Leg Power, Arm Strength, and Smash Accuracy in Female Volleyball Athletes: A Correlational Study

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Abstract: This study aimed to investigate the correlation between leg power, arm strength, and smash accuracy in female volleyball athletes. This study highlights the significance of having both strong leg muscles and arm strength to achieve high levels of smash accuracy in female volleyball athletes. A total of 15 female volleyball players, aged 15 years, participated in this study. Leg power was measured using a Jump DF, arm strength was measured using a pull and push dynamometer, and smash accuracy was measured using a smash test from Robert E. Laveage. Correlation analysis was performed to examine the relationship between the variables. The data analysis technique used in this study was regression analysis at a significance level of 5%. The results of the data analysis showed that at a significance level of $\alpha = 5\%$, the obtained Ftabel was 4.67. The research findings revealed that: 1) the correlation coefficient rx1y was Fscore = 6.028 > Ftabel 4.67, indicating a significant relationship between leg power and smash accuracy; 2) the correlation coefficient rx2y was Fscore = 18.059 > Ftabel 4.67, indicating a significant relationship between arm strength and smash accuracy; and 3) the correlation coefficient ry(x1.x2) was Fscore = 6.797 > Ftabel 3.88, indicating a significant relationship between leg power, arm strength, and smash accuracy. In conclusion, this correlational study provides evidence that both leg power and arm strength are positively correlated with smash accuracy in female volleyball athletes. Coaches and trainers can use this information to design training programs that focus on improving leg power and arm strength to enhance the performance of female volleyball players in the sport.
Keywords: leg power, arm strength, smash accuracy, female volleyball athletes.

INTRODUCTION

Sports is one of the most important aspects in the development of a nation. With good sports achievements, the self-esteem or dignity of a nation will be better perceived by other nations, and one of them is achievements in the sport of volleyball. Volleyball is a widely popular sport that requires skill, power, accuracy, and agility. Volleyball is a complex game that is not easy for everyone. Playing volleyball effectively requires knowledge of basic and advanced techniques, and one of the basic technique that needed for volleyball players is smash. Smash accuracy is a crucial aspect of volleyball gameplay. A successful smash can earn a team a point and can also demoralize the opposing team. Smash accuracy is a crucial aspect of volleyball gameplay, and there are several theories that explain why it is important. One theory is that the accuracy of a

smash is influenced by various factors such as the player's position, the type of set, and the opponent's block (Putri et al., 2021). Another theory suggests that mastery of the basic techniques of volleyball game is one of the elements that can determine the win or loss of a team in a volleyball game, and one of the most difficult basic techniques in volleyball is the basic smash technique (Fikri et al., 2021). Additionally, research has shown that factors such as arm muscle explosive power, leg muscle explosive power, abdominal muscle strength, and hand-eye coordination can all have an impact on smash accuracy (Oktariana & Hardiyono, 2020). Therefore, it is important for volleyball players to practice their smash accuracy and consider these factors during gameplay.

Numerous studies have been conducted to determine the relationship between leg power, arm strength, and smash accuracy in female volleyball athletes. The smash accuracy skill, also known as a spike, is a technique of hitting the ball with the intention of killing the opponent's play. It is done by hitting the ball from above the net (Hambali & Sobarna, 2019). The smash skill, commonly referred to as a spike, is a striking technique utilized in order to terminate the opposing team's play. This technique is executed by hitting the ball from above the net with the intention of making it difficult or impossible for the opposing team to return the ball (Hasmarita & Husaeni, 2021).

Leg power is a crucial aspect of volleyball gameplay, and there are several theories that explain why it is important. Volleyball involves movements with and/or without horizontal approaches, such as spike jumps, jump setting, and blocking (Ayed et al., 2020). Leg power is essential for executing these movements effectively. Research has shown that leg power is positively correlated with measures of power and change of direction speed in collegiate volleyball players (Tramel et al., 2019). Additionally, studies have found that increased power output under load is associated with improved vertical jump ability in volleyball players (Sheppard & Newton, 2012). Proper workouts, such as plyometric exercises, can reinforce the importance of muscular leg power and improve leg muscle power in volleyball players (Pérez-Turpin et al., 2014). Therefore, it is important for volleyball players to develop their leg power through training and exercise to enhance their performance on the court.

