2024, Retos, 55, 163-169

Relationship of muscle strength, power, and leg flexibility with the swim start of the butterfly style
Relación de la fuerza muscular, potencia y flexibilidad de las piernas con la salida de natación del estilo mariposa

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Resumen. Este estudio tiene como objetivo explorar la relación entre la fuerza de los músculos de las piernas, la potencia de las piernas y la flexibilidad de las piernas con la capacidad de inicio de natación mariposa. Se utilizó un método descriptivo con técnica de estudio correlacional con una población conformada por deportistas de la Asociación de Natación, y una muestra de 12 deportistas masculinos que cumplían con los criterios de edad y habilidad para nadar establecidos. Los datos se recopilaron a través de encuestas, pruebas y mediciones, y luego se analizaron utilizando la técnica de correlación momento-producto y test-retest para determinar su validez y confiabilidad. Los resultados mostraron una relación significativa entre la fuerza de los músculos de las piernas, la potencia de las piernas y la flexibilidad de las piernas con la capacidad de inicio de natación mariposa, siendo la potencia de las piernas la que mostró la relación más fuerte. Específicamente, la fuerza de los músculos de las piernas tuvo una correlación del 66,67 %, la potencia de las piernas tuvo una correlación del 83,33 % y la flexibilidad de las piernas tuvo una correlación del 50,00 % con la capacidad de inicio de la natación mariposa. Estos hallazgos proporcionan información valiosa para los entrenadores y atletas en el diseño de programas de entrenamiento más efectivos para mejorar la capacidad de inicio en la natación mariposa.
Palabras clave: fuerza, potencia, flexibilidad, inicio de natación.

Abstract. This study aims to explore the relationship between leg muscle strength, leg power, and leg flexibility with the butterfly swimming start ability. A descriptive method with correlational study technique was used with a population consisting of Swimming Association athletes, and a sample of 12 male athletes who met the age and swimming ability criteria set. Data were collected through surveys, tests, and measurements, then analyzed using the product moment correlation technique and test-retest for validity and reliability. The results showed a significant relationship between leg muscle strength, leg power, and leg flexibility with the butterfly swimming start ability, with leg power showing the strongest relationship. Specifically, leg muscle strength had a correlation of 66.67%, leg power had a correlation of 83.33%, and leg flexibility had a correlation of 50.00% with the butterfly swimming start ability. These findings provide valuable insights for coaches and athletes in designing more effective training programs to enhance butterfly swimming start ability.
Keywords: strength, power, flexibility, swimming start

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Introduction

The strength used in swimming is leg muscle (Mujika & Crowley, 2019; Nurmukhanbetova et al., 2023) In swimming, each person has different (Guillen Pereira, L., Manangón Pesantez, RM, Rendón Morales, PA, & Beltrán Vásquez, 2023; Irtyshcheva et al., 2022). Especially in matters that are very influential, such as leg muscle strength as encouragement (Muehlbauer et al., 2017). The parts of the leg muscles that play a role include: Quadriceps extensor, gastrocnemius, and gluteus maximus (Yamakawa et al., 2022). These muscles are involved when performing start and contribute to the push forward, power legs as explosive power (Carazo-Vargas & Moncada-Jiménez, 2019; Illera-Delgado et al., 2022). This explosive power is needed in several acyclic movements (Gualter Santana et al., 2023; Ikhwani, 2021). In order to use force efficiently and reduce resistance, force techniques require better joint flexibility (Sammoud et al., 2018; Smith et al., 2023). In swimming competitions, start refers to the start of the competition and has an impact on the outcome (Taladriz Blanco, S., de la Fuente Caynzos, B., & Arellano Colomina, 2017). Not a few swimmers fail in competitions due to lack of mastery start and reversal (Garcia et al., 2015). And the need for good underwater gliding capabilities (Hermosilla et al., 2022; Prieto González & Sedlacek, 2020). The physical components needed by butterfly swimming athletes are strength, flexibility, speed, endurance, balance and coordination (Jovanovic, 2017; Zemková, 2022). Among the strength components used by butterfly swimming athletes are those related to leg muscle strength as encouragement (Martins et al., 2020; Nabellafaradilla et al., 2020). Muscle strength greatly influences the success of swimming performance in addition to mastering the correct stroke technique (Guillen Pereira, L., Manangón Pesantez, RM, Rendón Morales, PA, & Beltrán Vásquez, 2023; Karpiński et al., 2020; McGibbon et al., 2018) Due to research limitations, the sample was determined using a purposive sampling technique. The sample in this study consisted of 12 athletes out of a total of 70 athletes who had abilities according to predetermined criteria such as: (1) had good butterfly swimming ability, (2) was able to start butterfly swimming or with a grab. good start, and (3) 10-16 years old. This study aims to identify the extent to which leg muscle strength, leg power, and leg flexibility influence the ability to start butterfly swimming in athletes.

