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The Relationship between Arm Muscle Strength and Togok Flexibility with Butterfly Swimming Speed

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Abstract

The purpose of this study was to determine how the arm muscle strength and trunk flexibility of Kendari City swimmers relate to their butterfly swimming speed. The descriptive correlational research category covers this work. The study population consisted of 35 swimmers from Kendari City, 30 of whom were male and 5 of whom were female. Thirty male swimmers from Kendari City were the sample for this study because the sampling method was applied by utilizing the overall sampling strategy, which uses the population as a sample. Static flexibility tests were used to assess trunk and neck flexibility, butterfly swimming tests were used to measure butterfly swimming speed, and grip strength tests were used to measure arm muscle strength. The mean, standard deviation, mean, media, maximum value, and minimum value were all calculated as part of the descriptive analysis. Using SPSS 26, conduct regression analysis of normality, linearity, and correlation tests. Based on the results of data analysis, arm muscle strength and body flexibility of Kendari City swimming athletes correlate significantly with butterfly swimming speed ($r_{x1,2.y} = 0.669 > r_{(0.05)(30)} = 0.361$). Based on the results of data analysis, it can be concluded that there is a significant relationship between arm muscle strength and trunk flexibility with butterfly swimming speed in Kendari City swimming athletes.

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INTRODUCTION

One of the physical activities that can help the body reach its full potential through increased muscle development and movement is sports (Vaara et al., 2022; Pleša et al., 2022). The characteristics of human behavior in various community-based activities are closely related to the characteristics of sports (Sullivan et al., 2022). According to research, the essence of sports is playing, in this context, people show off their ability to perform a movement (Sahabuddin et al., 2022). Improving physical fitness is one of the goals of exercise (Rusli et al., 2023). Swimming is one of the activities that is increasingly in demand by society today. Because swimming is very important for everyone to learn.

Swimming is one of the healthy sports and almost all the muscles in the body move, so it can improve the swimmer's ability in their activities (ÇETİN et al., 2023; Hadiansyah et al., 2022). Swimming is a sport that is competed in at the national and international levels, namely through the Olympics, Asian Games and national championships such as the Regional Sports Week (Moreno et al., 2022). Basic swimming techniques consist of four styles, namely breaststroke, freestyle, backstroke and butterfly (Firdaus et al., 2022). One of the swimming sports that has quite difficult movements is butterfly swimming, one of the four officially recognized swimming styles.

Butterfly swimming is characterized by alternating movements between swinging both arms above the water surface and swinging both legs in the water (Chen et al., 2022). In this swimming style, hand and arm movements are very important in creating a strong thrust to propel the body forward in the water (Austin et al., 2022). Therefore, good arm and trunk muscle strength is needed to achieve high speed in butterfly swimming.

Swimmers who have good arm muscle strength will be able to produce a stronger thrust when launching their hands into the water and when lifting their bodies from the water (Wirth et al., 2022; Rusmi et al., 2023). In addition, good arm muscle strength will also allow athletes to withstand the tension that occurs in their muscles when swimming at high intensity (Zumwalt, 2023). On the other hand, hand flexibility (torso) is also very important in butterfly swimming. A flexible togok will allow athletes to produce more efficient and faster movements in paddling the water (Johansson & Henningsson, 2021). In addition, a flexible togok will also minimize tension in the arm and shoulder muscles, allowing athletes to swim faster and longer without feeling tired (Yoma et al., 2022). Arm muscle strength and togok flexibility are two important factors that contribute to the speed of butterfly swimming in athletes (Özkadı et al., 2022). Therefore, training that focuses on increasing arm muscle strength and developing a more flexible stick is very important for athletes to achieve optimal speed in butterfly swimming (Ruiz-Navarro et al., 2022).

