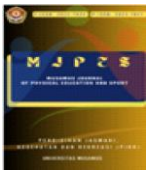
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The Effects of Push-Up and Plank Exercises on Volleyball Smash Accuracy Among Budi Agung High School Students

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Abstract
Objectives:
This study aims to analyze and empirically prove the effect of push up training, plank training, and a combination of both exercises on improving volleyball smash accuracy among extracurricular students at SMA Budi Agung Medan in the 2025/2026 academic year.
Materials and Methods:
The research method employed was a pre experimental design utilizing a One Group Pre test and Post test Design. The population comprised all 20 male students participating in the volleyball extracurricular program, all of whom were selected as samples using total sampling.
Results:
The results and data analysis using descriptive statistics and inferential testing (Paired Sample t Test and Multiple Linear Regression via SPSS v29) revealed: (1) Push up training significantly increased arm muscle power from a pre test mean of 23.15 kg to a post test mean of 35.65 kg (mean gain = 12.50 kg; t calculated = 30.685; p = 0.000 < 0.05), contributing 69.6% (r^2 = 0.696) to smash accuracy; (2) Plank training significantly enhanced core stability from a pre test mean of 3.42 m to a post test mean of 5.24 m (mean gain = 1.82 m; t calculated = 29.088; p = 0.000 < 0.05), contributing 66.5% (r^2 = 0.665) to smash accuracy; (3) The combined intervention of push up and plank exercises simultaneously had a highly significant impact on improving volleyball smash accuracy scores from a pre test mean of 11.45 (Poor category) to a post test mean of 19.15 (Good category), yielding an average gain of 7.70 points.
Conclusions:
In conclusion, the combination of push up and plank exercises provides an effective contribution of 83.5% toward enhancing volleyball smash accuracy among extracurricular students at SMA Budi Agung Medan.
Keywords: Push Up; Plank; Core Stability; Arm Muscle Power; Smash Accuracy; Volleyball.

Introduction

Volleyball is a sport that requires a combination of basic technical skills, physical strength, accuracy, and body coordination. One of the important techniques in volleyball is the smash, which is a powerful overhead hit aimed at scoring points and putting pressure on the opponents defense. The success of a smash is influenced not only by hitting technique but also by good arm muscle strength and core stability, which are essential for achieving greater hitting speed and accuracy.

Upper body muscle strength, particularly in the arms and shoulders, as well as core stability, plays an important role in the execution of the smash technique. Push up training is an effective form of exercise for improving the functional strength of the chest, arms, and shoulders and is therefore commonly incorporated into various athletic training programs. In volleyball, upper body strength contributes to generating greater hitting momentum when performing a smash. Rahmanto et al. (2025) found that push up training had a positive effect on smash technique among extracurricular volleyball students, demonstrating improvements in technical performance following a structured push up training program.

In addition to upper body strength, core strength or core stability is also an important component of physical training for volleyball. Core stability helps the body maintain

balance and proper positioning during dynamic movements such as jumping and hitting the ball. Various international studies on core strength training among volleyball athletes have shown that core training programs can improve physical attributes such as balance, anaerobic explosive power, and speed, which indirectly contribute to attacking skills, including the smash. Other research on plank exercises as part of core stability training has also found that such exercises significantly improve dynamic balance and core muscle strength in athletes following an eight week training program.

Although many studies have focused on plyometric training, lower body power, or circuit training and their effects on volleyball smash performance, relatively few studies have specifically examined the combination of push up and plank exercises and how these two forms of training simultaneously affect smash accuracy among volleyball players in a high school extracurricular context. Gunawan and Jatra (2024) reported that plyometric training significantly improved smash performance among volleyball players, indicating that physical training focused on muscular power can improve technical performance. These findings confirm that systematic physical training has an impact on smash performance; however, they did not examine upper body and core training in combination.

In addition, other national level studies have shown that circuit training and variations of push up exercises can improve smash performance among volleyball players, although they differ in terms of training structure. Miftahurrahman et al. (2025) also demonstrated that push up variations can improve smash hitting performance in another sport, namely pickleball. These findings have relevant implications for the development of similar training programs in volleyball and other racket sports.

The importance of core stability training in modern sports is not limited to improving specific technical movements but also includes its essential role in maintaining body posture and facilitating the transfer of force from the lower body to the upper body. International review articles have indicated that core training can improve dynamic balance, power, and body control, which are important elements of overall athletic performance. Research specifically utilizing plank exercises as core training in volleyball has also found that a six week plank training program can improve the accuracy and stability of fundamental volleyball techniques, such as reception and setting. This provides evidence that plank training is also relevant to smash performance, although the technical aspects examined differ.

Based on initial observations conducted during extracurricular volleyball activities at SMA Budi Agung Medan in the 2025/2026 Academic Year, data obtained from 20 male students who were selected as the research sample indicated that smash accuracy was still relatively low. This was evident from the results of the initial smash accuracy test (pretest), in which most students achieved scores within the low to moderate categories, with the average success rate of accurate hits still far below expectations. Many of the smashes performed did not reach the intended targets, particularly in terms of ball placement and directional control. This condition indicates that the students basic smash skills, particularly in terms of accuracy, have not yet developed optimally.

