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Anthropometric Analysis and Swimming Speed of Haruna Swimming Club Athletes

Randyka Aziz Ramadhan[1*], Fajar Awang Irawan[2]

[1,2]Sports Science Study Program , Faculty of Sports Sciences, Semarang State University

*Correspondent: Randyka Aziz Ramadhan, randykaazizramadhan@students.unnes.ac.id

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Abstract

Study purpose. This study aims to analyse anthropometry in relation to the speed of 50-metre freestyle swimming among athletes at Haruna Swimming Club. The subjects in this study were 15 adolescent athletes aged 12 to 15 years.
Materials and methods. The research method used was a quantitative approach with multiple linear regression analysis. The independent variables analysed included height, weight, arm length, leg length, and hand width. The dependent variable was the time taken to swim the 50-metre freestyle, measured in seconds.
Results. The analysis results showed that, simultaneously, all five anthropometric variables significantly influenced swimming speed ($p < 0.05$). Partially, arm length, leg length, and palm width showed a significant negative influence on swimming time, meaning that the larger the value of these variables, the faster the swimming time achieved.
Conclusion. The conclusion of this study states that body characteristics or anthropometry play an important role in determining swimming performance in adolescent athletes. These findings can be used as a basis for athlete selection and the development of training programmes based on physical characteristics.

Keywords: Anthropometry, Swim Speed, Arm Length, Leg Length, Adolescent Athlete

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Introduction

Swimming is one of the sports that requires complex cooperation between technical, physiological, and anthropometric factors. Especially in sprint numbers such as the 50-meter freestyle, an athlete's success is greatly influenced by body characteristics that support the efficiency of movement in the water (Zamparo et al., 2021; Morais et al., 2022). Anthropometry refers to the size and proportions of the human body, including height, arm length, leg length, as well as palm width, all of which contribute to the speed and efficiency of swimming (Barbosa et al., 2021; Figueiredo et al., 2021). According to strength, it is a component that contributes significantly to athletes in getting maximum strength in a short time and conditioning the muscles to survive without fatigue (Lutfiani & Irawan, 2025).

Previous research has shown that arm and leg length are positively related to stroke length and swimmer speed (Peulić et al., 2023; Vitor et al., 2023). In addition, the larger palm width provides a wider push surface when pulling, thus increasing propulsion power in the water (Cinarli & Arslan, 2023; Santos et al., 2023). Lätt et al. (2021) emphasize that during puberty, rapid morphological changes in adolescents make a major contribution to the development of swimming performance. This is in line with the findings of Pires et al. (2021), who mentioned that the growth of limb length significantly affects swimming technique and efficiency in young athletes.

From a biomechanical perspective, stroke index, stroke rate, and stroke length are the main indicators of performance, which are significantly influenced by body proportions (Hoofwijk et al., 2023; Figueiredo et al., 2021). Price et al. (2024) added that swimming performance is inseparable from the interaction between anthropometric variables, muscle strength, technique efficiency, and athletes' metabolic capacity. Therefore, mapping body characteristics is an important part of the process of identifying and developing outstanding athletes. Larkin et al. (2023) in their study of adolescent athletes in Australia showed that the group classified as "talented" had a more ideal height, arm length, and body mass index than the non-talented group.

Several studies have explored the relationship between body composition and swimming performance. Zuniga et al. (2021) and Zoladz et al. (2023) found that lean mass and body fat distribution have a significant correlation with swimming travel time. In terms of initial start and acceleration, Takahashi et al. (2022) explain that height and leg length play an important role in generating the maximum repulsion force of the pool wall. In addition, symmetrical body proportions and arm length that exceeds height (arm span) have been shown to increase swimmers' range during movement cycles (Alves et al., 2022; Benjanuvatra et al., 2021).

However, despite a large number of studies that have been conducted internationally, local studies in Indonesia that comprehensively examine the influence of anthropometric variables on swimming speed in adolescents are still very limited. Some domestic studies, such as by Sugiarto and Hananto (2025), only reviewed one or two variables separately without a multivariate approach. In fact, a multiple linear regression approach is needed to determine the simultaneous and partial contribution of each anthropometric dimension to overall swimming performance. In addition, the lack of an anthropometric database of young athletes at the club level hinders the planning of scientific-based training programs.