Arm muscle strength plays a role in providing the main thrust when performing underwater arm pulls. A strong and effective pull determines how far the body can advance in each movement cycle (Syukriadi & Fajrial, 2020). Athletes with good arm muscle strength are able to generate great power to overcome water resistance, thereby

increasing swimming efficiency and speed (Noveminaila et al., 2020). A flexible togok allows the body to perform undulation movements efficiently, namely the up-and-down wave-like movements that are characteristic of the butterfly stroke (Johansson & Henningsson, 2021). Good togok flexibility helps reduce water resistance (drag) and allows a wider range of motion, thereby increasing the effectiveness of the movement (Hu et al., 2024). In the butterfly stroke, arm muscle strength and togok flexibility work synergistically. The arm muscles produce thrust, while togok flexibility helps the body move in an aerodynamic pattern. This combination greatly determines the effectiveness of each movement, which ultimately affects swimming speed.

Some problems that often occur in butterfly swimming in Kendari City athletes, there are some athletes who face difficulties in mastering the correct butterfly swimming technique. This can include problems with unsynchronized arm and leg movements, incorrect body position, or breathing errors. Improper technique can reduce the speed and efficiency of movement, so athletes need to train and improve their technique regularly. then inadequate arm and leg muscle strength can be an obstacle in butterfly swimming. Weak arm muscles can inhibit an athlete's ability to produce a strong thrust, while weak leg muscles can affect the speed of the leg swing and thrust in the water. Strengthening and strengthening the muscles involved in the butterfly swimming movement can help overcome this problem.

Lack of flexibility, especially in the trunk area, can hinder efficient movement in butterfly swimming. A stiff or inflexible trunk can interfere with optimal movement and affect the athlete's speed. Targeted and routine flexibility can help improve trunk flexibility and overcome this problem. Butterfly swimming requires good physical fitness, including cardiovascular endurance, overall body strength, and sufficient stamina. If athletes experience deficiencies in physical condition and general fitness, they may have difficulty maintaining speed and quality of movement during swimming. Overall fitness and an exercise program that includes that can help improve overall physical condition. So the purpose of this study was to determine the relationship between arm muscle strength and trunk flexibility with butterfly swimming speed in Kendari City swimming athletes.

METHODS

This study is included in the category of descriptive correlational research where researchers want to know the strength of the arm muscles and trunk flexibility with the speed of butterfly swimming in Kendari City swimming athletes. The population in this study were all Kendari City swimming athletes totaling 35 people consisting of 30 male and 5 female. The sampling technique was carried out using the total sampling technique, namely the population used as a sample, so in this study the sample was 30 male Kendari City swimming athletes. The instrument used to measure arm muscle strength was a hand dynamometer (Ismaryati & Sarwono, 2018), to measure trunk flexibility using the static flexibility test trunk and neck (Sepdanius, 2019), and to measure butterfly swimming speed using the butterfly swimming test (Sulastri & Syafaruddin, 2021). Data analysis used descriptive statistical tests, analysis prerequisite tests and correlation tests using SPSS Version 26.

RESULT

The results of the research in the descriptive statistical data analysis obtained several values which are listed in table 1.

Table 1. Descriptive Statistical Analysis of Arm Muscle Strength (X1), Trunk Flexibility (X2) with Butterfly Swimming Speed (Y)

Variable	X1	X2	Y
Mean	15.1667	50.4367	33.1390
Median	15.4350	50.4150	33.7700
Mode	15.32[a]	50.00	33.77[a]
Std. Deviation	1.40107	3.68865	2.58315
Minimum	12.28	42.71	27.22
Maximum	16.92	56.25	35.92
Sum	455.00	1513.10	994.17

Table 2. Arm Muscle Strength (X1)

Class Interval	Frequency	Percentage (%)
12,28 - 13,06	3	10
13,07 - 13,85	4	13
13,86 - 14,64	4	13
14,65 - 15,43	4	13
15,44 - 16,22	7	23
16,23 - 16,92	8	27
Total	30	100

Based on the results of the arm muscle strength interval class using the grip strength test, it was obtained 12.28 - 13.06, frequency 3 people, with a percentage of 10%. Obtained 13.07 - 13.85, frequency 4 people, with a percentage of 13%. Obtained 13.86 - 14.64, frequency 4 people, with a percentage of 13%. Obtained 14.65 - 15.43, frequency 4 people, with a percentage of 13%. Obtained 15.44 - 16.22, frequency 7 people, with a percentage of 23%. Obtained 16.23 - 16.92, frequency 8 people, with a percentage of 27%. The results of the interval score data analysis can be described in histogram 1.

