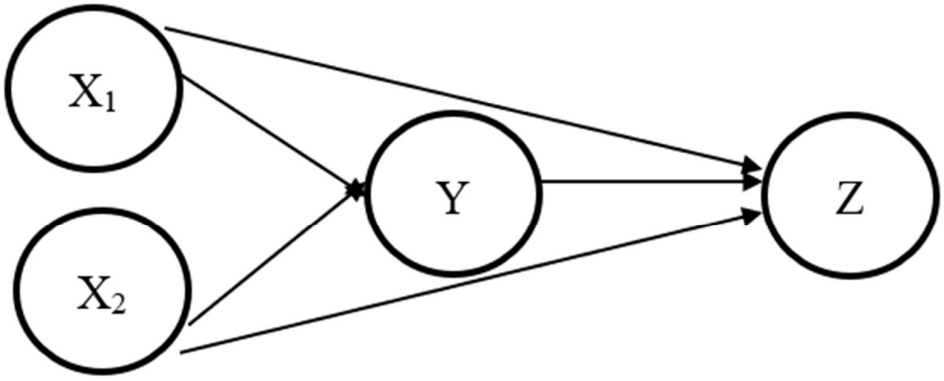

Figure 1. Research design

Information:

X1 : Explosive power

X2 : Flexibility

Y : Self-confident

Z : Badminton smash skills

3. RESULTS AND DISCUSSION

Results

The results of this descriptive analysis indicate that explosive power, flexibility, and self-confidence have a significant influence on the quality of badminton athletes' smash skills at the high school level. The integration of physical components in the form of muscular explosive power and body flexibility is a crucial biomechanical foundation for producing powerful shots, while the aspect of self-confidence plays a psychological role that strengthens the accuracy and composure of athletes when executing techniques on the court. Overall, the synergy of these three variables is proven to be the main determinant in optimizing athlete performance comprehensively to achieve maximum match results.

Table 1. Descriptive Analysis of Explosive Power, Flexibility, Self-Confidence, and Badminton Smash Skills Variables

Research Data	N	Min	Max	Sum	M	Std.Dev
Explosive power	30	32	72	1574	52.47	9.609
Flexibility	30	10	45	717	23.90	8.903
Self-confident	30	52	81	2078	69.27	6.236
Badminton smash skills	15	26	595	19.83	2.780	15

The results of descriptive statistical analysis of 30 samples, the research data shows a variety of physical and psychological profiles of athletes, where the explosive power variable has an average value of 52.47 with a standard deviation of 9.609 (range 32–72), while the flexibility variable recorded an average value of 23.90 with a standard deviation of 8.903 (range 10–45). In the mental aspect, the level of athlete confidence is in a relatively high category with an average of 69.27 and a standard deviation of 6.236 (range 52–81). Finally, the performance of badminton smash skills shows consistency with an average value of 19.83 and a standard deviation of 2.780, which is obtained from a score distribution between 15 and 26.

Table 2. Results of Data Normality Test

Variable	Research Data	Sig	Ket
Explosive power	0.118	0.200	Normal
Flexibility	0.107	0.200	Normal
Self-confident	0.134	0.182	Normal
Badminton smash skills	0.118	0.200	Normal

The results of the normality test using the Kolmogorov-Smirnov Test showed that all research variables—including explosive power, flexibility, and self-confidence, as well as smash skills in badminton athletes—had a significance value greater than 0.05 ($p > 0.05$). Based on these findings, it can be concluded that all research data were normally distributed, thus fulfilling the basic assumptions for continuing inferential statistical analysis in testing the influence of these variables on athlete performance.

Table 3. Data Homogeneity Test Results

Research Data	Levine Statistic	Sig	Information
Research data results	10.373	0.071	Homogeneous

Bauilding upon the results of the homogeneity test, the results above show that the value of the research data on athletes high schools obtained a Levine statistic of 10.373 with a significance value of 0.071 > 0.05, which has the same or homogeneous variance.

Table 4. Regression Test Results of the Effect of Explosive Power on Badminton Smash Skills

Variables	Regression Coefficient	t_{count}	Sig
The effect of explosive power on badminton smash skills	0.102	3.622	0.001

Table 4 shows that the t-value is 3.622 with a significance level of 0.001 <0.05. Therefore, the regression model can be used to predict the R variable, meaning that the endurance variable (X1) influences badminton smash skills (Y). The table above further explains the regression coefficient of 0.102, which implies that the better an

athlete's endurance, the better their badminton smash skills. Therefore, the hypothesis stating that endurance has a positive effect on badminton smash skills is accepted.