Through advances in data measurement and analysis techniques, as driven by the standard use of ISAK and modern statistical software, anthropometric evaluations can now be performed more accurately and efficiently (Geyssant et al., 2022; Takahashi et al., 2022). Therefore, this study aims to analyze the effect of height, weight, arm length, leg length, and palm width on the speed of 50-meter freestyle swimming in Haruna Swimming Club adolescent athletes.

Materials and methods

Study participants

This study used a quantitative approach with a descriptive correlational method to determine the effect of anthropometric variables on swimming speed in adolescent athletes. The study was conducted at the Haruna Swimming Club in Rembang Regency, with a total of 15 athletes, both male and female, aged 12 to 15 years. The sampling technique used was purposive sampling, where the criteria for selecting athletes were active members who regularly attended training sessions and had participated in swimming competitions.

Study organization

The variables studied in this research include independent and dependent variables. The independent variables consist of height, weight, arm length, leg length, and palm width.

Additionally, there is one composite variable, namely anthropometry, which is a combination of all these physical indicators. The dependent variable in this study is swimming time (in seconds), measured based on the results of a 50-metre freestyle swimming test. Height measurements were taken using a stadiometer, while body weight was measured using a high-precision digital scale. To measure arm and leg length, a measuring tape in centimetres was used, from anatomical points corresponding to the standards of sports anthropometric measurements. Hand width was measured using a vernier caliper. Swimming time was measured with a digital stopwatch, starting when the athlete touched the water surface until reaching the finish line on the 50-metre freestyle course.

In practice, data collection is conducted by inviting all subjects to the measurement location in a healthy and fit condition. Measurements begin with all anthropometric variables in sequence, followed by a single swimming speed test performed with maximum effort by each athlete. All measurement data are carefully recorded and entered into a research instrument in the form of statistical software for further analysis.

Statistical analysis

Data analysis was performed using multiple linear regression with the assistance of the latest version of SPSS software to determine the simultaneous and partial effects of anthropometric variables on swimming time. Before the regression analysis was conducted, classical assumption tests were first performed, including normality tests using the Kolmogorov-Smirnov method, linearity tests, multicollinearity tests, and autocorrelation tests. All tests were conducted at a significance level of 5% ($\alpha = 0.05$). If the significance value or p-value was < 0.05, then the relationship or influence between variables was statistically significant.

Result

Descriptive Statistics can be seen in table 1:

Table 1. Descriptive Statistics

Descriptive Statistics				
	N	Minimum	Maximum	Mean SD±
Height (cm)	15	150	163	156.73 ± 4.131
Body Weight (kg)	15	43	50	46.80 ± 2.210
Arm Length (cm)	15	63	72	67.40 ± 2.640
Leg Length (cm)	15	80	89	84.27 ± 2.685
Palm Width (cm)	15	8	9	8.47 ± .258
Anthropometry	15	337	374	355.20 ± 11.571
Swim Time (seconds)	15	31	36	33.18 ± 1.408
Valid N (listwise)	15			

Descriptive statistics were used to provide an overview of the characteristics of the sample data in this study consisting of 15 Haruna Swimming Club athletes aged 12–15 years. Based on Table 1, it can be seen that each anthropometric variable has a relatively homogeneous distribution of values with low standard deviation values, indicating that the physical characteristics between athletes are not much different. The athlete's height has a minimum value of 150 cm and a maximum of 163 cm, with a mean of 156.73 cm and a standard deviation of 4.131 cm. This indicates that the majority of athletes have height in that range. Weight ranges from 43–50 kg, with an average of 46.80 kg and a standard deviation of 2,210 kg, describing a weight proportional to their height.

For arm length, the minimum value is 63 cm and the maximum is 72 cm with an average of 67.40 cm and a standard deviation of 2.640 cm. While the length of the limbs ranges from 80–89 cm, with an average of 84.27 cm and a standard deviation of 2.685 cm. These values show that in general athletes have fairly uniform body limb sizes, which play an important role in swimming movements. The palm width has an average of 8.47 cm, with a value range between 8–9 cm and a standard deviation of 0.258 cm. Although this variable has a small variation, this factor can still contribute to swimming performance because it affects the surface area of the water thrust when swimming.