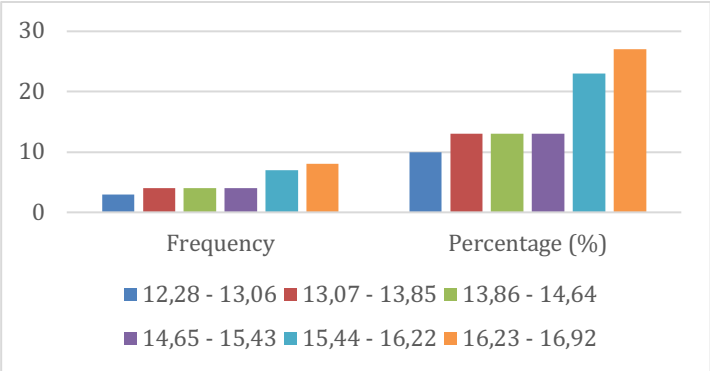

Figure 1. Histogram of Arm Muscle Strength (X1)

Table 3. Flexibility of Togok (X2)

Class Interval	Frequency	Percentage (%)
42,71 - 45,01	4	13
45,02 - 47,32	1	3
47,33 - 49,63	6	20
49,64 - 51,94	8	27
51,95 - 54,25	7	23
54,26 - 56,56	4	13
Total	30	100

Based on the results of the trunk flexibility interval class using the static flexibility test trunk and neck, it was obtained 42.71 - 45.01, frequency 4 people, with a percentage of 13%. Obtained 45.02 - 47.32, frequency 1 person, with a percentage of 3%. Obtained 47.33 - 49.63, frequency 6 people, with a percentage of 20%. Obtained 49.64 - 51.94, frequency 8 people, with a percentage of 27%. Obtained 51.95 - 54.25, frequency 7 people, with a percentage of 23%. Obtained 54.26 - 56.56, frequency 4 people, with a percentage of 13%. The results of the interval score data analysis can be described in histogram 2.

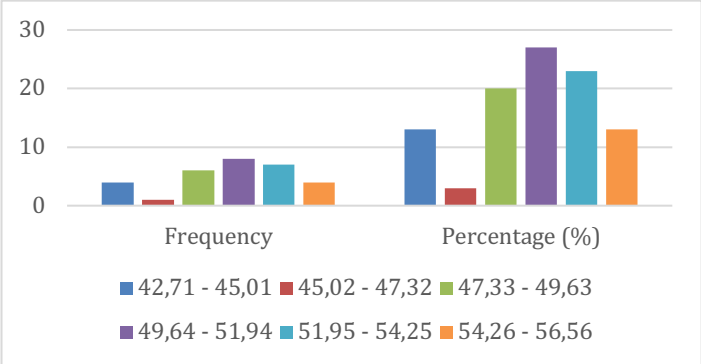

Figure 2. Togok Flexibility Histogram (X2)

Table 4. Butterfly Swimming Speed (Y)

Class Interval	Frequency	Percentage (%)
27,22 - 28,70	3	10
28,71 - 30,19	1	3
30,20 - 31,68	4	13
31,69 - 33,17	3	10
33,18 - 34,66	7	23
34,67 - 36,15	12	40
Total	30	100

Based on the results of the butterfly swimming speed interval class, it was obtained 27.22 - 28.70, frequency 3 people, with a percentage of 10%. Obtained 28.71 - 30.19, frequency 1 person, with a percentage of 3%. Obtained 30.20 - 31.68, frequency 4

people, with a percentage of 13%. Obtained 31.69 - 33.17, frequency 3 people, with a percentage of 10%. Obtained 33.18 - 34.66, frequency 7 people, with a percentage of 23%. Obtained 34.67 - 36.15, frequency 12 people, with a percentage of 40%. The results of the interval score data analysis can be described in histogram 3.

