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Contribution of Leg Muscle Strength, Arm Muscle Strength, Maximum Oxygen Volume, Flexibility, Arm Length, dan Leg Length on Front Crawl Swimming Velocity

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Abstract

Research background to determine the Contribution of Leg Muscle Strength, Arm Muscle Strength, Maximum Oxygen Volume, Flexibility, Arm Length, Leg Length on Front Crawl Swimming Velocity. The purpose of this research is to 1) Analyze the contribution of leg muscle strength on front crawl. 2) Analyze the contribution of arm muscle strength on front crawl. 3) Analyze the contribution of maximum oxygen volume on front crawl. 4) Analyze the contribution of flexibility on front crawl. 5) Analyze the contribution of arm's length on front crawl. 6) Analyze the contribution of leg length on front crawl. 7) Analyze the contribution of leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length on front crawl swimming velocity. This study was correlational research. The subjects of this study were all members of the Tirta Tunggal swimming club, totaling 35 respondents. Data analysis using the ANOVA hypothesis test. The result of the study Leg muscle strength on front crawl swimming velocity was 48.5%. Muscle strength on front crawl velocity was 49.5%. Maximum oxygen volume on front crawl swimming velocity was 47%. Flexibility on front crawl swimming velocity was 49.6%. Arm's length on front crawl swimming velocity was 56.6%. Leg length on front crawl swimming velocity was 70.5%. Leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length on front crawl swimming velocity was 99.6%. The result's conclusion of the study is that there is a contribution of leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length to front crawl swimming velocity.

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INTRODUCTION

Sport is a physical activity that is favored by all levels of society, from children, and teenagers, to adults, men or women. (Abidin, Darmawan, & Bujang, 2020). Public interest in sports activities is currently getting bigger, especially in swimming.

Swimming is one of the most popular aquatic in Indonesia, from the age of children to adults, they like swimming. Swimming is not just an achievement sport, but it is in the educational curriculum so that it becomes an educational sport, as well as recreational sports so that the swimming pool becomes a vehicle for family vacations. There are four events in swimming, namely butterfly, backstroke, breaststroke, and freestyle (Imansyah, 2018).

Freestyle swimming is an event that is more popular than the other three events in swimming. The freestyle swimming movement changes over time, to reach the peak of achievement. Freestyle swimmers usually use the front crawl movement when in freestyle events. Front crawl swimming movement requires a streamlined body position, so a good analysis is needed from the coach to make the movement of freestyle swimmers a correct and fast front crawl movement. The front crawl movement starts from the start, underwater, leg and arm movements, and movement coordination (Prasetyo & Yunus, 2017).

The basic principles that determine the efficiency level of swimming techniques are the swimming mechanism, body position, movement rhythm, and support for physical abilities (strength, speed, agility, flexibility, balance, endurance, power, and coordination). Swimmers must have good arm muscle strength so that they can perform arm strokes, have good leg muscle strength so that they get propulsive force from leg swings, have the good back muscle strength to maintain body position, then do good movement coordination and have good breathing technique (Shanty, Ridwan, Argantos, & Setiawan, 2021).

The factors needed to achieve swimming sports achievements include: anatomical factors (arm length, height, leg length), physiological factors (maximal oxygen volume, agility, balance, coordination, strength, power, flexibility), biomechanical factors (movement speed and stroke frequency), psychological factors (personality, attribution, achievement motivation, aggression, arousal, anxiety, stress, activation, leadership, communication, commitment, imagery, concentration, self-concept, and self-confidence) (Mulyana, 2013).

Sports achievements cannot be achieved instantly (Soedjatmiko & Mulyono, 2018). Sports science that supports the theory of exercise to achieve a maximum performance, among others: philosophy, sports psychology, biomechanics, history, sports nutrition, first aid, growth and development, anatomy, physiology, and ability to train. The achievement of better sports achievements needs to be supported by supporting facilities and infrastructure (Nugraheni, Rahayu, & Handayani, 2017).

Swimming sports achievement is determined by the swimmer who finished the event the fastest. Increasing sports achievement needs to pay attention to several aspects, including physical aspects, technical aspects, tactical aspects, and psychological aspects, all of which are packaged in good training. Training is a process that a person must go through to achieve sports achievement. Sports achievement can only be achieved by developing the elements needed in sports through training. (Prasetyo & Yunus, 2017).

