



Effects of Push-Up Training on Smash Speed among Badminton Athletes

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ABSTRACT

The purpose of this study was to examine the effect of push-up training on the improvement of smash speed among badminton athletes at PB Ksatria, Demak Regency. This study employed a quantitative approach using a one-group pretest–posttest design. The participants consisted of 23 badminton athletes who underwent a structured push-up training program for 12 weeks, three sessions per week. Data were collected using a smash speed test conducted before and after the intervention. The data were analyzed using the Shapiro–Wilk normality test, paired sample t-test, and N-Gain analysis. The results showed that the mean of smash speed increased from 47.43 in the pretest to 79.39 in the post-test. The paired sample t-test revealed a statistically significant difference ($t = -118.247$, $p < 0.001$), indicating that push-up training had a significant effect on smash speed improvement. In addition, the N-Gain score of 0.61 indicated a moderate improvement category. In conclusion, push-up training could significantly improve smash speed performance in badminton athletes at PB Ksatria, Demak Regency. These findings suggest that push-up exercise can be effectively integrated into club-level training programs to enhance upper-body power and sport-specific performance.

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INTRODUCTION

In contemporary society, sports have become an essential part of human life (Isauraya et al., 2025). Badminton is a highly popular sport in Indonesia, experiencing tremendous development as both a recreational and competitive activity (Gomez et al., 2019). As a competitive sport, badminton requires structured training programs to support the understanding and implementation of game tactics (Dameria et al., 2023). Badminton is widely recognized as an accessible and enjoyable sport that can be played across different age groups and genders (Utomo et al., 2023). The development of badminton in Indonesia has been strongly supported by local and national training institutions, contributing to consistent achievements at both national and international levels (Zafira & Ditya Candra, 2024).

The primary objective in badminton is to score points by directing the shuttlecock strategically into the opponent court (Sahabuddin, 2023). Performance in badminton is influenced by multiple interrelated components that must be developed through systematic training, including physical, technical, tactical, psychological, and maturational factors (Rahadhi et al., 2025). In competitive sports such as badminton, physical, technical, tactical, mental, and maturity factors are all essential components that contribute to optimal performance (Ashary, 2025). Physical conditioning plays a fundamental role in supporting technical execution and enhancing overall athletic performance (Petisco et al., 2019). Technical training in badminton includes fundamental skills such as grip technique, stroke execution, and footwork, which are typically developed after the athlete has achieved adequate physical preparation (Rusdiana et al., 2020). Effective performance in badminton requires the integration of physical fitness and technical mastery to achieve consistent competitive success (Qian, 2024).

Among the various techniques in badminton, the smash is one of the most important offensive strokes due to its direct contribution to scoring points (Priambudi & Syaukani, 2022). Badminton players must master the basic techniques well in order to achieve high performance, such as smash, dropshot, serve, lob, drive, and netting. In badminton, an important and core stroke is the smash because it can score points (Kuswanti et al., 2024). The smash is a powerful overhead stroke characterized by high speed and downward trajectory, requiring coordinated movement of the upper and lower body (Titis Pambudi et al., 2023). Effective smash execution depends on arm muscle strength, explosive power, and neuromuscular coordination to generate high shuttlecock velocity (Rusdiana et al., 2021). Continuous and structured practice is required to improve smash performance, particularly through the development of upper-limb power, which is a key determinant of stroke effectiveness (Wibowo et al., 2022).

There are various exercises used to train and enhance arm muscle power, one of which is the push-up exercise (Salman, 2023). Push-up is a bodyweight resistance exercise that improves upper-body strength and muscular endurance relevant to sport performance demands (Darmawan & Setiawan, 2025). This exercise primarily aims to improve upper-limb muscular strength and power output, which supports explosive movements in sport contexts (Dhote et al., 2024). Resistance training such as push-ups improves neuromuscular activation and enhances the ability to generate force rapidly during high-intensity movements (Bernstorff et al., 2024). In badminton, these physical capacities are essential because athletes must perform rapid transitions, maintain reaction speed, and sustain high-intensity movement patterns during competitions (Boullosa, 2023).