Materials and methods

This research uses a descriptive approach with correlational study techniques. This approach was chosen because it allows researchers to identify relationships between

2024, Retos, 55, 163-169

variables without intervening or manipulating the research subjects.

Participant

The research population consisted of 70 athletes from one swimming club. because it has certain criteria, including the ability to swim butterfly style, being male, and having the ability to start swimming butterfly style, which is considered worthy of research. with 12 athletes selected as samples using a purposive sampling technique. The samples in this study were athletes with abilities according to predetermined criteria such as: (1) having good butterfly swimming ability; (2) being able to start swimming butterfly style or with grab start style; and (3) being aged 10–16 years.

Instrument

Implementation of research using methods such as surveys, test techniques, and measurements is carried out by measuring leg muscle strength, power feet, and leg flexibility. Tests start swimming butterfly style. The test to measure leg muscle strength uses a back and leg dynamometer (Prasetyo & Nasrulloh, 2017; Suhadi, S., Guntur, G., Setyo Kriswanto, E. ., & Nopembri, 2023). The test to measure leg power uses a vertical jump (Figueiredo et al., 2020; Krishnan et al., 2017). The test to measure leg flexibility uses a sit-and-reach (flexometer) device in centimeters (cm) (Hoffmann et al., 2019; Norambuena et al., 2020). A test to measure butterfly swimming starts with a meter and a whistle. Measured from the starting block to the distance from entering the water and sliding, continued to a distance of 15 meters. Prerequisite Tests: Linearity Test, Normality Test, Regression Homogeneity Test, and Correlation Test.

Design and research procedures

Through this correlational study, it can be seen whether a variable is related to other variables, so that a clear picture between variables will be seen. Independent variables: leg muscle strength, leg power, and leg flexibility. Dependent variable: butterfly swimming start.

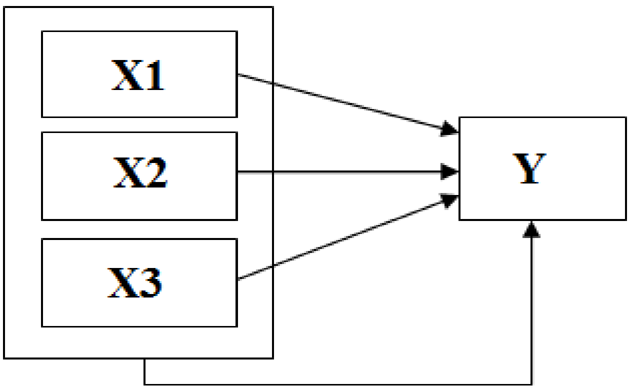

Figure 1. Research design. Information. X1 = leg muscle strength, X2 = leg power, X3 = leg flexibility, Y = Start butterfly swimming

Data analysis

The validity test, in this research to determine the validity of the test instrument, logical validity is used because this validity is obtained with careful effort through correct methods so that, according to logic, a desired level of validity will be achieved. The reliability test referred to is not to test the reliability of the instrument. Reliability test using techniques: retest, namely correlating the results of the first test with the second test. The linearity test is used to determine the nature of the linear relationship between the independent variable and the dependent variable. Next, the F price is consulted with the table price at a significance level of 5%. It is said to be linear if the F value of the observation is smaller than the F table, and vice versa.