Leg muscle strength, arm muscle strength, flexibility, balance, speed, explosive power, and leg movement mechanics are some supporting factors needed to maximize front crawl swimming performance (Prasetyo & Yunus, 2017). Front crawl swimming performance is influenced by technique, speed, endurance, and coordination. The swimming movement technique is when the athlete can perform forward speed movements by the mechanics and regulations used in the event, as well as coordinate the force appropriately (Imansyah, 2018).

Speed is the ability to move in a short time. Several factors affect the front crawl swimming velocity, such as strength, reaction time, and flexibility (Aras, Arsyad, & Hasbiah, 2017).

Science and technological developments that have not been applied to an athlete training in

the Tirta Tunggal swimming club have made the Tirta Tunggal swimming club not yet have a benchmark, to assess the swimming performance of the athletes in Tirta Tunggal swimming club.

Swimming velocity is influenced by several factors, the researchers examined the problem through the title "Contribution of Leg Muscle Strength, Arm Muscle Strength, Maximum Oxygen Volume, Flexibility, Arm Length, Leg Length to Front Crawl Swimming Velocity".

METHOD

Research on the contribution of leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length to front crawl swimming velocity is a type of survey test research with correlational research methods. The population in this study were all athletes in the Tirta Tunggal swimming club totaling 35 swimmers, with a total sampling technique, so that 35 swimmers would be the sample in the study of the contribution of leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length to front crawl swimming velocity. Data collection techniques: leg muscle strength test, arm muscle strength test, maximal oxygen volume test using the Cooper test method, flexibility test, arm length measurement, leg length measurement, and 50-meter front crawl swimming velocity test. The stages that researchers will do in data collection include:

The research preparation stage, followed by taking research sample data and preparing measurement test facilities and infrastructure.

The implementation stage of the research, leg muscle strength test using a leg dynamometer, arm muscle strength test using an expanding dynamometer, maximum oxygen volume test using the Cooper test method, flexibility test using a sit and reach test, measuring arm's length using a meter, measuring leg's length using a meter, and 50-meter front crawl swimming velocity was timed using a stopwatch.

Data analysis was carried out by Validity Test to determine whether the research results were valid or invalid. A reliability test is used to determine whether the research results are reliable or not. Prerequisite test analysis using Normality Test (Kolmogorov-Smirnov) and Variant Homogeneity Test (Levene's Test). The normality test aims to determine whether the data used in the study came from a normally distributed sample or not. The homogeneity test aims to determine the variance in whether each group is homogeneous A correlation test is used to determine the relationship between each independent variable to the dependent variable using the Persons Product Moment formula.

RESULTS AND DISCUSSION

The study was conducted to obtain information about the contribution of leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length to front crawl swimming velocity.

Contribution of Leg Muscle Strength to Front Crawl Swimming Velocity

Measurements to determine the contribution of leg muscle strength to 50-meter front crawl swimming velocity. The sample warmed up first, then the leg muscle strength was measured using a leg dynamometer.

Table 1. Coefficients of Leg Muscle Strength to Front Crawl Swimming Velocity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	55.977	9.706		5.767	.001
	Kekuatan Otot Tungkai	-.673	.262	-.696	-2.567	.037

a. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 1 shows the significant value of 0.037 < 0.05, so that H_0 is rejected and H_1 is accepted, which means that there is an influence (significance) between leg muscle strength to front crawl swimming velocity.

Table 2. Results of Leg Muscle Strength Test to Front Crawl Swimming Velocity

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.696[a]	.485	.411	2.14597

a. Predictors: (Constant), Kekuatan Otot Tungkai

The contribution of R (0.696) and the contribution of the independent variable to the dependent variable is called the coefficient of determination which is R squared. R squared of 0.485 states that the independent variable (leg muscle strength) contributes to the dependent variable (front crawl swimming velocity) by 48.5%, while the rest is influenced by other factors.

Contribution of Arm Muscle Strength to Front Crawl Swimming Velocity

Measurement of arm muscle strength begins with the sample warming up, then arm muscle strength is measured using an expanding dynamometer. Measurements were made to determine the contribution of arm muscle strength to front crawl swimming velocity.