The smash technique requires high levels of arm muscle strength and explosive power to generate effective shuttlecock velocity. The purpose of push-up exercises is to train and increase the power of the arm muscles so that the muscles can achieve maximum strength in a short time (Firdausi et al., 2021). This task requires players to exhibit rapid movement, transition seamlessly between offensive and defensive roles, and maintain high speed and reaction time (Kadafi et al., 2024).

Based on previous studies, most badminton training research had focused on plyometric training, strength training, or combined conditioning programs without isolating simple resistance exercises such as push-up training in relation to sport-specific performance outcomes (Albayati & Kaya, 2023). In addition, most studies had examined elite or university-level athletes, while limited research had focused on club-level adolescent badminton athletes in real training environments (Yang et al., 2024). Furthermore, many studies tended to emphasize general physical performance variables such as strength or power without specifically measuring smash speed as a sport-specific performance indicator (Subarkah et al., 2023). Previous research was also often conducted in controlled laboratory settings, which might not fully reflect practical training conditions in real coaching environments (Bobrownicki et al., 2026). Therefore, there is a need for simple, practical, and field-based training studies that can be directly applied by coaches at the club level to improve badminton-specific performance (Lestari et al., 2025).

Based on these limitations, the novelty of this study lies in examining the effect of a structured push-up training program on smash speed performance in adolescent badminton athletes at PB Ksatria, Demak Regency. This study used a one-group pretest–posttest experimental design to evaluate changes in smash speed before and after the training intervention. By focusing on a simple resistance exercise applied in a real training environment, this study is expected to provide both scientific and practical contributions to badminton training methodology, particularly for developing athletes at the club level.

METHODS

Participants

This study involved a total of 23 youth badminton athletes under the age of 19 (U19) from PB Ksatria in Demak Regency. In accordance with the one-group pretest-posttest experimental design, all participants were observed as a single experimental group. Participants were selected using purposive sampling. The inclusion criteria consisted of (1) registered as active badminton athletes at PB Ksatria, (2) aged between 15 and 19 years old, and (3) routinely participating in the club structured training sessions. The purpose of selecting this group was to evaluate the changes in smash speed performance based on the implementation of a structured push-up exercise training program.

Sampling Procedures

The study employed a one-group pretest-posttest experimental design involving 23 badminton athletes aged 15–19 years from PB Ksatria in Demak Regency. Participants were selected using a total sampling technique, in which all athletes who met the inclusion criteria were included in the study. The push-up training program served as the independent variable, while smash speed performance served as the dependent variable.

Participants completed a structured push-up training program for 12 weeks (three months), with training sessions conducted three times per week following the regular badminton stroke-drill practice. The program was designed to improve the upper-body muscular strength, particularly in the arms, shoulders, and chest muscles, which contribute

to the execution of badminton smashes. All training sessions were supervised by the researcher and club coaches to ensure that participants followed the prescribed training procedures consistently throughout the intervention period. Smash speed performance was assessed before and after the intervention period using the same testing procedures and environmental conditions to ensure consistency in data collection.

Materials and Apparatus

The push-up training program was the independent variable in this study, while smash speed performance was the dependent variable. The instruments used in this study involved (1) a push-up training program, which demonstrated a validity coefficient of 0,991 and a reliability coefficient of 0,97 (Siregar et al., 2022) and (2) a badminton smash test used to measure smash performance, with a validity coefficient of 0.84 and a reliability coefficient of 0.78 (Edmizal & Barlian, 2022).

Procedures

This study employed a one-group pretest-posttest experimental design to investigate the effect of a push-up training program on badminton smash speed performance. The research was conducted through a series of systematic stages. Initially, participants who satisfied the established inclusion criteria were recruited. All research instruments, equipment, and testing protocols were prepared and standardized prior to data collection.

Subsequently, a pretest (O_1) was administered to assess the baseline smash speed performance of all participants before the implementation of the training intervention. Following the pretest, participants completed the push-up training program according to the prescribed protocol for a period of 12 weeks, with training sessions conducted three times per week following regular badminton stroke-drill practice. Throughout the intervention period, the implementation of the training program was supervised by the researcher and club coaches to ensure adherence to the prescribed procedures and training protocols.

Upon completion of the intervention period, a posttest (O_2) was conducted using the same smash speed testing procedures, equipment, and environmental conditions as those employed during the pretest. The resulting pretest and posttest data were subsequently recorded, compiled, and analyzed to evaluate the effectiveness of the push-up training program in improving badminton smash speed performance.