Table 5. Regression Test Results of the Effect of Flexibility on Badminton Smash Skills

Variables	Regression Coefficient	T_{count}	Sig
The effect of flexibility on badminton smash skills	0.140	4.684	0.000

Table 5 shows that the t-value is 4.684 with a significance level of 0.000 <0.05. Therefore, the regression model can be used to predict the R variable, indicating that the flexibility variable (X2) influences badminton smash skills (Y). The table above further explains the regression coefficient of 0.140, which implies that the better an athlete's flexibility, the better their badminton smash skills. Therefore, the hypothesis stating that flexibility has a positive effect on badminton smash skills is accepted.

Table 6. Regression Test Results of the Influence of Self-Confidence on Badminton Smash Skills

Variables	Regression Coefficient	T_{count}	Sig
The influence of self-confidence on badminton smash skills	0.204	4.628	0.000

Table 6 shows that the t-value is 4.628 with a significance level of 0.000 <0.05. Therefore, the regression model can be used to predict the R variable, meaning that the self-confidence variable (Z) influences badminton smash skills (Y). The table above further explains the regression coefficient of 0.204, which implies that the greater an athlete's self-confidence, the better their badminton smash skills. Therefore, the hypothesis stating that self-confidence has a positive effect on badminton smash skills is accepted.

Table 7. Regression test results of the effect of explosive power on self-confidence

Variables	Regression Coefficient	T_{count}	Sig
The effect of explosive power on self-confidence	0.134	1.213	0.236

Table 7 shows that the t-value is 1.213 with a significance level of 0.236 > 0.05. Therefore, the regression model can be used to predict the R variable, indicating that there is no influence of the explosive power (X1) variable on self-confidence (Z). The table above further explains the regression coefficient of 0.134, indicating that there is no significant relationship between explosive power and self-confidence. Therefore, the hypothesis stating that explosive power has a positive effect on self-confidence is rejected.

Table 8. Regression test results of the influence of flexibility on self-confidence

Variables	Regression Coefficient	t_{count}	Sig
The effect of flexibility on self-confidence	0.231	1.834	0.078

Table 8 shows that the t-value is 1.834 with a significance level of 0.078 > 0.05. Therefore, the regression model can be used to predict the R variable, indicating that there is no influence of the flexibility (X2) variable on self-confidence (Z). The table above further explains the regression coefficient of 0.231, indicating that there is no significant relationship between flexibility and self-confidence. Therefore, the hypothesis stating that flexibility has a positive effect on self-confidence is rejected.

Discussion

The data analysis in this study indicates that smashing skills in high school badminton athletes are the result of a complex interaction between physical capacity and psychological state. Overall, these findings reinforce the theory that high-level motor performance depends not only on muscle strength but also on the integration of explosive power, flexibility, and self-efficacy.

The Effect of Leg Muscle Explosive Power on Smashing Skills

The finding that leg muscle explosive power significantly influences smashing skills (sig = 0.001) aligns well with the principles of badminton biomechanics, where explosive leg strength acts as the primary driver in the kinetic chain. Theoretically, the explosive power generated through the stretch-shortening cycle mechanism in the leg muscles enables athletes to perform an optimal vertical jump to reach the shuttlecock at its highest point. This aligns with previous studies that emphasize that a sharp shot angle and resulting ball speed are highly dependent on the height of ball contact, which can only be achieved if students have sufficient leg muscle power capacity to overcome gravity instantly during a jump smash (Tan & Teoh, 2024).

In the context of physical education in schools, these results confirm that a measurable physical training program for the leg muscles is a mandatory foundation before students are directed to more complex attack techniques. Linking these findings to motor development theory, mastery of technical skills such as the smash is inseparable from the maturity of basic physical components (Li et al., 2023). Therefore, the integration of functional weight training or simple plyometric exercises into the school sports curriculum is crucial, because the effectiveness of the smash technique is not just a matter of hand coordination, but rather the result of the transfer of energy that begins with the powerful push of the foot towards the floor.

The Role of Wrist Flexibility in Smash Accuracy

The finding that wrist flexibility makes a highly significant positive contribution (sig = 0.000) reinforces biomechanical theory that positions the wrist joint as the

"spearhead" in the kinetic chain of a smash. Technically, optimal flexibility enables a whipping effect that drastically increases racket head speed upon impact with the shuttlecock. This aligns with previous studies that suggest that the effectiveness of a badminton attack is determined not only by the strength of large muscles but also by the joint's ability to perform maximal flexion and extension movements (Lin et al., 2025; Wang et al., 2025). For high school students, this flexibility is key to smoothly yet powerfully manipulating the ball's direction, creating a variety of attacks that are difficult for opponents to anticipate.

