

**The Relationship between Arm Muscle Explosive Strength,
Leg Muscle Explosive Strength, and Abdominal Muscle Strength
on Volleyball Smash Performance in High School Students**

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Abstract: The purpose of this research is to establish the extent to which the explosiveness of the arm muscles, the explosiveness of the leg muscles, and the strength of the abdominal muscles have an impact on the results of volleyball smashes at SMA Negeri 8 Medan. Quantitative route analysis is the method that is utilized in this research approach. All the students that are enrolled at SMA Negeri 8 Medan make up the study population, whereas the research sample is comprised of students who have satisfied the criteria, which can number up to eighty individuals. The methodologies that were utilized in this study for the purpose of data gathering included two hand medicine ball put tests, vertical leap, sit-ups, and volleyball smash tests. To the data analysis method, the t test was utilized with the assistance of the SPSS application. It was discovered, based on the findings of the study, that the degree of influence that arm muscle explosiveness had on volleyball smash in students from SMA Negeri 8 Medan was 18.9%. 26.4% of the students at SMA Negeri 8 Medan believe that leg muscle explosiveness has a significant impact on their ability to smash while playing volleyball. 16.4% of the students at SMA Negeri 8 Medan indicate that the strength of their abdominal muscles has a significant impact on their ability to smash the volleyball.

Keywords: Arm Muscle Explosive Strength, Leg Muscle Explosive Strength, Abdominal Muscle Strength, Volleyball, Smash, High School, Students

Introduction

According to Winata et al. 2023, physical education serves as a medium that encourages the development of physical potential, knowledge, reasoning, appreciation of values (attitude-emotional-mental-spiritual-social), and the habituation of a healthy lifestyle, all of which contribute to the stimulation of growth and balanced development. Article 6 paragraph 1 of Law Number 19 of 2005 on national education standards states that the objective of school is to foster sportsmanship, discipline, cooperation, and healthy living, as well as to increase the potential for physical activity (Batitusta and Hardinata 2024). People are encouraged to establish healthy life habits, sportsmanship, discipline, and collaboration, according to this legislation, which we might read as

providing this advice. By having a passion for physical activity, one can steer clear of things that have a negative odor (Widiyani et al. 2024).

A human need that is a fundamental component and has a significant impact on the development of a robust spirit and body (body or body) is the opportunity to participate in sports. As a result, every single human being who participates in sports activities on a regular basis will have superior spiritual and physical health than people who participate in sports activities on a less frequent or nonexistent basis (Agus et al. 2024). Within the context of human existence, sports, particularly in Indonesia, play a very significant role. Volleyball is one of the sports that is favored by the community or among students (Nugroho et al. 2024). In today's modern world, humans cannot be separated from sports activities. This is because sports activities help increase achievement and satisfy the desire to keep the body fit.

There is a consensus across all strata of Indonesian society that volleyball is a sport that they play. According to Alfiansyah Putra Karo Karo et al. 2024, this sport can be enjoyed by people of all ages, from youngsters to adults, and by both men and women. In volleyball, there are fundamental methods that players need to learn and become proficient in. These techniques include the upper serve, the lower serve, the upper pass, the lower pass, the block, and the smash move. It is common practice to refer to the smash technique as the most effective method for accumulating points (Silaban et al. 2024). This is because the smash is a devastating strike that can result in a significant number of points if it is executed with precision and accuracy. It is necessary to have a high achievement level and a high jumping ability to obtain good results when doing smash. Smash may be broken down into numerous different sorts, including normal smash (open smash), smash pull (rapid), smash cekis (drive smash), smash half, and smash push.

Therefore, explosive power in sports is related to the results of all performance both individually and in groups that are doing sports activities as the most important component in sports (Keswando, Septi Sistiasih, and Marsudiyanto 2022). This is because explosive power is one of the components that must be possessed in most sports. According to Rasyid and Aristrianto 2020, explosive power is defined as the capacity of an individual to execute at their highest possible strength. On the other hand, strength refers to the power of muscle contraction that may be achieved with a single maximum effort. A muscle or group of muscles exerts their utmost effort to overcome a resistance using this greatest effort. As stated in the Ramli 2021 report. According to Liu, Xie, and Ahmed 2021, there are several different forms of strength, including general strength, specialized strength, maximum strength, absolute strength, and relative strength.

