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Research Article

The relationship between shoulder and wrist muscle flexibility and hand muscle strength with the smash accuracy in Badminton

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ABSTRACT
Background: Smash accuracy in badminton games is often the primary problem athletes face to earn points, so it is necessary to investigate the relationship between smash accuracy with shoulder and wrist muscle flexibility and hand muscle strength. Objective: This study aimed to determine the relationship between shoulder and wrist muscle flexibility and hand muscle strength with smash accuracy in badminton. Methods: This study uses a correlation method to assess the relationship between shoulder and wrist muscle flexibility, hand muscle strength, and badminton smash accuracy. In this study, all male athletes of PB Club. Mandiri Palembang, totaling 30 people with an age range of 13-17 years. The instruments include flexibility tests (static flexibility tests for shoulders and wrists), hand muscle strength assessments (push-ups), and badminton smash accuracy tests. Results: The results of data processing and analysis using simple regression and multiple regression tests obtained the following results: (1) The relationship between shoulder and wrist muscle flexibility and badminton smash ability produces an R-value of 0.435 with a significance of 0.193 ($p>0.05$). (2) The relationship between hand muscle strength and badminton smash ability produces an R-value of 0.419 with a significance of 0.790 ($p <0.05$). (3) The relationship between shoulder and wrist muscle flexibility and hand muscle strength with badminton smash accuracy results in an R-value of 0.591 with a significance of 0.737 ($p<0.05$). Conclusion: The results showed a relationship between shoulder and wrist muscle flexibility and hand muscle strength in badminton smash accuracy. The magnitude of the relationship between shoulder and wrist muscle flexibility and hand muscle strength to the results of badminton smash accuracy is with an R-value of 0.591, which is greater than the r-table 0.374. This means that the better the shoulder and wrist muscle flexibility and hand muscle strength an athlete has, the better the accuracy of the athlete's smash results will be.

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Introduction

Exercise is a necessity in human life because if someone exercises regularly, it will positively influence their physical development. Apart from being beneficial for growth in human physical development, it also influences spiritual development; this influence can provide work efficiency for the tools of the body so that blood circulation, breathing, and digestion become regular (Khairuddin, 2020). Physical education is an educational process through physical activity that aims to improve physical fitness and develop motor skills, sportsmanship, emotional intelligence, knowledge, and healthy living behavior. The material in physical education learning is small ball game material. One of the small ball game materials is badminton (Aryanti et al., 2021). Developing outstanding sports needs attention from the government, as described in Law 11 of 2022 concerning sports, which states that Sports are all activities that involve mind, body, and soul in an integrated and systematic manner to encourage, foster, and develop physical, spiritual, social, and cultural potential (UU No 11 Tahun 2022, 2022).

Badminton is a sport that uses rackets, and two or four people play it with positions on different courts (Subarkah & Marani, 2020). As per the research by Lestari et al. (2023), the fundamental badminton techniques that generally need to be learned can be categorized into several aspects, namely the method of gripping the racket, the stance or body position, footwork movements, and various stroke techniques. On the other hand, according to the research by Nofrizal (2019), flexibility is defined as the ability of joints and the surrounding muscles to perform movements with a maximum range of motion. According to the research by Utami (2013), another term commonly used in conjunction with flexibility is elasticity, which refers to the ability of muscles to change in length by extending or contracting.

The smash stroke is synonymous with an offensive shot, as its primary purpose is to win the point against the opponent. The jump smash is considered one of the most effective shots to gain an advantage over the opponent. Adding a jump further enhances the power and velocity of the smash stroke. This is because the swing generated from the entire body during the jumping motion translates into greater force, resulting in a faster and more potent shuttlecock delivery (Pratama, Wardiah, & Fajar, 2023). According to the research by Sefriana & Wiguna (2023), executing an effective jumping smash shot requires excellent coordination among the involved body parts. When performed accurately, the jumping smash can significantly challenge the opponent during the return due to the incredible speed and power imparted by the shuttlecock. According to the study by Wea & Samri (2022), a Smash in badminton games is a blow often used and is the mainstay of athletes to kill the ball and score points. Therefore, athletes must pay attention to the factors that support the accuracy of smash. Power will create good accuracy in the presence of speed generated (Hadi et al., 2013). According to the research by Ningrum et al. (2022), hand muscle strength is crucial for delivering powerful, precise, and accurate strikes.