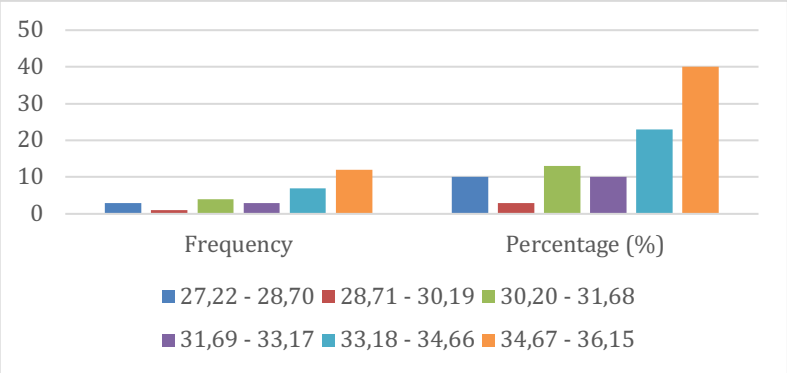

Figure 3. Histogram of Butterfly Swimming Speed (Y)

Table 5. Normality of Data X1, X2, with Y

Data Variable	*p*	Significance	Information
Arm Muscle Strength	0,117	0,05	Normal Data
Togok's flexibility	0,200		Normal Data
Butterfly Style Swimming Speed	0,070		Normal Data

From the table above, it shows that the significance value (p) is greater than 0.05, so the data is normally distributed.

Table 6. Linearity of Data X1.Y, and X2.Y

Correlation Variable	*p*	Significance	Information
X1 with Y	0,406	0,05	Data Linear
X2 with Y	0,481		Data Linear

From table 6 above, it can be seen that the significance value (p) is greater than 0.05, so the relationship between all independent variables and the dependent variable is stated as linear.

Table 7. Arm Muscle Strength with Butterfly Swimming Speed in Correlation Test Coefficient

Correlation	r_{hitung}	r_{tabel}	Information
X1 with Y	0,662	0,361	Significance

Based on the findings of the analysis above, there is a positive relationship between arm muscle strength and butterfly swimming speed (0.662), which means that the higher an athlete's arm muscle strength, the faster their butterfly swimming speed. The significance test of the correlation coefficient was carried out by comparing the calculated r value with the r table; at α = 5% with N = 30, the r table is 0.361. The correlation coefficient is significant, as indicated by the relationship between rx1.y = 0.662 > r (0.05) (30) = 0.361. "There is a strong relationship between arm muscle strength and butterfly swimming speed" is the approved test hypothesis. The constant

number is 14.614, and the regression coefficient X1 has a value of 0.662. These numbers allow the preparation of the regression line equation, namely Y = 14.614 + 0.662 X1. The structure of the regression equation shows that the arm muscle strength at the butterfly stroke speed will remain at 14.614 if X1 is considered constant or unchanged. The Y value increases by 0.662 units for each unit increase in the value of X1

Table 8. Body Flexibility with Butterfly Swimming Speed in Correlation Test Coefficient

Correlation	r count	r table	Information
X2 with Y	0,669	0,361	Significance

Based on the results of the study, there is a positive relationship between togok flexibility and butterfly swimming speed (0.669), which shows that the higher the togok flexibility of an athlete, the faster the butterfly swimming speed. The significance test of the correlation coefficient was carried out by comparing the calculated r value with the r table; at α = 5% with N = 30, the r table value is 0.361. The correlation coefficient is significant, as indicated by the relationship between rx2.y = 0.669 > r (0.05) (30) = 0.361. "There is a strong relationship between togok flexibility and butterfly swimming speed" is an acceptable test hypothesis. The constant number is 9.497, and the regression coefficient X2 is 0.669. These numbers allow the preparation of the regression line equation, namely Y = 9.497 + 0.669 X2. The form of the regression equation shows that the flexibility of the torso against the speed of the butterfly stroke will remain at 9.497 if the value of X2 is considered constant or unchanged. The Y value grows by 0.669 units for each unit increase in the value of X2

Table 9. Body Flexibility with Butterfly Swimming Speed in Correlation Test Coefficient