According to Faiz, Permana Putra, and Nugraha 2022, a smash is a forceful shot in which the hand makes complete contact with the ball at the top of the ball. According to Sovensi, Supriyadi, and Suhdy (2019), the ball can be hit hard downwards (floor) to cause the ball to glide down at a fast speed above the net. This is done to achieve the desired situation. There are also several kinds of smash, specifically: (open smash) is a batter in making a prefix movement after the ball is released from the feeder's hand, the ball is hit at the top of the jump and a high arm reach, smash (semi) is an act of hitting the ball over the net with a height of 1 to 2 metres from the lip of the net, so that the ball will move quickly and over the net towards the opponent's field so that the opponent blocks it, smash (quick) is a hitter passing to the passer, then the hitter makes a prefix as quickly as possible, with a long step, Drive a smashing cekis (smash one) In accordance with Rahmalia, Susilawati, and Lengkana 2022, this smash can be utilized to strike the ball whose bait is either somewhat to the right of the smasher or slightly over the head of the smasher. The movement of the hand from the front of the body is rotated in an anti-clockwise direction, the palm of the hand forms a spoon-like depression, smash

push the beginner's attitude to take the smasher's prefix immediately places itself outside the field near the net, facing the direction of the feeder, and smash pull is used as a variation of attack, especially for playing at a fast tempo (Esser 2019).

According to Saputra et al. 2023, the results of smah are primarily influenced by three physical factors: the explosiveness of the arm muscles, the explosiveness of the leg muscles, and the strength of the abdominal muscles. According to Priono and Lestari (2024), the term "arm muscle explosiveness" refers to a trait that enables a muscle or set of muscles to undertake explosive physical effort. The ability of a person to execute at their maximal strength is referred to as arm muscle explosiveness, as stated by Baresi, Permadi, and Hermawan (2023). The arm muscle explosiveness test is conducted with two hand medicine balls, as stated by Naimatul Jamaliah (2020). While leg muscle power is the ability of a person's muscle or group of muscles to use maximum strength exerted in the shortest possible time according to (Rasyid and Aristrianto 2020) the test used to measure leg muscle explosive power using a vertical jump according to (Keswando, Septi Sistiasih, and Marsudiyanto 2022). The ability of muscles to generate energy against a prisoner is referred to as abdominal muscle strength, as stated by Erniyanti, Hudain, and Basith (2017). According to Anggara, Ari., and Firdaus 2020, the test included sit-ups to evaluate abdominal muscle strength.

It is evidenced by doing basic volleyball techniques, specifically smash on SMA Negeri 8 Medan students who are still lacking because there are still many students when doing basic smash techniques, the ball cannot pass the net from the prefix movement to the final smash attitude is still not good. This is done to prove the above statement that the three physical elements have an effect, and it is based on observations and interviews with professionals in the field of physical education that they have not met the criteria. Since students have been given the opportunity to try the smash multiple times, but the results have remained the same, the ball is still unable to cross the net, it is reasonable to believe that there are additional factors that influence the performance of the smash. A study will be carried out with the title "The Effect of Arm Muscle Explosiveness, Limb Muscle Explosiveness, and Abdominal Muscle Strength on Volleyball Smash Results." This study will be based on the description that was provided earlier.

Method

A research method is a scientific approach to acquiring data with the intention of achieving aims and objectives. Methods that fall under the category of quantitative research include the route analysis method. In the field of social sciences, the term "quantitative research methods" refers to the systematic empirical research of quantitative properties and phenomena, as well as their relationship to the existence of targets of quantitative research in general. The purpose of quantitative research is to develop and use mathematical models, theories, and hypotheses regarding a specific phenomenon. Furthermore, quantitative research makes extensive use of statistics to carry out a variety of measurements, beginning with the collecting of data and continuing to validity and other related topics, as stated by Cahyono, Naheria, and Fauzi 2021.

In accordance with Ramadhan et al. 2023, this research is a path analysis study that is used to examine the strength of the direct and indirect association between the independent factors (exogenous) and the dependent variable (endogenous). In path analysis research, it is possible to understand it as a research approach that is used to determine the effect of each variable that is reliant on other variables (Kim and Kim 2023).