According to the research by Suratman & Mesiyani (2016), hand muscle strength refers to the ability of the hand muscles to perform activities rapidly and forcefully, generating power. On the other hand, as stated by Arifin et al. (2022), hand muscle strength plays a crucial role in determining the trajectory of the shuttlecock during a strike. Without adequate hand muscle strength, the speed and velocity of the shuttlecock would be significantly reduced after the stroke. Muscle strength is the physical aspect of an athlete's ability to use their muscles to withstand load over a certain period. The study by Ibrohim et al. (2022), suggests that the greater the hand muscle strength generated, the more powerful and impactful the resulting stroke. Based on initial observations in the field and interviews with coaches, some athletes have mastered basic badminton techniques. However, most athletes need more mastery of smash-hitting techniques in terms of accuracy.

Previous research related to the "Relationship between Arm Muscle Strength and Wrist Flexibility with Full Smash Accuracy in Badminton Games" (Yuliawan, 2017), reported that flexibility is a crucial aspect of sports and physical activities. If an individual experiences a limited range of motion in their joints, it can impede their movements and potentially lead to muscle injuries (Digantara et al., 2020). The solution I offer is to use shoulder and wrist muscle flexibility compared to wrist flexibility, which, according to the author, is more effective. The arm is divided into two main sections: the upper arm and the lower arm. The arm is divided into two main sections: the upper arm and the lower arm. According to the research by Purnomo (2019), the shoulder joint is an articulation between the scapula and the humerus (upper arm bone), while the elbow and forearm consist of three bones: the humerus, ulna, and radius. Together, these three bones form four joints – three at the proximal end of the lower arm (radiohumerale, glenohumeral, and proximal radioulnar) and one at the distal end of the lower arm (distance radioulnar).

This study will employ a correlational research design to investigate the strength of the relationships between the variables under examination and the degree to which variations in one

variable are associated with variations in the other variables. Data will be gathered through tests and measurement procedures. The results obtained from this inquiry could inform the development of specialized training regimens focused on augmenting shoulder and wrist muscle flexibility and hand muscle strength, thereby potentially enhancing precision in executing the smash shot technique.

Method

Research Design

The method used is the correlation method, and this study uses instruments in the form of static shoulder and wrist flexibility tests (Static flexibility test- shoulder and wrist) to assess flexibility and range of motion, specific instruments are needed, such as an 18-inch rod, a 1-meter ruler, and a evaluator to administer and record the assessments (Mackenzie, 2005), hand muscle strength (push up) the test will require participants to complete as many push-up repetitions as they can within a 1-minute time frame (Wiriawan, 2017) and badminton smash accuracy tests with targets that have been set in such a way that amounts to 5 points and each target has a different score (Musthafa, 2022).

Instrument

This study uses instruments in the form of static shoulder and wrist flexibility tests (Static flexibility test-shoulder and wrist), hand muscle strength (push), and badminton smash accuracy tests with targets that have been set in such a way that amount to 5 points, and each target has a different score. The sample taken in this study were male athletes who participated in training activities at the PB Club. Mandiri Palembang comprised 30 male athletes aged 13-17 years at the PB Club. Mandiri Club Palembang.

Static flexibility test—shoulder and wrist is a static flexibility test used to measure how much an individual can extend or bend their shoulder and wrist in a given position without any active or dynamic movement. This test provides an overview of joint and muscle flexibility in the shoulder and wrist region and aims to see the development of shoulder and shoulder and wrist muscle flexibility (Mackenzie, 2005).

The measurement of hand muscle strength is a comprehensive process. It involves a face-down body lift test (push up) and is carried out for both straight leg (push up) and bent leg / kneeling (knee push up) techniques. Men perform the straight leg technique, while women use the bent/kneeling leg technique (Wiriawan, 2017). The total score obtained is divided by the total maximum score and multiplied by 100% to calculate the percentage of product feasibility. The value categories are explained in detail in Table 1, Table 2, and Figure 1, ensuring a thorough understanding of the results.