Normality test

This test is carried out to determine whether the distribution of all the variables studied is normally distributed or not. To test the normality of each score.

Regression Homogeneity Test

Homogeneity testing was carried out to determine the distribution of variance among subjects. The regression homogeneity test was carried out using the F statistical test. Homogeneity of the leg muscle strength variable (x1), the leg power variable (x2), the leg flexibility variable (x3), and the butterfly swimming start variable (y).

Simple Correlation Test

The correlation test is used to determine the relationship between each independent variable and the dependent variable using a formula for the product moment.

Multiple Correlation Tests

Multiple correlation is used to determine the relationship between the three independent variables and the dependent variable. The F value is then consulted with the table F value with N-m-1 degrees of freedom at a significance level of 5%. If the calculated F value is greater than or equal to the table F value, then there is a significant relationship between the dependent variable and each independent variable.

Table 1.
Research Results Data

No.	TES			
	Leg Strength (X1)	Power Limbs (X2)	Flexibility (X3)	Start swimming butterfly style (Y)
1.	214	1.91	46	3.05
2.	78	0.95	35	2.75
3.	64	1.06	34	2.75
4.	215.5	2.40	47	3,00
5.	41	1.05	37	2.50
6.	45	0.91	37	2.75
7.	56	1.07	37	2.95
8.	47	0.94	35	2.65
9.	67	1.52	37	2.80
10.	63	0.81	37	2.75
11.	64	0.94	37	2.78
12.	81	2.01	36	2.65

Results and Discussion

The data in this study consisted of leg muscle strength, leg power, leg flexibility, and butterfly swimming start. The measurement results data can be seen in the Table 1.

Leg Muscle Strength

The results of calculating leg muscle strength data produced a mean of 86.29, a median of 64.00, a mode of 64.00, and a standard deviation of 61.22. The smallest value is 41.00, and the largest is 215.50. The leg muscle strength distribution can be seen in Table 2.

Table 2.
Leg muscle strength.

No.	Interval	Frequency	Percentage
1	185 – 220	2	16.67
2	149– 184	0	0.00
3	113 – 148	0	0.00
4	77 – 110	2	16.67
5	41– 76	8	66.67
Amount		12	100

Based on Table 2, it can be seen that the majority of respondents have leg muscle strength in the interval 41–76, with a percentage of 66.67%. This means that leg muscle strength has a significant relationship when performing the start swimming butterfly style.

Limb Power

The results of calculating leg power data produced a mean of 1.30, a median of 1.06, a mode of 0.94, and a standard deviation of 0.53. The smallest value obtained was 0.81, and the largest value was 2.40. The leg power distribution can be seen in Table 3.

Table 3.
Frequency Distribution of Leg Power

No	Interval	Frequency	Percentage
1	2,08 – 2,40	1	8,33
2	1,76 – 2,07	1	8,33
3	1,44 – 1,75	0	0,00
4	1,13 – 1,43	0	0,00
5	0,81 – 1,12	10	83,33
Amount		12	100

Based on Table 3, it can be seen that the majority of respondents' limbs were in the range of 0.81–1.12, with a percentage of 83.33%. It means power legs have a significant influence on the ability to start swimming butterfly style.

Leg Flexibility

The results of calculating leg flexibility data produced a mean of 37.92, a median of 37.00, a mode of 37.00, and a standard deviation of 4.14. The smallest value obtained was 34.00, and the largest value was 47.00. The leg flexibility distribution can be seen in Table 4. Based on Table 4, it can be seen that most of the respondents' limb flexibility was in the range of 36.61–39.20, with a percentage of 50.00%. This means that flexibility also has a significant relationship with the ability to start in a butterfly style.

Table 4.
Frequency Distribution of Leg Flexibility

No	Interval	Frequency	Percentage
1	44,41 – 47,00	2	16.67
2	41,81 – 44,40	0	0.00
3	39,21 – 41,80	0	0.00
4	36,61 – 39,20	6	50.00
5	34,00 – 36,60	4	33.33
Amount		12	100

Butterfly Swimming Start

The results of calculating butterfly swimming start data produced a mean of 2.78, a median of 2.75, a mode of 2.75, and a standard deviation of 0.16. The smallest value obtained was 2.50, and the largest value was 3.05. The distribution table for butterfly-style swimming can be seen in Table 5.