SMA Negeri 8 Medan was the location where the research was carried out. The entire process of research is focused on the population. Objects that are part of the

population are subjected to research, the findings are analyzed, and conclusions are drawn throughout the population. It is possible to divide the population into two categories, namely: 1) A population that is made up of elements that have a specific number is referred to as an infinite number population. 2) A population that is comprised of elements that are extremely difficult to locate bounds for is referred to as an endless population. The population that is being employed in this investigation is one that has an infinite number of members, and the precise number can be precisely determined. In this study, the population consisted of forty students from SMA Negeri 8 Medan.

To the study, a straightforward random sampling approach was utilized. As stated by Cahyono, Naheria, and Fauzi (2021), simple random sampling is a method that involves taking samples from populations that are chosen at random. In this study, the samples consist of the following: 1) students from SMA Negeri 8 Medan, 2) individuals between the ages of 16 and 17 years old 8) Are willing to adhere to all the guidelines that have been established by the author. Eighty students are eligible based on these criteria. On the other hand, ten other students were unable to fulfill these standards because they were unable to take the examination owing to a variety of motivating causes. The following are the instruments that were utilized in this study, An explosive power test of the arm muscles utilizing the two-handed medicine ball put respectively; Assessment of the explosive power of the leg muscles through the use of the Vertical Jump Test; The sit-up test which is used to evaluate the strength of the abdominal muscles, and A test of your volleyball smashing skills with the smash test.

All the tests are conducted with a significance level of 0.05. The method of data analysis that was utilized to test the hypothesis was path analysis (Path Analysis) trimming model. First, the normality test is performed using the Lilefors technique, then the variance homogeneity test is performed using the Bartlett test technique, and finally, the significance and linearity test is performed using anova (Analysis Variance). All these tests are performed before the hypothesis is tested. In line with the framework that was developed to determine the relationship between the explosiveness of the arm muscles (X1), the explosiveness of the leg muscles (X2), and the strength of the abdominal muscles (X8), the calculations were carried out with the use of computer computers. In accordance with Ramadhan et al. 2023, the software that was utilized was a data management tool known as SPSS (Static Package for Social Science) kind 22.

Results & Discussion

Results

Effect of Arm Muscle Explosiveness on Volleyball Smash

According to the findings of the calculation that was performed using SPSS to determine the impact of arm muscle explosiveness on volleyball smash, the t-count value is 2.558, which is greater than the t-table value of 1.697. Furthermore, based on the findings of the statistical significance value obtained, which was 0.016, which is less than the threshold of 0.05. The conclusion that can be drawn from this is that the effect of arm muscle explosiveness on volleyball smash is significant. Based on the calculation of the coefficient of determination, which was found to be 18.9%, it is possible to draw the conclusion that the proportion of the influence of arm muscle explosiveness on volleyball smash is 18.9%, while the remaining 81.1% is influenced by other elements that were not addressed in this study. Considering the findings of the research, it has been determined that the rcount value is 0.484, which falls within the range of 0.60 to 0.80 and is within a sufficient category. Therefore, the influence of arm muscle explosiveness on volleyball smash is considered to fall under the sufficient group.

Table 1. Effect of Arm Muscle Explosiveness on Volleyball Smash

| Calculation Results | Rate | Description |
|------------------------------|-------------|--|
| t-count | 2,558 | Greater than t-table (1.697) |
| Sig. | 0,016 | Smaller than 0.05 |
| Conclusion | Significant | There is an effect of arm muscle explosive power on volleyball smash |
| Coefficient of Determination | 18,9% | The effect is 18.9% |
| Other Factors | 81,1% | Other factors not mentioned |
| Value of r-count | 0,484 | Located between 0.60 to 0.80 (sufficient category) |
| Category of Influence | Fair | The influence of arm muscle explosiveness on volleyball smash |

Effect of Limb Muscle Explosiveness on Volleyball Smash

A t-count value of 8.166 > t-table of 1.697 was achieved by using SPSS to analyze the explosive power of leg muscles on volleyball smash. In addition, based on the findings of the significance value reached at 0.004 which is less than the threshold of 0.05. Consequently, it is possible to draw the conclusion that the impact of explosive strength in the leg muscles on volleyball smash. Based on the calculation of the coefficient of determination, which was found to be 26.4%, it is possible to draw the conclusion that the proportion of the influence of leg muscle explosiveness on volleyball smash is 26.4%, while the remaining 78.6% is influenced by other elements that were not addressed in this study. Considering the findings of the research, it was discovered that the rcount value was 0.518, which is within the range of 0.60 to 0.80 and is within a sufficient category. It may be concluded that the impact of leg muscle explosive power on volleyball smash falls inside the sufficient category.