Correlation	r count	r table	Information
X1, X2 with Y	0,708	0,361	Significance

Based on the findings of the analysis above, there is a positive correlation between arm muscle strength and trunk flexibility with butterfly swimming speed (0.708), which means that the higher the arm muscle strength and trunk flexibility of an athlete, the faster their butterfly swimming speed. The significance test of the correlation coefficient was carried out by comparing the calculated r value with the r table; at α = 5% with N = 30, the r table is 0.361. The correlation coefficient is significant, as indicated by the relationship between rx1,2.y = 0.669 > r (0.05) (30) = 0.361. It is agreed that "Arm muscle strength and trunk flexibility have a substantial relationship with butterfly swimming speed." The constant number is 9.193, while the regression coefficients X1 and X2 have values of 0.708. The regression line equation can be composed as follows using these numbers: Y = 9.193 + 0.708 X1, X2. The form of the regression equation shows that the strength of the arm muscles and body flexibility against the speed of the butterfly style will remain at 9.193 if the values of X1 and X2 are considered constant or unchanged. The Y value increases by 0.708 units if the values of X1 and X2 increase by one unit.

DISCUSSION

Butterfly is one of the most demanding swimming strokes in terms of technique, strength, and flexibility. Arm muscle strength and trunk flexibility are two important components that complement each other in supporting the athlete's performance and speed in this stroke. Both play a role in producing optimal thrust, maintaining movement efficiency, and minimizing water resistance. In butterfly, the pull and push phases of the arms in the water are the main sources of forward body propulsion. Muscles such as the biceps brachii, triceps brachii, deltoids, and latissimus dorsi play an important role in generating the power to propel the body through the water. Good arm strength allows for stronger and faster movements, thereby increasing stroke frequency. In addition, strong muscles reduce the risk of premature fatigue, allowing athletes to maintain speed for longer.

The flexibility of the trunk, particularly in the thoracic and lumbar spine, allows the swimmer to perform efficient undulating strokes. This movement is important to help create harmonious body momentum from head to toe. A flexible trunk helps the swimmer maintain a streamlined body position, minimizes drag, and increases efficiency of movement in the water. The flexibility of the trunk allows for effective transfer of power from the upper body to the lower body (and vice versa), thereby increasing total propulsion (Rahmaneli et al., 2024). Arm muscle strength and trunk flexibility work together to create efficient and effective strokes. Arm strength propels the body forward, while trunk flexibility helps produce a smooth undulating stroke pattern. Athletes with good arm strength and a flexible trunk are able to maintain a consistent stroke rhythm, which contributes to optimal speed. A flexible trunk helps the body move more efficiently, allowing the power generated by the arm muscles to be fully utilized to propel the body forward without the interference of stiff movements.

Arm muscle strength and trunk flexibility have a significant relationship with butterfly swimming speed. Arm strength provides the main thrust, while trunk flexibility supports movement efficiency and power transfer. The combination of the two creates a harmonious and efficient movement, which is essential to improving athlete performance. Therefore, swimming training should be designed to develop both aspects simultaneously.

The results of this study support a number of previous findings showing a significant relationship between arm muscle strength and trunk flexibility with butterfly swimming speed. Research by Romadan et al., (2024), showed that arm muscle strength makes a major contribution to propulsion in butterfly swimming. In our study, the data showed a positive correlation of 0.91 between arm muscle strength and swimming speed, in line with these findings. According to Amadea et al., (2023), arm muscle strength is a dominant factor, but our results show a lower correlation. This difference may be due to differences in muscle strength measurement methods. These results also support research by Narlan et al., (2023), which found that trunk flexibility supports the efficiency of undulation movements, thereby minimizing water resistance. All relevant studies, including this study, agree that arm muscle strength and trunk flexibility have a positive relationship with butterfly swimming speed. Previous studies and our results suggest

that the combination of arm muscle strength and trunk flexibility increases movement efficiency, thereby accelerating butterfly swimming. Our study found that arm muscle strength has a greater contribution than trunk flexibility, while some other studies suggest that both factors are equally important.

CONCLUSION

Based on the results of data analysis, description, testing of research results, and discussion, it can be concluded that there is a significant relationship between arm muscle strength and butterfly swimming speed in Kendari City swimming athletes. There is a significant relationship between trunk flexibility and butterfly swimming speed in Kendari City swimming athletes. There is a significant relationship between arm muscle strength and trunk flexibility with butterfly swimming speed in Kendari City swimming athletes.

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