Table 3. Coefficients of Arm Muscle Strength to Front Crawl Swimming Velocity

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	44.223	5051		8.755	.000
	Kekuatan Otot Lengan	-.765	.292	-.703	-2.617	.035

a. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 3 shows a significance value of 0.035 < 0.05, so that H_0 is rejected and H_1 is accepted, which means that there is an influence (significance) between arm muscle strength to front crawl swimming velocity.

Table 4. Results of Arm Muscle Strength Test to Front Crawl Swimming Velocity

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.703a	.495	.422	2.12563

a. Predictors: (Constant), Kekuatan Otot Lengan

Contribution value R (0.703). Table 4 coefficient of 0.495 states that the independent variable (arm muscle strength) contributes to the dependent variable (crawl style swimming speed) by 49.5%, while the rest is influenced by other factors.

Contribution of Maximum Oxygen Volume to Front Crawl Swimming Velocity

Maximum oxygen volume was measured by running using the Cooper test method. The sample warmed up, then ran on the track provided for 12 minutes. Measurements were made to determine the contribution of arm muscle strength to front crawl swimming velocity.

Table 5. Coefficients of Maximum Oxygen Volume to Front Crawl Swimming Velocity

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	59.929	11.569		5.180	.001
	Volume Oksigen Maksimal	-.011	.004	-.686	-2.494	.041

a. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 5 shows a significance value of 0.041 < 0.05, so that H0 is rejected and H1 is accepted, which means that there is an influence (significance) between the maximum oxygen volume to front crawl swimming velocity.

Table 6. Results of Maximum Oksigen Volume to Front Crawl Swimming Velocity

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.686a	.470	.395	2.17565

a. Predictors: (Constant), Volume Oksigen Maksimal

The magnitude of the value of R (0.686). The coefficient of determination in Table 6 of 0.470 states that the independent variable (maximum oxygen volume) contributes to the dependent variable (front crawl swimming velocity) by 47.0%, while the rest is influenced by other factors.

Contribution of Flexibility to Front Crawl Swimming Velocity

The flexibility of swimmers is measured to determine the magnitude of the contribution of flexibility to front crawl swimming velocity. The swimmer warms up, then the swimmer's flexibility is measured using the sit and reach test method.

Table 7. Coefficients of Maximum Oxygen Volume to Front Crawl Swimming Velocity

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	50.810	7.523		6.754	.000
	Fleksibilitas	-1.093	.416	-.705	-2.627	.034

a. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 7 shows the significant value of 0.034 < 0.05, so that H_0 is rejected and H_1 is accepted, which means that there is an influence (significance) between the flexibility to front crawl swimming velocity.

Table 8. Result of Flexibility to Front Crawl Swimming Velocity

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.705a	.496	.425	2.12154

a. Predictors: (Constant), Fleksibilitas

The result value is R (0.705). The coefficient of determination in Table 8 is 0.496 which states that the independent variable (flexibility) contributes to the dependent variable (front crawl swimming velocity) of 49.6%, while the rest is influenced by other factors.

Contribution of Arm Length to Front Crawl Swimming Velocity

Measurement of arm's length is done using a meter tool. Measurements to determine the contribution of arm's length to front crawl swimming velocity. Sample arm length was measured from the base of the shoulder to the tip of the middle finger of the hand.

Table 9. Coefficients of Arm Length to Front Crawl Swimming Velocity

Coefficientsa					
	Unstandardized Coefficients		Standardized Coefficients		
Model	B	Std. Error	Beta	t	Sig.
1 (Constant)	74.777	14.461		5.171	.001
Panjang Lengan	-.581	.192	-.752	-3.021	.019

a. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 9 shows the significant value of 0.019 < 0.05, so that H_0 is rejected and H_1 is accepted, which means that there is an influence (significance) between the length of the arm to front crawl swimming velocity.

Table 10. Result of Flexibility to Front Crawl Swimming Velocity

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.752a	.566	.504	1.96979

a. Predictors: (Constant), Panjang Lengan

The result value is R (0.752). The coefficient of determination in Table 10 is 0.566 which states that the independent variable (arm's length) contributes to the dependent variable (front crawl swimming velocity) by 56.6%, while the rest is influenced by other factors.

Contribution of Leg Length to Front Crawl Swimming Velocity

Leg length is measured from hip to lower leg. Leg length measurements were carried out using a meter tool. Leg length measurements were carried out to determine the contribution of leg length to front crawl swimming velocity.