Table 2. Effect of Limb Muscle Explosiveness on Volleyball Smash

| Calculation Results | Rate | Description |
|------------------------------|-------------|--|
| t-count | 8,166 | Greater than t-table (1.697) |
| Sig. | 0,004 | Smaller than 0.05 |
| Conclusion | Significant | There is an effect of leg muscle explosive power on volleyball smash |
| Coefficient of Determination | 26,4% | The effect is 26.4% |
| Other Factors | 78,6% | Other factors not mentioned |
| Value of r-count | 0,518 | Located between 0.60 to 0.80 (sufficient category) |
| Category of Influence | Fair | The influence of leg muscle explosiveness on volleyball smash |

Effect of Abdominal Muscle Strength on Volleyball Smash

Using SPSS, the results of the calculation of the effect of abdominal muscular strength on volleyball smash obtained a t-count value of 2.247 > t-table of 1.697. This indicates that the t-count value is significantly significant. In addition, based on the findings of the statistical significance value achieved, which was 0.026, which is less than the threshold of 0.05. The conclusion that can be drawn from this is that the effect of abdominal muscular strength on volleyball smash is significant. It is possible to draw the conclusion that the proportion of the influence of abdominal muscle strength on volleyball smash is 16.4%, based on the calculation of the coefficient of determination that was achieved, which was 16.4%. The remaining 78.6% of the influence is influenced by other elements that were not addressed in this study. Considering the findings of the research, it was discovered that the rcount value was 0.405, which is within the moderate range of values, which ranges from 0.60 to 0.80 units. The influence of abdominal muscular strength on volleyball smash is therefore considered to fall under the sufficient group.

Table 3. Effect of Abdominal Muscle Strength on Volleyball Smash

| Calculation Results | Rate | Description |
|------------------------------|-------------|---|
| t-count | 2,247 | Greater than t-table (1.697) |
| Sig. | 0,026 | Smaller than 0.05 |
| Conclusion | Significant | There is an effect of abdominal muscle strength on volleyball smash |
| Coefficient of Determination | 16,4% | The effect is 16.4% |
| Other Factors | 78,6% | Other factors not mentioned |
| Value of r-count | 0,405 | Located between 0.60 to 0.80 (sufficient category) |
| Category of Influence | Fair | The effect of abdominal muscle strength on volleyball smash |

Discussion of the Effect of Arm Muscle Explosiveness, Leg Muscle Explosiveness, and Abdominal Muscle Strength on Volleyball Smash

The F-count value is 5.568, which is greater than the F-table value of 2.87, according to the table of the findings of the calculation of the effect of arm muscle explosiveness, leg muscle explosiveness, and abdominal muscle strength on volleyball smash using SPSS. In addition, based on the findings of the significance value reached at 0.004 which is less than the threshold of 0.05. Therefore, it is possible to draw the conclusion that the influence of the explosiveness of the arm muscles, the explosiveness of the leg muscles, and the strength of the abdominal muscles on volleyball smash. Based on the calculation of the coefficient of determination, which was found to be 89.1%, it is possible to draw the conclusion that the percentage of the influence of arm muscle explosiveness, leg muscle explosiveness, and abdominal muscle strength on volleyball smash is 89.1%, while the remaining 60.9% is influenced by other factors that were not mentioned in this study. According to the findings of the research, the rcount value was found to be 0.625, which is within the range of 0.60 to 0.80 and is within a sufficient category. As a result, the influence of arm muscle explosiveness, leg muscular explosiveness, and abdominal muscle strength on volleyball smash is in the high category.