Table 5.
Capabilities Start Butterfly Swimming

No	Interval	Frequency	Percentage
1	2,94 – 3,04	3	25,00
2	2,83 – 2,93	0	0.00
3	2,72 – 2,82	6	50.00
4	2,61 – 2,71	2	16,67
5	2,50 – 2,60	1	8.33
Amount		12	100

Based on Table 5, it can be seen that the majority of respondents have started swimming butterfly style in the interval 37.37–40.27 seconds, with a percentage of 46.67%.

This means leg muscle strength, power legs, and leg flexibility have a significant relationship with starting butterfly-style swimming.

Normality test

The variable normality test was carried out using the Kolmogorov-Smirnov formula. The rule used to determine whether a distribution is normal or not is that if $p > 0.05$, the distribution is declared normal, and if $p < 0.05$, the distribution is said to be abnormal. The summary of the normality test result can be seen in Table 6.

Table 6.
Summary of Normality Test Results

Variable	Kolmogorov-smirnov		
	WITH	p	Information
Leg muscle strength	1,274	0,078	Normal
Power limbs	1,154	0,140	Normal
Leg flexibility	1,048	0,285	Normal
Start swimming butterfly style	0,704	0,705	Normal

Data on leg muscle strength, leg power, leg flexibility, and butterfly swimming starts were normally distributed.

Linearity Test

Testing the linearity of the relationship was carried out through the F statistical test. The relationship between the leg muscle strength variable (x1), the leg power variable (x2), the leg flexibility variable (x3), and the butterfly swimming start variable (y) was declared linear if the F value table < F count with db = m; N-m-1 at the 5% significance level. The summary of the relationship linearity test results can be seen in Table 7.

Table 7.
Summary of Relationship Linearity Test Results

Functional Relationships	F			Conclusion
	count	db	table	
Leg muscle strength (x1) with speed (y)	0,013	1:11	4,484	Linear
Power limbs (x2) with speed (y)	1,163	1:11	4,484	Linear
Leg flexibility (x2) with speed (y)	0,205	1:11	4,484	Linear

The relationship between leg muscle strength (x1) and butterfly swimming start (y), leg power (x2) with butterfly swimming start (y), and leg flexibility variable (x3) with butterfly swimming start (y) is expressed as linear.

Regression Homogeneity Test

Homogeneity testing was carried out to determine the distribution of variance in the subjects. The regression homogeneity test was carried out using the F statistical test. Homogeneity of the leg muscle strength variable (x1), variable power limbs (x2), and variable leg flexibility variables (x3) and with variables start butterfly swimming (y) is declared homogeneous if the table F value < F calculated with db = m; N-m-1 at the 5% significance level. The summary of the regression homogeneity test results can be seen in Table 8.

Table 8.
Summary of Regression Homogeneity Test Results

Functional Relationships	F			Conclusion
	count	db	table	
Leg muscle strength (x1)	2,015	1:10	4,965	Homogeneous
Power legs (x2)	1,141	1:10	4,965	Homogeneous
Leg flexibility (x3)	2,118	1:10	4,965	Homogeneous
Speed(y)	1,653	1:10	4,965	Homogeneous

Based on Table 8, it can be seen that the calculated F value of the four variables is smaller than the F table. So, the variables x1, x2, x3, and y are stated to come from homogeneous variants.

Correlation Test of the Independent Variable with the Dependent Variable

Test the correlation between an independent variable and the dependent variable using the correlation test product moment. Table 9 shows the simple correlation test results.

Table 9.
Simple Correlation Test Results

Correlation	r count	r table (0.05;13)	Information
X1. y	0,751	0,497	Significant
X2. y	0,798	0,497	Significant
X3. y	0,726	0,497	Significant

From the results of the correlation between the independent variable and the dependent variable, it can be concluded that leg muscle strength (x1) and butterfly swimming start (y) have a significant relationship. The variable leg power (x2) and butterfly swimming start (y) have a significant relationship.