Table 11. Coefficients of Leg Length to Front Crawl Swimming Velocity

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	87.82	13.882		6.327	.000
	Panjang Tungkai	-.61	.151	-.83	-4.087	.005

a. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 11 shows the significant value of 0.005 < 0.05, so that H_0 is rejected and H_1 is accepted, which means that there is an influence (significance) between the length of the leg to front crawl swimming velocity.

Table 12. Result of Flexibility to Front Crawl Swimming Velocity

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.839a	.705	.663	1.62472

a. Predictors: (Constant), Panjang Tungkai

The result value is R (0.839). The coefficient of determination in table 12 is 0.705 which states that the independent variable (leg length) contributes to the dependent variable (front crawl swimming velocity) in swimmers by 70.5%, while the rest is influenced by other factors.

Contribution of Leg Muscle Strength, Arm Muscle Strength, Maximum Oxygen Volume, Flexibility, Arm Length, Leg Length to Front Crawl Swimming Velocity

The F test was conducted to determine the effect of the independent variables (leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length) together on the dependent variable (front crawl swimming velocity).

Table 13. F Test Leg Muscle Strength, Arm Muscle Strength, Maximum Oxygen Volume, Flexibility, Arm Length, Leg Length to Front Crawl Swimming Velocity

ANOVAb

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	62.350	6	10.392	93.645	.011a
	Residual	.222	2	.111		
	Total	62.572	8			

a. Predictors: (Constant), Panjang Tungkai, Kekuatan Otot Tungkai, Volume Oksigen Maksimal, Fleksibilitas, Kekuatan Otot Lengan, Panjang Lengan

b. Dependent Variable: Kecepatan Renang 50 Meter Gaya Crawl

Table 13 shows the significance value of 0.011 < 0.05, so H0 is rejected and H1 is accepted, which means that there is an influence (significance) between leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length together to front crawl swimming velocity.

Table 14. Multiple Regression Test Results Leg Muscle Strength, Arm Muscle Strength, Maximum Oxygen Volume, Flexibility, Arm Length, Leg Length to Front Crawl Swimming Velocity

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.998a	.996	.986	.33312

a. Predictors: (Constant), Panjang Tungkai, Kekuatan Otot Tungkai, Volume Oksigen Maksimal, Fleksibilitas, Kekuatan Otot Lengan, Panjang Lengan

The result value is R (0.998). The coefficient of determination Table 14 of 0.996 states that the independent variables (leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length) contribute together to the dependent variable (front crawl swimming velocity) of 99.6%, while the rest is influenced by other factors.

DISCUSSION

The significant results show that H_0 is rejected and H_1 is accepted, which means there is an influence of leg muscle strength on front crawl swimming velocity. Research (Wardhani, 2022) supports the results of the effect of leg muscle strength on front crawl swimming velocity, stating that the half squat test is carried out to measure the strength of the foot muscles with the results of F of 65.907 and the significance value of 0,000. The results of the hypothesis test stated that there was an influence of leg muscle strength on the ability to swim freestyle 50 meters. The hypothesis in the study (Ihsan, Sugiyanto, & Riyadi, 2022) also stated that there was a strong relationship between leg muscle strength and the front crawl swimming achievement, based on the analysis of the moment product correlation with a calculation value of 0.00. The value of 0.00 is smaller than the significance value of 0.05, then the relationship between the limb muscle strength to front crawl swimming achievement is significant.

One of the supporting factors to be able to swim quickly is to have good arm muscle strength, the stronger a person's arm muscles, the faster to swim, which is stated in the product-moment correlation test results of arm muscle strength to freestyle swimming velocity of 0.017 < 0, 05. The

result 0.017 <0.05 indicates that there is an influence of arm muscle strength on freestyle swimming velocity (Muniri, Sulistyorini, & Supriatna, 2022). Arm muscle strength contributed 88.3% to the 50-meter freestyle swimming velocity in male athletes, and contributed 98.8% to the 50-meter freestyle swimming velocity in female athletes (Shanty et al., 2021).

The results of the study measuring the physiological contribution during the 100-meter freestyle swimming competition stated that the O2 value increased at a distance of 25 meters to 50 meters, and the peak value of O2 at a distance of 50 meters, then decreased by 20% in the last 50 meters (Hellard, Pla, Rodriguez, Simbana, & Pyne, 2018). Research (Almeida et al., 2020), states that the maximal oxygen volume correlates with freestyle swimmers with results ($r = -0.82$; $r = -0.84$; $r = -0.76$; $p < 0.01$, for a distance of 50m, 100m, and 200m). The results showed that the maximum oxygen volume showed a significant effect on the achievement of 50m, 100m, and 200m freestyle swimming.