The low level of smash accuracy is suspected to be influenced by insufficient arm muscle strength and core stability, both of which play important roles in producing accurate and well directed hits. In addition, the training program implemented so far has tended to be less structured and has placed insufficient emphasis on specific physical exercises such as push ups and planks, which can contribute substantially to improving strength and body stability during the execution of a smash. In volleyball, the smash is one of the primary attacking techniques that strongly determines the acquisition of points during a match. Good smash accuracy requires not only proper technique but also adequate physical fitness.

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Based on this background, a research gap remains in the context of high school students participating in extracurricular volleyball activities, particularly regarding the combined effects of push up and plank training on smash accuracy. Smash accuracy is an important aspect because it determines the effectiveness of attacks during matches and contributes significantly to team success. Therefore, this study is important to examine the extent to which a combination of push up and plank training can affect the smash accuracy of students participating in extracurricular volleyball activities at SMA Budi Agung Medan.
Thus, this study is expected not only to contribute scientifically to the field of physical training in volleyball but also to serve as a practical reference for sports coaches in school environments when designing effective and efficient training programs to improve the performance of volleyball athletes at the high school level.

Materials and Methods

Study Design

This study is an experimental study. Experimental research is designed to determine whether a particular intervention applied to the subjects produces any effect. The research design employed is a "one group pre test and post test design" an experiment conducted on a single group without a comparison group.

Study Participants

In this study, the population consists of 20 male students who are active in the volleyball extracurricular program at SMA Budi Agung Medan. The sample size for the study is 20 (twenty) individuals, selected using the total population sampling technique.

Study Organization

The research instruments included a Pull Dynamometer to measure arm muscle power (push up training), an Overhead Medicine Ball Throw to evaluate core stability (plank training), and a standardized volleyball smash accuracy target test (scores ranging from 5 to 30 across 6 trials). The training intervention was administered over a 6 week period with a frequency of 3 sessions per week.

Statistical Analysis

The information in this study consists of numerical data, specifically regarding the accuracy of smashes in volleyball among students participating in the extracurricular program at SMA Budi Agung Medan for the 2025/2026 academic year. This includes data on push ups (measured using a pull dynamometer), core stability (assessed via overhead medicine ball throws), and smash accuracy (evaluated using a standardized volleyball smash test instrument). The information collected initially exists as raw data, which is then processed through statistical procedures, including regression analysis, normality testing, and homogeneity testing.

Results

Based on the measurement results of arm muscle power using a pull dynamometer (in kg) for 20 samples taken before the intervention (pre test) and after a 6 week push up training program (post test) the statistical data are described as follows:

Table 1. Pre test and Post test Data Results for Arm Muscle Power (Push up / Pull Dynamometer)

Statistical Measures	Pre test Arm Power (kg)	Post test Arm Power (kg)	Improvement (Gain)
Sample Size (N)	20	20	
Minimum Value	18.00	29.00	9.00
Maksimum Value	30.00	45.00	16.00
Average	23.15	35.65	12.50

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Standard Deviation (SD)	3.17	4.16	1.82
Variance	10.03	17.30	3.31

Based on Table 1 above, it can be seen that the mean arm muscle power of the students prior to the intervention (pre test) was 23.15 kg, with a minimum value of 18.00 kg and a maximum value of 30.00 kg (standard deviation of 3.17). Following a structured 6 week push up training program, the mean arm muscle power showed a significant increase to 35.65 kg, with a minimum value of 29.00 kg and a maximum value of 45.00 kg (standard deviation of 4.16). The mean gain in arm muscle power was 12.50 kg.

A description of the data obtained from core stability measurements assessed via the distance of an Overhead Medicine Ball Throw (in meters) before and after a plank exercise intervention is presented in Table 2 below:

Table 2. Pre test and Post test Data for Core Stability (Plank / Overhead Medicine Ball Throw)

Statistical Measures	Pre test Core Stability (m)	Post test Core Stability (m)	Improvement (Gain)
Sample Size (N)	20	20	
Minimum Value	2.80	4.30	1.20
Maksimum Value	4.20	6.40	2.30
Average	3.42	5.24	1.82
Standard Deviation (SD)	0.39	0.55	0.28
Variance	0.15	0.30	0.08

Table 2 shows that before the plank exercise intervention, the students average performance in a medicine ball throw an indicator of core stability and the transfer of explosive power was 3.42 meters (falling within the Average/Below Average norm). Following a 6 week regimen of plank exercises, the average throwing performance improved significantly to 5.24 meters (categorized as Good). The average increase in throwing distance was 1.82 meters.