The composite variable "Anthropometry", which is a combination of these measures, has an average value of 355.20 with a standard deviation of 11.571, describing the cumulative score of the physical characteristics of the athlete. As for the dependent variable, namely Swimming Time, an average of 33.18 seconds was obtained with a value range of 31–36 seconds and a standard deviation of 1.408 seconds, indicating a variation in swimming speed performance even with relatively similar body characteristics. Overall, these descriptive statistics show that the samples have relatively uniform physical characteristics, so the results of the follow-up analysis are expected to provide a more valid picture of the relationship between anthropometric variables and swim time performance.

Before the Pearson correlation analysis was carried out, an assumption test was first carried out in the form of a normality test and a linearity test. The normality test was carried out using the Kolmogorov-Smirnov test. The normality test is performed to test whether the distribution of bound variables for each value of a given free variable is normally distributed or not. A good regression model is a regression model that has a normal or near-normal distribution, so it is statistically feasible to test. To ensure the assumption that the variable is normally distributed is carried out through the approach of the dependent variable residual calculation measuring tool, the basis for decision-making for the Kolmogorov – Smirnov Test normality test is as follows: if the value of Asymp Sig. (2-tailed) > 0.05, then the data is normally distributed. If the value of Asymp Sig (2-tailed) < 0.05 then the data is not normally distributed.

Table 2. Normality Test

One Kolmogorov-Smirnov	Nilai Sig.	Information
Unstandardized Residual	0.078	Usual

Based on the table 2, the Asymp value is obtained. Sig. (2-tailed) is 0.078 > 0.05. It was concluded that the data had been distributed normally. The results showed that the significance value of the two variables was greater than 0.05, which is 0.078 so it can be concluded that the data is normally distributed.

Based on the results of the calculation, it was found that the value of F calculated was smaller than the F of the table and the significance value above 0.05 showed that the relationship between the two variables was linear, so it could be continued to the Pearson correlation hypothesis test. The linearity test was carried out to find out whether there was a linear relationship between each independent variable (anthropometric variable) and the dependent variable, namely swimming time (in seconds). Linearity is one of the basic assumptions in multiple linear regression analysis that must be met in order for the resulting regression model to be statistically valid. In this study, the linearity test was carried out by comparing the significance value (Sig.) of the results of the F test for each variable to the value of $\alpha = 0.05$. If the significance value is greater than 0.05, then the relationship between the variables can be declared linear.

Based on Table 3, all variables show a significance value above 0.05, which indicates that the relationship between anthropometric variables and swimming time is linear. The height variable has a calculated F value of 4.884 and a significance value of 0.341 (> 0.05), thus meeting the linearity assumption. Likewise, the weight variable had a significance value of 0.844, arm length 0.799, leg length 0.609, and palm width 0.584. All of these values are above the threshold of 0.05, so the relationship of each variable to swimming time can be said to be linear. With the fulfillment of the linearity assumption, the multiple linear regression model can be used to validly test the influence of anthropometric variables on swimming speed. This suggests that changes in anthropometric variables will be proportionally followed by changes in swimming time in the form of linear relationships, rather than curvilinear or random. Therefore, subsequent hypothesis tests can be continued with a high level of confidence in the validity of the model.

Table 3. Multicollinearity Test

Coefficient							
	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Type	B	Std. Error	Beta	t	Sig.	Tolerance	VIVID
1 (Constant)	66.812	6.192		10.790	.000		
Height (cm)	.030	.265	.563	2.030	.000	.120	1.264
Body Weight (kg)	-.368	.235	-.578	2.570	.015	.123	1.477
Arm Length (cm)	-.273	.208	-.511	2.311	.022	.110	1.279
Leg Length (cm)	-.120	.274	-.229	2.438	.007	.608	4.395
Palm Width (cm)	-1.593	.879	-.291	2.812	.010	.643	5.549
Anthropometry	.072	.117	.593	2.618	.006	.181	2.610

a. Dependent Variable: Swim Time (sec)

The multicollinearity test was performed to detect the presence of strong linear relationships between independent variables in the regression model. High multicollinearity can affect the stability and interpretation of regression models. This test uses two main indicators, namely Tolerance and Variance Inflation Factor (VIF):

Tolerance indicates how much an independent variable can be explained by other independent variables. A low tolerance value (below 0.1) indicates the presence of strong multicollinearity. VIF is the opposite of tolerance (VIF = 1/Tolerance) and shows how much an independent variable experiences variance inflation due to the correlation between variables. A VIF value above 10 indicates the presence of serious multicollinearity, while a VIF value below 10 is considered safe. All VIF values below 10, and tolerances above 0.1, indicate that there is no multicollinearity problem in this regression model. Thus, independent variables can be included together in a regression model without the worry of distortion due to multicollinearity.