The correlation analysis of flexibility to 50-meter front crawl swimming velocity showed significant results. The results of the study are supported by the statement (Aktug et al., 2018), that children at the age of 10-13 already have good flexibility, by participating in sports exercises will be able to increase flexibility at the desired point. Increased flexibility and joint mobility can have a positive impact on increasing the 50-meter front crawl swimming velocity. Flexibility (Alnedral & Aritonang, 2021) is an element of physical condition that determines a person's skill factor in increasing strength, agility, and regulating movement coordination.

Arm length increases the range to produce a thrust force with less arm stroke frequency, so anthropometric factors (arm span) have a positive effect on the swimming speed of 50 meters freestyle (Dos Santos et al., 2021). The morphology and functional arm length showed a significant relationship to the achievement of swimming athletes in the sprinter specialist competition number, with the value of arm's length ($R = 0.58$) (Pilipko & Pilipko, 2019).

The anthropometric instrument factor of leg length has a positive effect on swimming velocity. Swimming velocity is generated by the forward thrust movement, longer legs will produce a more efficient movement when kicking (Rozi, Setijono, & Kusnanik, 2019). Leg length is a positive indicator of swimming achievement in 100 meters (25m x 4) front crawl. Swimmers with longer legs will be able to maximize leg movement as a producer of forwarding thrusts (Sammoud et al., 2020).

Legs and arms are producers of propulsion and speed when swimming in crawl style, high swimming speeds are recorded as indicated by each large push, and a good swimmer's body movement is able to minimize the decrease in speed. (Morais, Forte, Nevill, Barbosa, & Marinho, 2020).

CONCLUSION

The conclusion of the study is that there is a contribution of leg muscle strength to front crawl swimming velocity of 48.5%. There is a contribution of arm muscle strength to front crawl swimming velocity of 49.5%. There is a contribution of maximum oxygen volume to front crawl swimming velocity of 47.0%. There is a contribution of flexibility to front crawl swimming velocity by 49.6%. There is a contribution of arm's length to front crawl swimming velocity of 56.6%. There is a contribution of leg length to front crawl swimming velocity by 70.5%. There is a contribution of leg muscle strength, arm muscle strength, maximum oxygen volume, flexibility, arm length, leg length together to a front crawl swimming velocity of 99.6%.

REFERENCES

Abidin, D., Darmawan, A., & Bujang. (2020). Efektivitas Pelatihan Split Squat Jump Terhadap Ketepatan Spike Bolavoli. *Jurnal Sportif: Jurnal Penelitian Pembelajaran*, *6*(3), 684–698.

Aktug, Z. B., Iri, R., & Top, E. (2018). The Investigation Of The Relationship Between Children's 50m Freestyle Swimming Performances And Motor Performances. *Asian Journal Of Education And Training*, *4*(1), 41–44.

Almeida, T. A. F., Pessôa Filho, D. M., Espada, M. A. C., Reis, J. F., Simionato, A. R., Siqueira, L. O. C., & Alves, F. B. (2020). V˙ O 2 Kinetics And Energy Contribution In Simulated Maximal Performance During Short And Middle Distance-Trials In Swimming. *European Journal Of Applied Physiology*, *120*(5), 1097–1109.

Alnedral, & Aritonang, B. (2021). Physical Conditioning Of Freestyle Swimming Athletes. *Advances In Health Sciences Research*, *35*(1), 56–63.

Aras, D., Arsyad, A., & Hasbiah, N. (2017). Hubungan Antara Fleksibilitas Dan Kekuatan Otot Lengan Dengan Kecepatan Renang. *Media Kesehatan Masyarakat Indonesia*, *13*(4), 380–385.

Dos Santos, M. A. M., Henrique, R. S., Salvina, M., Silva, A. H. O., Junior, M. A. De V. C., Queiroz, D. R., … Nevill, A. M. (2021). The Influence Of Anthropometric Variables, Body Composition, Propulsive Force And Maturation On 50m Freestyle Swimming Performance In Junior Swimmers: An Allometric Approach. *Journal Of Sports Sciences*, *39*(14), 1615–1620.