Smash accuracy is measured based on the accumulated target scores from 6 smash attempts directed at designated target areas, in accordance with the test instrument (Suharno HP, 2012). The descriptive statistical results for smash accuracy are presented in Table 3 below:

Table 3. Pre test and Post test Data Results for Volleyball Smash Accuracy

Statistical Measures	Pre test Smash Accuracy	Post test Smash Accuracy	Improvement (Gain)
Sample Size (N)	20	20	
Minimum Value	8.00	16.00	6.00
Maksimum Value	16.00	23.00	10.00
Average	11.45	19.15	7.70
Standard Deviation (SD)	2.04	1.95	1.08
Variance	4.15	3.82	1.17

Data in Table 3 show that the students mean score for smash accuracy during the pre test was 11.45 (falling within the Poor to Moderate normative range). Following a 6 week

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intervention program consisting of a combination of push ups and plank exercises, the mean score for smash accuracy increased to 19.15 (placing it in the Good category). The mean gain in smash accuracy scores was 7.70 points.

To provide a qualitative overview of the changes in students smash accuracy proficiency levels, the pre test and post test score data were categorized according to the assessment norms for smash accuracy (Suharno HP, 2012). The frequency distribution of these categories is presented in Table 4 below:

Table 4. Distribution of Students Smash Accuracy Categories

Category/ Classification	Value Range	Pre test (Frequency)	Pre test (%)	Post test (Frequency)	Post test (%)
Very Good	22 - 25	0	0.0%	3	15.0%
Good	19 - 21	0	0.0%	10	50.0%
Currently	14 - 18	3	15.0%	7	35.0%
Poor	9 - 13	15	75.0%	0	0.0%
Very Poor	5 - 8	2	10.0%	0	0.0%

Based on Table 4, a significant change in the quality of students smash accuracy is evident. During the pre test, the majority of students (75%) fell into the Poor category, 10% into the Very Poor category, and only 15% into the Currently category. Following a 6 week training program consisting of push ups and planks, no students remained in the Poor or Very Poor categories. Instead, 50% of the students reached the Good category, 15% reached the Very Good category, and 35% fell into the Average category.

Discussion

The results of this experimental study empirically demonstrate that a structured physical training program combining push up and plank exercises for six weeks is effective in improving smash accuracy among students participating in the volleyball extracurricular program at SMA Budi Agung Medan.

Push up exercise is a form of bodyweight exercise that specifically develops the strength and explosive power of the upper extremity muscle groups, including the pectoralis major, triceps brachii, deltoideus, and serratus anterior. During the ball contact phase of a volleyball smash, the arm is rapidly and forcefully swung forward and downward. Strong arm and chest muscles provide stable driving force and acceleration during the stroke.

The findings of this study are consistent with those of Mulyana and Nurdiansyah (2025) and Rahmanto et al. (2025), who found that increasing arm muscle strength through push up exercises significantly affects smash control and accuracy. Strong arm muscles reduce the likelihood of muscle fatigue during ball contact in the air, thereby allowing the consistency of the wrist snap and accurate contact with the center of the palm to be maintained.

Plank exercise is an isometric exercise that strengthens the core muscles, including the rectus abdominis, transverse abdominis, obliques, and erector spinae. The core muscles function as stabilizers that facilitate the transfer of kinetic energy from the lower extremities (the legs during jumping) to the upper extremities (the arms during ball contact).

These findings support the studies by Al Zubaidi (2025) and Sedaghati et al. (2023), which emphasize the importance of core stability in volleyball. During the flight phase of a smash, the players body is highly unstable. Without adequate core stability, the body may oscillate or tilt excessively, causing the point of ball contact to become inaccurate. Regular plank training helps maintain torso stability, enabling the smasher to maintain an

optimal posture when contacting the ball and thereby substantially improving the accuracy of directing the ball toward the intended target.

From a biomechanical perspective, an effective smash requires harmonious synergy between the force generating muscles (the arm and shoulder muscles developed through push up exercises) and the postural stabilizers (the core muscles developed through plank exercises). This combination of exercises produced a substantially greater positive effect, with an R^2 value of 83.5%, compared with either exercise performed separately.

By applying the principles of regular, progressive, and periodized sports training over six weeks, as described by Harsono (2015) and Bompa and Buzzichelli (2020), positive physiological adaptations occurred in the students neuromuscular systems. The simultaneous improvement in arm muscle strength and core stability enabled the students to control the direction of the smash with greater precision within the opponents playing area.

Conclusions

Based on the research findings, statistical analysis using SPSS, and discussion, it can be concluded that push up and plank exercises have significant effects on smash accuracy in volleyball among extracurricular students at SMA Budi Agung Medan in the 2025/2026 academic year. Push up exercises contributed 69.6%, while plank exercises contributed 66.5%. Simultaneously, both exercises had a significant combined contribution of 83.5%, as indicated by an F count of 43.082 > F table of 3.59 and a significance value of 0.000 < 0.05. The average smash accuracy score increased from 11.45 (Poor category) to 19.15 (Good category), demonstrating that the combination of push up and plank exercises significantly improves students smash accuracy.

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Conflict of Interest

The authors declare no conflict of interest.

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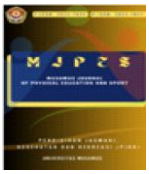
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