Table 1. Shoulder and wrist muscle flexibility Test Norm

No	Category	Men	Women
1.	Very good	>12.50	>11.75
2.	Good	12.50-11.50	11.75-10.75
3.	Average	11.49-8.25	10.74-7.50
4.	Poor	8.24-6.00	7.49-5.50
5.	Very Poor	<6.00	<5.50

Table 2. Push-Up Test Norm

No.	Category	Men	Women
1.	Very good	>56	>35
2.	Good	55 - 36	34 - 22
3.	Average	35 - 19	21 - 11
4.	Below average	18 - 12	10 - 6
5.	Bad	<11	<5

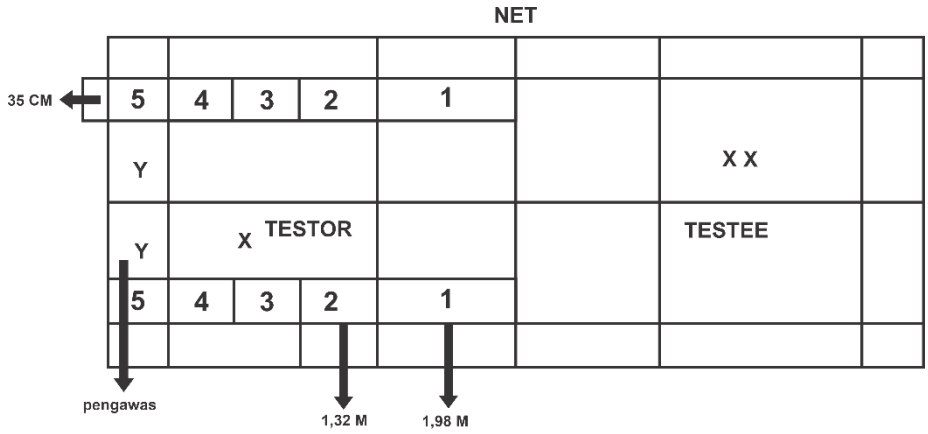

Figure 1. Field for Smash Accuracy Test

Data Analysis

For this study, the normality of the data was assessed utilizing the Shapiro-Wilk test function available in the SPSS 28 statistical software package. The linearity of the relationships between variables was evaluated through the deviation from linearity test, also conducted using SPSS 28. To examine the presence of multicollinearity, or interrelationships among the predictor variables, the linearity test in SPSS 28 was employed. Multiple regression analysis was performed using the multiple regression test feature in SPSS 28 to model the relationships between the variables. Finally, each variable's relative and practical contributions were calculated using the corresponding tests available in the SPSS 28 program.

Results and Discussion

Result

This study uses a correlation method to assess the relationship between shoulder and wrist muscle flexibility, hand muscle strength, and smash accuracy. This study is of male athletes from the PB Club. Mandiri Palembang, totaling 30 people with an age range of 13-17 years. The first step is to conduct a flexibility test used to measure shoulder and wrist muscle flexibility; the test that can be used for this is the Static flexibility test- shoulder and wrist is a static flexibility test used to measure the extent to which an individual can stretch or bend their shoulders and wrists in a particular position without any active or dynamic movement.

Table 3. Shoulder and wrist muscle flexibility Test Results

N	Valid	30
	Missing	0
Mean		1,83
Median		1,00
Mode		1
Std. Deviation		1,177
Variance		1,385
Minimum		1
Maximum		4

From the Table 3, the mean value is 1.83, the median value is 1.00, the mode value is 1, the standart deviation value is 1.177, the variance value is 1.385 the smallest value is 1 and the largest value is 4, this value is obtained after the Static flexibility test- shoulder and wrist.

The next test, namely the strength measurement test, was carried out using the push up test. The results obtained after the test are as follows.