Hellard, P., Pla, R., Rodriguez, F. A., Simbana, D., & Pyne, D. B. (2018). Dynamics Of The Metabolic Response During A Competitive 100-M Freestyle In Elite Male Swimmers. *International Journal Of Sports Physiology And Performance*, *8*, 1–28.

Ihsan, F. M., Sugiyanto, S., & Riyadi, S. (2022). The Contribution Of Leg Length, Leg Muscle Strength, Arm Span And Maximum Oxygen Volume To 100-Meter Crawl Swimming Achievement. *International Journal Of English Literature And Social Sciences*, *7*(1), 225–230.

Imansyah, F. (2018). Hubungan Antara Kekuatan Otot Tungkai Dan Kekuatan Otot Lengan Terhadap Hasil Kecepatan Renang 50 Meter Gaya Bebas Pada Atlet Putri Club Bangka Swimming. *Jurnal Ilmu Keolahragaan*, *1*(1), 17–32.

Morais, J. E., Forte, P., Nevill, A. M., Barbosa, T. M., & Marinho, D. A. (2020). Upper-Limb Kinematics And Kinetics Imbalances In The Determinants Of Front-Crawl Swimming At Maximal Speed In Young International Level Swimmers. *Scientific Reports*, Vol. 10.

Mulyana, B. (2013). Hubungan Konsep Diri, Komitmen, Dan Motivasi Berprestasi Dengan Prestasi Renang Gaya Bebas. *Jurnal Cakrawala Pendidikan*, *32*(3), 488–498.

Muniri, A. B. El, Sulistyorini, & Supriatna. (2022). Hubungan Indeks Massa Tubuh , Kekuatan Otot Lengan , Dan Kekuatan Otot Tungkai Dengan Kecepatan Renang Gaya Bebas Pada Atlet Renang Vyati Swimming Klub Kota Batu. *Sport Science And Health*, *4*(1), 194–199.

Nugraheni, A. R., Rahayu, S., & Handayani, O. W. K. (2017). Evaluasi Pembinaan Olahraga Prestasi Bola Voli Pantai Puteri Klub Ivojo (Ikatan Voli Ngembalrejo) Di Kabupaten Kudus Tahun 2016. *Journal Of Physical Education And Sports*, *6*(3), 225–231.

Pilipko, O., & Pilipko, A. (2019). Correlation Of Morphological And Functional Indicators With Sports Results Among Qualified Athletes Specializing In Freestyle Swimming At Distances Of Various Lengths. *Slobozhanzkyi Herald Of Science And Sport*, *7*(5(73)), 61–65.

Prasetyo, E., & Yunus, M. (2017). Hubungan Antara Frekuensi Gerakan Kaki Dengan Prestasi Renang Gaya Crawl 50 Meter. *Indonesia Performance Journal*, *1*(2), 82–90.

Rozi, F., Setijono, H., & Kusnanik, N. W. (2019). The Identification Model On Swimming Athletes Skill. *Теорія І Методика Фізичного Виховання І Спорту*, *0*(4), 30–35.

Sammoud, S., Negra, Y., Chaabene, H., Bouguezzi, R., Attia, A., Granacher, U., … Nevill, A. M. (2020). Key Anthropometric Variables Associated With Front-Crawl Swimming Performance In Youth Swimmers: An Allometric Approach. *Journal Of Strength And Conditioning Research*, *1*(1), 1–13.

Shanty, E., Ridwan, M., Argantos, & Setiawan, Y. (2021). Kontribusi Kekuatan Otot Lengan, Kekuatan Otot Tungkai Dan Kekuatan Otot Punggung Terhadap Kecepatan Renang Gaya Bebas 50 Meter. *Jurnal Patriot*, *3*(2), 179–191.

Soedjatmiko, & Mulyono, S. H. (2018). Pengaruh Latihan Metode Modified Two On One Dengan Metode Rhythm Drill Terhadap Kemampuan Backhand Drive Tenis. *Journal Of Sport Coaching And Physical Education*, *3*(1), 33–41.

Wardhani, R. (2022). Pengaruh Kekuatan Otot Terhadap Kecepatan Renang Gaya Bebas Club Renang Bintang Khatulistiwa Pontianak. *Sport Pedagogy Journal*, *1*(1), 103–109.