Power is utilized during service and smash strokes. The power of the arm plays a crucial role in movements such as service, strokes, and defense (Alsah et al., 2016). This technique can only be executed when the used power has reached its maximum and is both fast and accurate. The leg acts as a passive moving tool that can only move if the muscles in the leg are stimulated by the nervous system. Every volleyball player should always strive to improve the strength of their

arm muscles. With greater arm strength, smash and service strokes are more forceful and faster, leading to a higher success rate. Large leg muscles produce maximum jumps, which is why a volleyball player must jump as high as possible to execute a smash (Pratomo et al., 2013). A good smash can only be accomplished if the player has strong leg muscles. The power of the leg muscles is crucial when executing a smash (Munizar, Razali, 2016). There is a positive and significant correlation between leg muscles and semi-smash results in volleyball. This indicates that leg muscles play an important role in the success of the smash. Large leg muscles will produce maximum jumps, and a volleyball player is expected to jump as high as possible to execute a smash (Pratomo & Muhammad, 2020). Furthermore, the athlete's emotional state during the smash can also affect the accuracy of the hit. Therefore, it can be said that hitting with precise targets strongly supports the aforementioned factors, and this should be a concern for volleyball coaches and athletes (Yulifri et al., 2018).

Arm strength is a crucial aspect of volleyball gameplay, and there are several theories that explain why it is important. One theory is that arm muscle explosive power is essential for a successful smash in volleyball (Oktariana & Hardiyono, 2020). Another theory suggests that strength of the external rotators (ERs) and internal rotators (IRs) of the shoulder is related to either serving or spiking performance, which are both important elements of success in volleyball (Hadžić et al., 2014). Research has shown that differences in IR and ER strength ratios appear to be related to injury in almost all players whose sports involve overhead throwing activities, such as volleyball (Hadžić et al., 2014). Additionally, studies have found that handgrip strength is correlated with some hand and arm anthropometric variables in female volleyball players (Koley & Kaur, 2011). Proper workouts, such as upper-extremity plyometric training, can reinforce the importance of muscular arm strength and improve arm muscle power in volleyball players (Turgut et al., 2019). Therefore, it is important for volleyball players to develop their arm strength through training and exercise to enhance their performance on the court. The muscle strength that can be trained includes leg, back, arm, and hand muscles that play an important role in supporting daily activities such as walking, lifting objects, exercising, and so on (Nasrulloh & Wicaksono, 2020). The strength of the arm muscles is the ability to resist resistance performed by a group of muscles contraction from the shoulder, upper arm, upper arm, to the palm of the hand (Nasution, 2015). A long arm can affect the speed of the hitting movement, and the speed is proportional to the size of the radius, which is the length of a person's arm. So, the longer the radius, the faster the speed obtained, thus

increasing the speed of the ball, and the initial hit can be a good backline attack (Efendi & Awang, 2020).

To determine the correlation between leg power, arm strength, and smash accuracy in female volleyball athletes, research must be conducted. Several studies have investigated the relationship between these factors in volleyball players (Hadžić et al., 2014), (Akarçeşme et al., 2017), (Acar & Eler, 2019). However, there is still a lack of research on the specific relationship between leg power, arm strength, and smash accuracy in female volleyball athletes especially for players who are 15 years old. Therefore, further research is needed to determine the extent to which leg power and arm strength contribute to smash accuracy in female volleyball athletes. This research could help coaches and athletes develop more effective training programs to improve smash accuracy and overall performance on the court.