Table 4. Hand Muscle Strength Test Results

N	Valid	30
	Missing	0
Mean		2,93
Median		3,00
Mode		2a
Std. Deviation		,868
Variance		,754
Minimum		2
Maximum		5

From the Table 4, the mean value is 20.80, the median value is 19.00, the mode value is 2a, the standart deviation value is 0.868, the variance value is 0.754 the smallest value is 2 and the largest value is 5, this value is obtained after the push up test. The next test, namely the smash accuracy measurement test, was carried out using the smash accuracy which can be seen in Figure 1.

The next test, namely the data normality test, was carried out using SPSS. The results obtained after conducting the test are as follows.

Table 5. Normality Test

	Statistic	Df	Sig.
Shoulder and wrist muscle flexibility (X_1)	0,948	30	0,153
Hand Muscle Strength (X_2)	0,948	30	0,152
Smash Accuracy (Y)	0,674	1.659	0,591

Based on Table 5, it is known that the Sig. value on shoulder and wrist muscle flexibility, arm strength, and smash accuracy> 0.05, so that the data is declared normally distributed. The next test is the linearity test which is intended to test whether the data obtained is linear or not, if the data is linear, then it can be continued with the regression technique, the data obtained is as follows.

Table 6. Linearity Test

			Sum of Squares	df	Mean Square	F	Sig.
Accuracy * Flexibility	Between Groups	(Combined)	7,867	19	,414	,690	,767
		Linearity	,840	1	,840	1,400	,264
		Deviation from Linearity	7,027	18	,390	,651	,795

The linearity test result (Table 6) between accuracy and flexibility in combined the sum of squares value is 7.867, the degrees of freedom value is 19, the mean square value is 0.414, the f value is 0.690, the Sig. deviation value is 0.767, in linearity, the sum of squares value is 0.840, the degrees of freedom value is 1, the mean square value is 0.840, the f value is 1.400, the Sig. deviation value is 0.264, and in deviation from linearity, the sum of squares value is 7.027, the degrees of freedom value is 18, the mean square value is 0.390, the f value is 0.651, data obtained from the linearity test using the help of the SPSS program is the Sig. deviation from the linearity value 0.795 with linearity test testing criteria if the

Sig. deviation from linearity value> 0.05, there is a linear relationship between flexibility and smash accuracy, and if the Sig. deviation from linearity value <0.05, there is no linear relationship between shoulder and wrist muscle flexibility variable and hand muscle strength and on the shooting variable. Thus, there is a linear relationship between shoulder and wrist muscle flexibility and hand muscle strength in male badminton athletes PB. Mandiri Palembang.

The next test is the Hypothesis Test by using the Multicollinearity test, this research formula is to test the relationship of each variable. The data obtained is as follows.

To test the hypothesis of leg muscle explosive power and togok flexibility with badminton jump smash results using multiple regression analysis. The data obtained are as follows:

Table 7. Multiple Regression Test

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	58,458	2	29,229	37,745	,000[b]
	Residual	20,908	27	0,774		

The multiple regression test result (Table 7) is the sum of squares value is 58.458, the degrees of freedom value is 2, the mean square value is 29.229, the f value is 37,745, the significance is 0.000b, in residual the sum of squares value is 20.908, the degrees of freedom value is 27, the mean square value is 0.774, The result data obtained from the multiple regression test using the help of the SPSS program is the sig value, which is 0.000 with the test criteria if the sig value. <0.05, then shoulder and wrist muscle flexibility is related to the shooting, and if the sig value. >0.05, there is no relationship between shoulder and wrist muscle flexibility and hand muscle strength and on the shooting. Thus, from the data obtained, the value of F count = 37.745 with a sig. The value of 0.000 <0.05, then the regression model can be used to predict a relationship between shoulder and wrist muscle flexibility, hand muscle strength, and shooting.

Table 8. Relative and effective

Relative and effective				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0,858[a]	0,737	0,717	0,87999

Table 8 shows that the adjusted R square value is 0.717, the standard error of the estimated value is 0.97999, the value (R) is 0.858 with the coefficient of determination (R Square) is 0.737, and also, according to the guideline table for providing interception of the correlation coefficient with a coefficient interval of 0.60- 0.799 the level of relationship is vital, so from the data that has been obtained there is a relationship between shoulder and wrist muscle flexibility and hand muscle strength and on the shooting.