Table 4. Effect of Arm Muscle Explosiveness, Leg Muscle Explosiveness, and Abdominal Muscle Strength on Volleyball

| Calculation Results | Rate | Description |
|------------------------------|-------------|--|
| t-count | 5,568 | Greater than F-table (2.87) |
| Sig. | 0,004 | Smaller than 0.05 |
| Conclusion | Significant | There is an effect of explosive power of arm muscles, legs, and abdominal muscle strength on volleyball smash. |
| Coefficient of Determination | 89,1% | The effect is 89.1% |
| Other Factors | 60,9% | Other factors not mentioned |
| Value of r-count | 0,625 | Located between 0.60 to 0.80 (sufficient category) |
| Category of Influence | High | The influence of explosive power of arm muscles, legs, and abdominal muscle strength on volleyball smash |

Discussion

This study confirms that muscle strength has an important role in the success of smashes in volleyball. Specifically, the muscle explosiveness of the arms, legs, and abdominal muscle strength contribute significantly to smash effectiveness. Panggraita, Tresnowati, and Putri (2020) stated that these three factors must be considered in developing an optimal smash technique. This is because smashes in volleyball involve a series of complex movements that include the start, jump, hit, and landing, all of which require good muscle strength.

Jumping is one of the key elements in volleyball smashes. According to Esser (2019), good jumping ability will greatly facilitate a player in performing smashes more effectively. A high jump allows the player to reach a better height when hitting the ball,

thus providing a sharper angle of attack and difficult for the opponent to block. This jumping ability is closely related to the strength of the leg muscles and abdominal muscles that can provide a strong upward thrust.

Abdominal muscle strength plays a crucial role in supporting the jumping performance of a volleyball player. Strong abdominal muscles help maintain body stability while jumping, provide additional thrust, and improve coordination between the upper and lower body. When a player has weak abdominal muscles, they tend to lose balance when jumping and landing, which can reduce the effectiveness of the smash performed.

In addition to the strength of the abdominal muscles and legs, the explosiveness of the arm muscles also plays an important role in producing powerful and targeted smashes. Rozi, Safitri, and Syukriadi (2021) emphasize that the ball hit after the jump must be done with optimal strength and accuracy. In this case, the explosive strength of the arm muscles allows players to hit the ball at high speed and produce smashes that are difficult for the opponent to return.

According to Hardiansyah (2018), muscle explosive power is the ability of a muscle or muscle group to perform physical work explosively. In the context of volleyball, this explosive power is very important because it allows a player to produce great power in a short time, especially when jumping and hitting the ball. Sovensi, Supriyadi, and Suhdy (2019) added that good muscle strength is the main basis in producing maximum explosive power.

In a volleyball game, an effective smash depends not only on muscle strength, but also on coordination of movements, correct technique, and the strategy applied. Players must be able to combine speed, accuracy, and power in every hit. In addition, mental aspects such as confidence and focus also affect the effectiveness of smashes performed.

To improve smash ability, structured physical training that focuses on muscle strengthening is crucial. A training program that involves strength training of arm muscles, leg muscles, as well as explosive power improvement exercises can help volleyball players in improving their performance. Exercises such as squat jumps, plyometric training, and weight training for the arms can increase the muscle explosiveness required in smashes.

The results of this study provide insight for volleyball coaches and athletes regarding the importance of developing muscle strength in supporting smash effectiveness. By understanding the main factors that affect smash, coaches can design more specific and effective training programs to improve player performance. This can also be the basis for developing more optimal training methods in increasing explosivity and muscle strength that are relevant to the needs in volleyball games.

This study confirms that arm muscle explosiveness, leg muscle strength, and abdominal muscle strength have a significant role in the ability to smash in volleyball. Good jumps, strong shots, and optimal coordination are the main factors in producing effective smashes. Therefore, training that focuses on improving muscle explosiveness and overall body strength is highly recommended for volleyball players to improve their performance in matches.

Conclusion

The following is the conclusion that can be drawn from the findings of the research and the debate that was presented in the prior chapter: Among the pupils of SMA Negeri 8 Medan, there is a significant influence of arm muscle explosive strength in volleyball smash, with the percentage of influence being 18.9%. 2) There is a significant influence

of leg muscle explosive power on volleyball smash on students from SMA Negeri 8 Medan, with the percentage of influence being 18.9%.

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