METHOD

Correlational research is a method used to investigate in this study about the relationship between leg power, arm strength, and smash accuracy in female volleyball athletes at Govita Volleyball Club, Semarang, Indonesia in 2023. To conduct a correlation between leg power, arm strength, and smash accuracy in female volleyball athletes, research using correlational method is needed. The sample of this study consisted of 15 female athletes aged 15 years old. The data collection used in this study was conducted through testing and measurement. The data collection in this study was carried out to measure leg muscle power using the vertical jump test (Jump DF), which was repeated twice and the best result was taken. The strength of the arm muscles was measured using the pull and push dynamometer test, and the best result was recorded in kilograms (kg). Then, the results of both tests were correlated with the data on the accuracy of the smash using a smash test from Robert E. Laveage. Furthermore, in this study, the data was analyzed at a significance level of 5% (0.05). The analysis employed prerequisite tests (normality and homogeneity tests) as well as hypothesis testing (linearity test, simple and multiple regression analysis).

RESULTS

The relationship between leg muscle power and accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang can be described by the regression equation $Y = a + BX_2$, as obtained in Table below, where $Y = -6.493 + 1.327X_1$. This means that for every one-point

increase in arm muscle strength, the accuracy of the smash decreases by 1.327 points, with a constant of -6.493. The regression equation was tested using the F-test, and the calculated F-value was 6.028, which is greater than the tabled F-value of 4.67 at α = 5% with numerator degrees of freedom (df) of 1 and denominator df of 13. This indicates that the equation is statistically significant.

Table 1. Regression

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	-6.493	26.170		-.248	.808
Power Otot Tungkai	1.327	.540	.563	2.455	.029
a. Dependent Variable: Ketepatan Smash					

The relationship between arm muscle strength and accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang can be described by the regression equation Y = a + BX2, as obtained in Table below, where Y = 18.059 + 1.458X2. This means that for every one-point increase in arm muscle strength, there is an increase of 1.458 points in the accuracy of the smash, with a constant of 18.059. The regression equation was tested using the F-test, and the calculated F-value was 18.059, which is greater than the tabled F-value of 4.67 at α = 5% with numerator degrees of freedom (df) of 1 and denominator df of 13. This indicates that the equation is statistically significant.

Table 2. Arm muscle strength and accuracy

Coefficients[a]					
Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	18.059	12.565		1.437	.174
Kekutan otot lengan	1.458	.458	.662	3.182	.007
a. Dependent Variable: Ketepatan Smash					

Based on the tabel below, the calculated F-value of 6.797 was obtained at α = 5% with numerator degrees of freedom (df) of 2 and denominator df of 12. The tabulated F-value is 3.88. Since the calculated F-value is greater than the tabled value (6.797 > 3.88), it can be concluded that there is a significant relationship between leg muscle power and arm muscle strength with the accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang.

Table 3. Annova

ANOVA[a]					
Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	740.288	2	370.144	6.797	.011[b]
	Residual	653.446	12	54.454		
	Total	1393.733	14			
a. Dependent Variable: smash accuracy						
b. Predictors: (Constant),arm strength, leg power						

Also based on the relationship between leg muscle power and arm muscle strength with the accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang, it can be observed from the obtained coefficient of determination in table below, which is 0.729 or 72.9%.

Table 4. Determinan

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.729[a]	.531	.453	7.379
a. Predictors: (Constant), arm strength, leg power				

DISCUSSION

Based on the hypothesis test results, it is evident that there is a significant relationship between leg muscle power and arm muscle strength with the accuracy of the smash. This is supported by the regression equation test using the F-test, where the calculated F-value of 6.797 is greater than the tabled F-value of 4.67 at α = 5% with numerator degrees of freedom (df) of 2 and denominator df of 12, indicating the significance of the equation. Therefore, increasing leg muscle power and arm muscle strength can have an impact on the smash performance of volleyball athletes.

The physical condition of an athlete is the most important factor in achieving success in the sport of volleyball. The physical components that are considered crucial in relation to the smash include leg muscle power and arm muscle strength. This is based on the fundamental theory that a powerful arm muscle and high jumping explosiveness are necessary for a strong smash (Anam et al., 2015). Additionally, physical factors such as strength, muscle power, and flexibility contribute

to volleyball performance. Muscle strength is one of the supporting factors that leads to difficult and lethal strikes (Munizar, Razali, 2016). Leg muscle power significantly influences high jumping performance, which facilitates players in executing desired smashes, while arm muscle strength greatly affects the striking force of the smash. The striking force is generated by the rapid contraction of arm muscles during the smashing process.