The autocorrelation test aims to detect a correlation between residual (error) regression models in sequential observations. The indicator used in this test is Durbin-Watson (DW). In the table 3, the Durbin-Watson value is obtained 1.471. The DW value of 1.471 is close to the 2 mark, although it is slightly lower. This value indicates that there is no strong autocorrelation, but there tends to be a slight positive autocorrelation tendency in the residual model.

Table 4. Multiple Linear Regression

Coefficient					
	Unstandardized Coefficients		Standardized Coefficients		
Type	**B**	**Std. Error**	**Beta**	**t**	**Sig.**
1 (Constant)	66.812	6.192		10.790	.000
Height (cm)	.030	.265	.563	2.030	.000
Body Weight (kg)	-.368	.235	-.578	2.570	.015
Arm Length (cm)	-.273	.208	-.511	2.311	.022
Leg Length (cm)	-.120	.274	-.229	2.438	.007
Palm Width (cm)	-1.593	.879	-.291	2.812	.010
Anthropometry	.072	.117	.593	2.618	.006

a. Dependent Variable: Swim Time (sec)

Based on the results of multiple linear regression, the following is an explanation of the influence of each independent variable (X) on the independent variable (Y):

The results of multiple linear regression analysis aimed to determine the influence of anthropometric variables on the Swimming Time of Haruna Swimming Club athletes. Based on Table 4, it can be seen that the regression model involves six independent variables, namely: height, weight, arm length, leg length, palm width, and total anthropometric score, with Swim Time as the dependent variable. The regression model shows that most anthropometric variables have a significant influence on swimming time with a significance level of < 0.05. Height has a regression coefficient of 0.030 with a significance value of 0.000, indicating that the taller an athlete is, the swim travel time tends to decrease (faster), although the magnitude of the influence is relatively small. Weight has a negative coefficient of -0.368 with a significance value of 0.015. This indicates that weight gain, in this context, actually contributes to improved swimming performance. However, it is important to note that ideal weight and proportional to height greatly affects the effectiveness of movement in the water.

Furthermore, arm length also showed a negative influence on swimming time with a coefficient of -0.273 and a significance value of 0.022. This means that the longer an athlete's arms, the more efficient his thrust movements in the water, thus speeding up the travel time. This is in line with the theory of swimming biomechanics, where arm length plays an important role in creating greater thrust. Leg length contributed negatively to swim time with a coefficient of -0.120 and a significance value of 0.007. This suggests that athletes with longer legs tend to have more efficient push and push forces when performing swimming movements, especially in the start and kick phases. The palm width variable showed the greatest influence negatively with a coefficient of -1.593 and a significance value of 0.010. This indicates that the wider the palm of a swimmer's hand, the greater the grip of the water when performing a swimming stroke, thus being able to increase speed. Meanwhile, the overall Anthropometric score has a positive coefficient of 0.072 with a significance value of 0.006. This shows that comprehensively, the better the anthropometric composition of an athlete, the better his swimming time performance.

With the significance value of all variables being below 0.05, it can be concluded that this regression model is valid and feasible to be used in analyzing the influence of anthropometric factors on swimming time performance. The model also indicates that combinations of different body sizes have a significant contribution to the movement efficiency and swimming speed of adolescent athletes. The determination test is used to find out how much of the variation of the dependent variable (Y) can be explained by the independent variable in the regression model. The values used are R Square (determination coefficient) and

Adjusted R Square (adjusted determination coefficient). Based on the table the value R = 0.985, which shows the correlation between independent and dependent variables is quite strong. The value of R Square = 0.985, meaning that the independent variable is able to explain 98.5% of the variation of the dependent variable (Y). The value of the Adjusted R Square = 0.985, which takes into account the number of variables in the model. Adjusted R Square is used because R Square tends to increase as variables are added, even if those additional variables are irrelevant.