Discussion

The analysis results of the relationship between the two independent and dependent variables need to be further studied by providing an interpretation of the relationship between the analysis results achieved and the theories underlying this research. This explanation is needed to determine the suitability of the theory put forward by the research results obtained.

The results showed that there was a relationship between shoulder and wrist muscle flexibility and the results of the badminton smash. This means that the more flexibility an athlete has, the better the athlete's smash accuracy. According to Asnaldi (2020) flexibility plays a role when a player is in the air

after making a jump. The player's body is pulled back lustily to take the prefix, and then the body is pushed forward, followed by hand movements in hitting the ball.

The results showed a relationship between hand muscle strength and the accuracy of badminton smash at PB Club. Mandiri Palembang, the magnitude of the relationship between hand muscle strength and the accuracy of smash results is with r-count 0.419, more significant than r-table 0.374. This means that the better the hand muscle strength an athlete has, the better the accuracy of the athlete's smash results. Strength and speed must support A good smash shot to produce a fastball path. The strength referred to here is the contraction of the muscles, which is the movement of the muscles from their first movement to the total distance of movement and repeating this ability against resistance as close as possible to their resistance to maximum pressure (Vinet & Zhedanov, 2011). Hand muscle strength is one of the critical factors when performing a smash properly.

The results showed a relationship between shoulder and wrist muscle flexibility and hand muscle strength on the badminton smash accuracy. The magnitude of the relationship between shoulder and wrist muscle flexibility and hand muscle strength to the results of badminton smash accuracy is with r-count 0.591, which is greater than r-table 0.374. This means that the better the shoulder and wrist muscle flexibility and hand muscle strength an athlete has, the better the accuracy of the athlete's smash results will be.

According to Muharram et al. (2022), smash accuracy is still a problem that appears in athletes in general, and of course, this is caused by various factors. Meanwhile, according to Setyawan (2016), arm muscle strength is one factor that affects the accuracy of badminton smashes. Smash in badminton games is a blow that is often used and is the mainstay of athletes to kill the ball and score points. Therefore, athletes must pay attention to the factors that support the accuracy of smash. Based on initial observations in the field and interviews with coaches, some athletes have mastered basic badminton techniques, but most athletes need more mastery of smash-hitting techniques in accuracy.

Achieving a precise and powerful smash in badminton relies heavily on having flexible arms and strong hand muscles. Supple arms facilitate a smooth, unrestricted swing motion, while robust hand muscles generate the necessary force to deliver a sharp, well-aimed shot. Nevertheless, mastering proper technique, developing impeccable timing, and maintaining overall physical fitness are crucial elements that contribute significantly to an effective smash. To gain a more comprehensive understanding of how each factor influences the accuracy and potency of the smash, the expertise of sports biomechanics professionals is invaluable. Their analysis and insights can significantly enhance an athlete's ability to deliver a powerful and accurate smash.

Conslusions

The findings show a significant relationship between shoulder and wrist muscle flexibility, hand muscle strength, and smash accuracy in badminton games. Although shoulder and wrist muscle flexibility and hand muscle strength contribute significantly, other factors such as technique, eye-hand coordination, timing, and overall physical condition also play an essential role in producing accurate smashes. The research findings suggest that players must train shoulder and wrist muscle flexibility and hand muscle strength while paying attention to other aspects of smash skills.

Further research needs to be conducted such as exploring the influence of other factors such as anthropometry, biomechanics, and psychology on smash accuracy, as well as the interactions among these factors, utilizing advanced motion analysis technology and methods to obtain more accurate and detailed data regarding ideal smash mechanics, and investigating the potential benefits of incorporating mental training techniques, such as visualization and focus training, along with physical exercise for smash accuracy.

Authors' contributions

ARA is responsible for data compilation, analysis, article conception, writing, and revision. Sand D is responsible for article conceptualization and strict and critically revised manuscripts. All authors read and approved the final manuscript.

Competing interests

The authors declare no competing interests.

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