Based on the data analysis results, it is evident that there is a significant relationship between leg muscle power and the accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang. The magnitude of this relationship can be observed from the coefficient of determination, which is 0.563 or 56.3%. The negative sign of the coefficient indicates that the relationship is negative. Leg muscle power is related to the accuracy of the smash because it is one of the physical components that volleyball players must possess to support high jumping during a smash (Oktariana & Hardiyono, 2020). The height of a volleyball player's jump is influenced by leg muscle power; the higher the leg muscle power, the higher the jump produced during a volleyball smash (Munizar, Razali, 2016). Having high leg muscle power enables a player to perform smashes to their maximum potential. The higher the leg muscle power, the higher the accuracy of the volleyball smash, and vice versa, a lower leg muscle power in a volleyball player will result in lower accuracy in the smash (Pratomo et al., 2013). Therefore, it is reasonable to conclude that in this study, it was found that leg muscle power is significantly associated with the accuracy of the smash.

Based on the data analysis results, it is evident that there is a significant relationship between arm muscle strength and the accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang. The magnitude of this relationship can be observed from the coefficient of determination, which is 0.662 or 66.2%. The positive sign of the coefficient indicates that the relationship is positive. Arm muscle strength is related to the accuracy of the smash because it is one of the physical components that a volleyball player must possess when executing a smashing stroke (Alfaza & Perwira, 2021). The quality of a volleyball player's smash is highly influenced by the strength of the arm muscles. The higher the arm muscle strength, the stronger and more directed the strike produced during a volleyball smash (Munizar, Razali, 2016). Having high arm muscle strength leads to optimal accuracy in the smash. The higher the arm muscle strength of a volleyball player, the better the accuracy of the smash achieved, and conversely, the lower the arm muscle strength, the poorer the accuracy of the smash produced by a volleyball player (Pratomo

et al., 2013). Therefore, it is reasonable to conclude that in this study, it was found that arm muscle strength is significantly associated with the accuracy of the smash.

Overall, based on the data analysis results, it is evident that there is a significant relationship between leg muscle power and arm muscle strength with the accuracy of the smash in the U-15 female volleyball athletes of Govita Semarang. The magnitude of the relationship between leg muscle power, arm muscle strength, and the accuracy of the smash can be observed from the coefficient of determination, which is 0.729 or 72.9%. The relationship between leg muscle power and arm muscle strength with the accuracy of the smash is positive. Leg muscle power and arm muscle strength are related to the accuracy of the smash because they support high jumps and precise strikes during the game of volleyball. Therefore, leg muscle power and arm muscle strength play a crucial role in determining the smash outcome. The higher the leg muscle power and arm muscle strength, the better and more directed the accuracy of the smash, whereas the lower the leg muscle power and arm muscle strength, the poorer and less directed the smash outcome, resulting in less sharp and deadly attacks against opponents.

CONCLUSION

Based on the results of the research and data analysis conducted, it can be concluded that there is a relationship between leg power and arm strength with the accuracy of smash in female volleyball athletes from Govita Volleyball Club, Semarang. The findings of this study suggest that improving leg power and arm strength may have a positive impact on the accuracy of smash in female volleyball athletes. Therefore, coaches and trainers can design training programs that focus on developing both leg power and arm muscles strength in order to enhance the performance of female volleyball athletes in the accuracy of smash. Additionally, this study provides insights into the importance of comprehensive physical fitness assessments in young athletes, as it may help identify potential areas of improvement in their performance. Further research may also be conducted to explore the effects of specific training programs on the development of leg power and arm muscles strength in female volleyball athletes.

Conflict of Interest

The authors declare that they have no conflict of interest.

Acknowledgment

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