Design or Data Analysis

This study used a pre-experimental design with a one-group pretest-posttest approach. Data analysis was performed using IBM SPSS Statistics version 25. Descriptive statistics, including mean, standard deviation, minimum score, and maximum score, were calculated to describe the data distribution.

Before hypothesis testing, the Shapiro–Wilk test was conducted to assess the normality of the data at a significance level of 0.05. If the data were normally distributed, a paired samples t-test was used to determine whether there was a significant difference between pretest and posttest smash speed scores. The push-up training program was considered effective if the significance value (Sig. 2-tailed) was ≤ 0.05 .

In addition, N-Gain analysis was used to measure the level of improvement in smash speed performance after the treatment. The N-Gain results were categorized into three levels, namely high (≥ 0.70), moderate (0.30–0.69), and low (< 0.30). The statistical findings were interpreted to evaluate the effectiveness of push-up exercise training on badminton smash speed performance.

RESULTS

The results of this study are presented in tables to describe the effect of the push-up training program on the smash speed of badminton athletes at PB Ksatria in Demak Regency. The data include descriptive statistics, normality test results, paired sample t-test analysis, and N-Gain analysis.

Table 1. Descriptive Statistics of Push-Up Training on Smash Speed Performance

	N	Minimum	Maximum	Mean	Std. Deviation
Pretest	23	40	56	47.43	3.776
Posttest	23	74	84	79.39	2.624
Valid N (Listwise)	23				

Table 1 shows that the total number of participants involved in this study was 23 athletes. The pretest results showed a maximum score of 56, a minimum score of 40, a mean value of 47.43, and a standard deviation of 3,776. After the implementation of the push-up training program, the posttest results increased substantially, with a maximum score of 84 and a minimum score of 74. The mean of posttest scores also rose to 79,39 with a standard deviation of 2,624. These findings indicate that the push-up training program has a positive effect on improving the smash speed of badminton athletes. The normality test of the data assessed using the Shapiro–Wilk test. The results showed that the pretest scores ($W = 0.988$, $p = 0.992$) and posttest scores ($W = 0.971$, $p = 0.720$) were normally distributed, as both significance values > 0.05 . Therefore, the assumption of normality was met. A paired-sample t-test was conducted to examine the effect of the push-up training program on smash speed performance.

Table 2. Descriptive Statistics of Pretest and Posttest Data

Pair 1	Mean	N	Std. Deviation
Pretest	47.43	23	3.776
Posttest	79.39	23	2.624

Table 3. Paired Sample T-Test of Push-Up Training on Smash Speed Performance

Variable	Mean Difference	t	df	Sig. (2-tailed)
Pretest–Posttest	-31,957	-118.247	22	0,000

Table 2 presents the descriptive statistics of the pretest and posttest smash speed performance scores. The mean of pretest score was 47.43 ($SD = 3.776$), while the mean of posttest score increased to 79.39 ($SD = 2.624$). The increase of 31.96 points indicated an improvement in smash speed performance following the push-up training program. Table 3 presents the results of the paired-samples t-test comparing the pretest and posttest smash speed performance scores. The analysis revealed a mean difference of -31.957, indicating that the posttest scores were substantially higher than the pretest scores. The paired-samples t-test showed a statistically significant difference between the two measurements, $t(22) = -118.247$, $p < 0.001$. Since the significance value was lower than 0.05, the null hypothesis was

rejected. These findings indicate that the push-up training program had a significant effect on improving the smash speed performance of badminton athletes at PB Ksatria in Demak Regency.

Table 4. N-Gain Analysis of Push-Up Exercise Training on Smash Speed Performance

N	Pretest Mean	Posttest Mean	N-Gain Score	Category
23	47.43	79.39	0,61	Average

Table 4 presents the N-Gain score analysis of smash speed performance. The results showed that the mean score increased from 47.43 in the pretest to 79.39 in the posttest, resulting in an N-Gain score of 0.61. Based on the N-Gain classification criteria, this value falls within the moderate category ($0.30 \leq g < 0.70$). These findings indicate that the push-up training program could produce a moderate improvement in the smash speed performance of badminton athletes at PB Ksatria, Demak Regency.