The variable leg flexibility (x3) with butterfly swimming start (y) has a significant relationship.

Multiple Correlation Coefficient of Two Independent Variables

Multiple correlation is the relationship between independent variables and the dependent variable. The results of the multiple correlation calculation with two independent variables obtained the correlation coefficient. Table 10 shows multiple correlation coefficients.

Table 10.
Multiple Correlation Coefficient

Relationship between Variables	Correlation Coefficient (R)	F count	F Table (0.05;3/11)	information
X1.X2.X3Y	0,835	6,141	3,587	Significant

Based on Table 10, it can be concluded that the multiple correlation coefficient between leg muscle strength, leg power, and leg flexibility on butterfly swimming starts is 0.835.

Discussion

Leg muscle strength has a significant relationship with butterfly swimming. This shows that the higher a person's leg muscle strength, the better their performance in butterfly swimming starts. As in research (Thng et al., 2022), that provides some insight into the potential magnitude of change in body composition, lower body force-time characteristics, and swim start performance in high-performance swimmers within a season. By increasing leg muscle strength, it will influence better swimming start results. Leg muscle strength is the ability of a muscle or group of muscles to provide load or pressure (Ricardo Martins, 2023). Therefore, fast or slow forward movement in swimming is determined by the amount of pushing force and the amount of resistance. Propulsion is largely determined by strength, including leg muscle strength.

Leg power also has a significant relationship with butterfly swimming starts, as stated (Thng et al., 2020). Swimmers who can already generate greater levels of concentric impulse may benefit more from improving their rate of force development and/or technical aspects of their swim start performance. Power is a combination of strength and speed, which is the basis for carrying out activities. This power is used to overcome lower resistance, but with maximum explosive power acceleration. Power is used when pushing the body to slide when starting. The large force will push the body to slide faster and further from the starting position (Sudirman et al., 2024). With greater leg power, you will have better explosive power to start swimming.

There is also a significant relationship between leg flexibility and starting butterfly swimming. Strengthens research from (Ariestika et al., 2022) to get a good launch start OK, that's it. It sure needs muscle-power limbs, because the greater the power of a person's leg muscles, the better and easier it is to launch. Flexibility is a person's ability to carry out movements with a wide amplitude. Flexible joints in the feet allow effective movement of the foot joints (Kara Kauki et al., 2024). Leg movements are needed to produce thrust when the body is in the water. Apart from that, flexible leg joints also provide an advantage when jumping, namely maximum leg propulsion because the leg joints can work optimally. This confirms that limb flexural strength plays an important role in butterfly swimming start performance. Athletes who have good leg flexibility tend to have better starting performance.

The three independent variables, namely leg muscle strength, leg power, and leg flexibility, have a significant relationship to butterfly swimming starts. This means that starting butterfly swimming is very much determined by whether or not the quality of the leg muscles consists of strength, power, and flexibility. The relationship between the three independent variables has a positive and significant relationship. The better the quality of strength, power, and flexibility of the legs, the greater the distance when starting the butterfly stroke. Conversely, the lower the quality of strength, power, and flexibility of the legs, the shorter the distance covered when starting. The significance is whether or not the start of butterfly swimming is good. It turns out that this is also determined by whether or not the quality of the strength, power, and flexibility of the legs is good.

Conclusion

There is a relationship between each variable, from leg muscle strength, leg power, and leg flexibility to the start of butterfly swimming. There is a relationship between the combination of the three independent variables (leg muscle strength, leg power, and leg flexibility) and butterfly swimming starts.

Conflict of interest

The authors have no conflicts of interest to declare.

Future investigations

Trainers who will improve their abilities to start butterfly swimming should pay attention to important factors, namely the quality of the legs, which include muscle strength, power, and flexibility. This form of attention can take the form of training the quality of the athlete's limbs, for example, with appropriate weight training to improve the abilities of each physical component.

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