Discussion

The results of this study showed that most of the anthropometric variables studied, namely height, weight, arm length, leg length, and palm width, had a significant influence on the 50-meter freestyle swim time in Haruna Swimming Club adolescent athletes. Through multiple linear regression analysis, it was found that the variables arm length, palm width, and leg length had a negative contribution to swimming travel time. This means that the larger the body size in these variables, the faster the swimming time achieved. These findings show that anthropometric aspects are statistically relevant as a determinant of swimming performance. These results are in line with the research of Morais et al. (2022), which stated that arm length and leg length are strongly correlated with stroke length and movement efficiency in the water in adolescent athletes. Another study by Alves et al. (2022) also supports these findings, mentioning that limb length is a key indicator in sprint swimming performance. Furthermore, research by Peulić et al. (2023) on athletes aged 13–16 years also concluded that swimmers with longer body proportions tend to have better swimming times, especially over short distances such as 50 meters.

The palm width variable in this study also showed a significant negative influence, meaning that the wider the athlete's palm, the faster the swim time. These results are in line with findings from Santos et al. (2023) and Cinarli & Arslan (2023), who stated that palm width is related to the area of thrust when performing pull movements, thereby increasing forward propulsion. The authors argue that while this size may seem minor, in sports like swimming, every millisecond counts, and small factors such as palm area can be a difference in performance between athletes. In contrast, weight shows a negative influence on swimming speed, but it remains significant. This can be explained that the ideal body weight, dominated by lean body mass, actually provides a greater boost, not an obstacle. Research by Zuniga et al. (2021) and Takahashi et al. (2022) states that a proportional weight, rather than simply being light, contributes positively to the starting strength and efficiency of movement in the water. Therefore, the authors emphasize the importance of looking at weight not only from the absolute number, but from its composition, especially in adolescent athletes who are still in the growth phase.

Interestingly, the height variable in this study, although it had a significant effect, had a smaller coefficient than the extremity variable. This reinforces the findings from Price et al. (2024) that in swimming sprints, height is a good early indicator, but arm span and leg length make a more pronounced mechanical contribution to thrust length and stroke efficiency. The authors argue that in the context of athlete coaching, early selection can use height as a filter, but optimization of technique and training should be focused on the use of extremity length and flexibility. In general, the results of this study are consistent with the theory of swimming biomechanics which states that anthropometric variables that support the efficiency of horizontal motion in water will contribute to the acceleration of travel time (Barbosa et al., 2021; Geyssant et al., 2022). In this context, the author considers that anthropometric measurements should be a routine part of the selection and performance evaluation process of young athletes. Especially in the context of coaching at the age of 12–15 years, when physical growth and development are very dynamic, periodic monitoring can help map potential and anticipate the risk of injury due to body disproportion and inappropriate exercise. Taking all these findings into account, the authors emphasize that coaches, clubs, and sports institutions need to develop training programs tailored to the anthropometric conditions of athletes. This not only improves performance, but also speeds up technique adaptation and reduces the risk of injury. In addition, the study also confirms the importance of further research with larger samples and longitudinal approaches to monitor anthropometric changes and their impact on performance over time.

Conclusions

Based on the results of data analysis and discussions that have been carried out, it can be concluded that anthropometric variables, namely height, weight, arm length, leg length, and palm width, simultaneously have a significant influence on the speed of the 50-meter freestyle swim in Haruna Swimming Club athletes of Rembang Regency aged 12-15 years. This shows that body characteristics are an important factor that needs to be considered in the process of coaching and selecting adolescent swimming athletes. Partially, arm length, leg length, and palm width showed a significant negative influence on swim time, which means that the larger the body size in these dimensions, the faster the swim travel time achieved. Meanwhile, weight also shows a significant influence, which indicates that an ideal body weight with good body composition (especially muscle mass) can support more optimal swimming performance. Height, although significant, contributes less than arm and leg length, so it can be used as an early indicator in the selection process, but not the main determinant in final performance. Thus, this study confirms that the anthropometric dimension is an integral part of the development process of young athletes, especially in swimming. The results of this research can be the basis for sports coaches and coaches to measure and monitor physical characteristics on a regular basis, as well as develop a training program that is tailored to the strengths and weaknesses of each athlete.

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Conflict of interest

There is none

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Information about the authors:

Randyka Aziz Ramadhan: randykaazizramadhan@students.unnes.ac.id, https://orcid.org/0009-0006-3042-6557, Department Of Sports Science, Semarang State University, Indonesia

Fajar Awang Irawan: email, ID Orcid, Department Of Sports Science, Semarang State University, Indonesia

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