DISCUSSION

The findings of this study demonstrated that the push-up training program improved the smash speed performance of badminton athletes at PB Ksatria, Demak Regency. The increase in the average of smash speed score from 47.43 in the pretest to 79.39 in the posttest indicates that the training intervention contributed positively to the athlete physical performance. This improvement suggests that the push-up training program enhanced upper-body muscular strength, which plays a crucial role in the execution of powerful badminton smashes (Cendra, 2018).

The findings of this study can be explained through physiological and biomechanical mechanisms associated with resistance training adaptations (Goods et al., 2022). Through continuously straining the pectoralis major, deltoid, and triceps muscles, push-up training is a type of bodyweight resistance exercise that can improve upper-body muscular strength (Ma et al., 2024). Previous studies have reported that upper-body strength contributes significantly to stroke effectiveness and shuttlecock velocity in badminton athletes (Aprilianti et al., 2023). Neuromuscular adaptations resulting from resistance training improve motor unit recruitment and firing frequency during high-intensity movements (Lin et al., 2023). These adaptations enhance the ability of athletes to generate force rapidly during explosive upper-limb movements, thereby contributing to greater power output during smash execution (Ramasamy et al., 2021). Athletes can generate force during stroke execution more quickly and efficiently contributing to increased neuromuscular efficiency (Anderson et al., 2025).

From a biomechanical perspective, the badminton smash depends on efficient force transfer through the kinetic chain from the lower limbs to the racket head (Li, F et al., 2023). The shoulder and arm muscles play an important role in accelerating the racket during the forward swing phase of the smash (McErlain-Naylor et al., 2020). Increased upper-body strength may enhance racket-head velocity and ultimately contribute to higher shuttlecock speed (Song et al., 2020). Effective smash performance is influenced not only by muscular strength but also by movement coordination and technical execution. Wrist speed and flexibility are additional factors that contribute to the direction and velocity of the shuttlecock during a smash stroke (Wang & Zhou, 2024). Therefore, the strength of the smash shot needs to receive sufficient attention by training it as often as possible (Hidayat et al., 2024).

The present findings are consistent with the principle of specificity, which states that physical adaptations occur according to the nature of the training stimulus applied (Soemardiawan et al., 2019). Push-up exercises strengthen several muscle groups that are directly involved in overhead badminton strokes (Syahputra et al., 2023). Improved physical conditioning provides a stronger foundation for the execution of technical skills in badminton (Genevois et al., 2020). Long-term athlete development requires the integration of strength, coordination, and sport-specific skills within the training process, as training aims to promote the functional development of the body and achieve physiological adaptations through regular physical exercise in response to increasing physical demands (Cahyadi et al., 2023). Comprehensive conditioning programs contribute to the enhancement of motor abilities required for sport performance (Muhsin, 2025).

Several limitations should be considered when interpreting the results of this study. The use of a one-group pretest-posttest design without a control group limits the ability to establish causal relationships with complete certainty (Fraenkel et al., 2019). The relatively small sample size and the inclusion of athletes from only one badminton club may reduce the generalizability of the findings (Van Simaey et al., 2025; Zaarour & Melachrinoudis, 2019). The study focused exclusively on smash speed and did not assess other performance variables such as smash accuracy, muscular power, or biomechanical characteristics (Artazila et al., 2024). Future studies should employ randomized controlled designs and include broader performance indicators to strengthen the evidence (Carter et al., 2024).

From a practical perspective, push-up exercises can be incorporated into badminton conditioning programs because they are simple, inexpensive, and easy to implement in club settings (Sterin, 2023). Coaches may use push-up training to support the development of upper-body strength required for powerful smash performance (Nurrochmah, 2020). However, resistance exercises should be combined with technical drills and sport-specific training to optimize performance outcomes (Singh, 2024). An integrated training approach is considered essential for maximizing athlete development and competitive performance in athlete (Wang et al., 2025).

CONCLUSION

Push-up training positively influenced smash speed in badminton athletes of PB Ksatria, Demak Regency. Athletes who completed the training program demonstrated significant improvement, as reflected by the increase in the average smash speed scores from pretest to posttest, highlighting the importance of upper body strength training in enhancing smash performance. These findings suggest that incorporating push-up exercises into regular training programs can effectively support athlete development at the club level. Future studies should examine long-term effects and involve larger and more diverse samples to strengthen generalizability.

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AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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