Furthermore, these results demonstrate that mastering effective smash technique requires a balance between physical strength and joint flexibility to achieve maximum movement efficiency. From the perspective of school sports development, these findings emphasize the importance of dynamic and specific stretching exercises in the wrist area to prevent muscle stiffness that can impede the distribution of kinetic energy (Day & Merriman, 2025). This proves that achieving students' technical performance should not only focus on weight or strength training alone, but should integrate joint mobility training as an integral component in the training curriculum to minimize the risk of injury while optimizing punching accuracy.

Self-Confidence as a Psychological Catalyst

The finding that self-confidence has the most dominant influence on smash performance (sig = 0.000) reinforces Albert Bandura's Self-Efficacy Theory, which states that an individual's belief in their abilities significantly determines the quality of their actions (Bandura, 2023; Lopez-Garrido, 2023). In the dynamics of badminton, self-confidence serves as a catalyst, transforming physical potential into precise technical execution. Psychologically, students with high levels of self-confidence are able to minimize mental obstacles such as anxiety or hesitation, allowing smashes to be executed with full commitment and high accuracy (Siong & Ali, 2024). Conversely, even if a student is in prime physical condition, without strong self-confidence, technical execution tends to be hesitant and lack power, ultimately reducing the effectiveness of attacks on the court.

In the context of education and coaching, this finding is crucial because it confirms that developing a winning mentality is as important as regular physical training (Ihsan et al., 2024). Teachers and coaches in schools need to recognize that self-confidence encourages students to be more willing to take risks and launch aggressive attacks at critical points in a match (Hidayat et al., 2023). Therefore, pedagogical approaches in sports should include mental strengthening strategies, such as providing positive feedback and simulating competitive situations, to build students' psychological resilience. This proves that mastery of the smash technique is the result of synergy between physical readiness and mental maturity, which collectively shape the athletic character of students within the framework of physical education.

Indirect Relationship and Path Analysis

The most interesting aspect of this study is the finding that explosive power and flexibility do not directly influence self-confidence (significance > 0.05) but rather through mediation of smash skill mastery. This provides new insights that align with Bandura's self-efficacy theory, specifically regarding mastery experiences (Kleppang et al., 2023). Excellent physical strength and flexibility do not automatically build students' mentality; self-confidence only emerges when students realize that their physical capacity has been successfully transformed into actual technical mastery. This phenomenon suggests that physical attributes are merely latent potentials that require "technical proof" to be internalized into strong psychological beliefs.

From a sports pedagogy perspective, this finding confirms that student athletes' self-efficacy grows from feelings of competence in effectively mastering techniques. Successfully executing a sharp smash—supported by a strong physique—serves as an essential source of mental empowerment. This aligns with previous studies that suggest that technical achievement is a stronger predictor of self-confidence than mere administrative physical readiness (Suratmin & Yudhistira, 2024). Thus, the training process at school level must be designed in such a way that students can experience technical success gradually, so that the physical strengthening they undergo contributes directly to the formation of mental toughness through the path of movement skills.

Overall, this study confirms that within the framework of sports education in high schools, the training approach must be holistic. Coaches cannot separate physical, technical, and mental training. To create student athletes who excel in smash skills, a training curriculum is needed that combines strengthening explosive power, regular flexibility training, and providing motivation to foster self-confidence through real technical achievements on the field.

4. CONCLUSION

Leg muscle explosiveness, wrist flexibility, and self-confidence are determining factors that significantly improve smash skills in high school badminton athletes. Findings indicate that physical excellence and mental preparedness have a strong positive correlation with the accuracy and power of the smash technique. Although explosiveness and flexibility do not directly influence confidence, path analysis revealed that both physical aspects contribute indirectly through improved technical skill mastery. Therefore, the integration of intensive motor training and psychological development is crucial within the framework of school sports education to achieve optimal smash technique mastery.

As a recommendation, high school physical education coaches and teachers are advised to develop training programs that integrate the development of physical and psychological components in a balanced manner, with a particular focus on increasing leg muscle explosiveness and wrist flexibility to support powerful smash mechanics. In addition to motor aspects, strengthening mental factors through self-confidence training should be prioritized, as it has been shown to be a crucial determinant in

enhancing technical execution on the court. Furthermore, athletes are expected to consistently conduct independent evaluations of their mastery of basic techniques, considering that good skill mastery is an important mediator in building self-confidence and optimizing overall competitive performance.

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