

Analysis of the physical components affecting 50-meter freestyle swimming performance among undergraduate students of the elementary school physical education study program

Ricardo Valentino Latuheru^{1*}, Muhammad Syahrul Saleh¹, Muhammad Imran Hasanuddin¹

¹Department of Physical Education, Faculty of Sport and Health Sciences, Universitas Negeri Makassar, Makassar, Indonesia

Abstract. This research is a quantitative descriptive study with a correlational design that aims to analyze the relationship of physical components to the 50-meter freestyle swimming ability of students in the Elementary School Physical Education Study Program, Faculty of Sport and Health Sciences, Universitas Negeri Makassar. The population of the research consists of all students who take the swimming course, with a sample of 30 people selected purposively. The research instruments include the push-up test (arm muscle strength), the beep test (cardiovascular endurance/ VO_2 Max), and the vertical jump test (leg explosive power). Swimming ability was measured using a manual stopwatch and an electronic system. Statistical analysis was carried out using SPSS version 25 with a significance level of $\alpha = 0.05$. The results of the research show a significant positive correlation between arm muscle strength ($r = 0.36$; $p = 0.041$), cardiovascular endurance ($r = 0.61$; $p = 0.001$), and leg explosive power ($r = 0.54$; $p = 0.002$) with 50-meter freestyle swimming ability. Regression analysis shows that the three physical components together contribute 56.9% to swimming performance. These findings confirm the importance of strength, endurance, and explosive power in achieving optimal performance and provide a scientific basis for designing effective training programs.

1. Introduction

Swimming is one of the aquatic sports that requires an optimal combination of technique, physical strength, endurance, and motor coordination. According to Bompa and Carrera [1], good swimming ability is not only determined by technical skills but also by adequate physical condition, especially in sprint events such as the 50-meter freestyle. This event requires high speed in a short period of time; therefore, muscle strength, anaerobic endurance, and leg explosive power are key determinants of success.

* Corresponding author: ricardo.valentino@unm.ac.id

In the context of physical education, swimming skills are not only part of the curriculum requirements but also play an important role for future sports educators. Students of the Physical Education, Sports, and Recreation Study Program are expected to have sufficient swimming proficiency as preparation for teaching at elementary schools or working as coaches. However, field observations show that many students still struggle to achieve optimal time in the 50-meter freestyle. This condition may be caused by the lack of structured training and limited understanding of the physical factors that support swimming performance.

The 50-meter freestyle has distinct characteristics compared to middle- or long-distance events. In short-distance events, the alactic anaerobic energy system is highly dominant, meaning that athletes require substantial muscular strength and explosive power to reach maximum speed from the start to the finish [2]. Therefore, training that focuses on developing arm muscle strength, cardiovascular endurance, and leg explosive power becomes crucial.

Arm muscle strength plays an important role in the pull and push phases during swimming. According to Rhea et al. [3], good muscle strength enables swimmers to produce greater propulsive force, thereby increasing swimming speed. Arm-strengthening exercises such as push-ups or resistance training have been proven to enhance propulsion, which directly contributes to reducing swimming time.

In addition to arm strength, cardiovascular endurance is also an essential component. This endurance is related to VO_2 Max capacity, which reflects the body's ability to consume oxygen optimally during physical activity. Although the 50-meter distance is short, a well-functioning cardiovascular system supports efficient oxygen distribution to the muscles, prevents early fatigue, and aids recovery after starts and each breathing phase [4]. Therefore, the development of both aerobic and anaerobic endurance should be the main focus of training.

Leg explosive power is also a crucial factor. During the start and wall push-off phases, the explosive strength of the leg muscles determines initial speed and swimming momentum. The vertical jump test is often used as an indicator of leg explosive power, which is associated with start velocity. Mujika [2] reported that swimmers with greater leg explosive power have a significant advantage in the start and turn phases, contributing substantially to final performance. Aside from physiological factors, swimming technique also needs to be considered. However, this study specifically emphasizes the analysis of physical components, as technical aspects are typically covered in the curriculum, while physical aspects are often overlooked. This evidence-based approach to physical factors provides novelty compared to previous studies that focused mainly on technique.

The low swimming performance among students may result from the absence of scientifically based training programs. Issurin [4] stated that systematic and well-planned training periodization is more effective in improving physical components than random, unspecific exercises. Without periodization, it is difficult for students to optimize the physical capacities that support swimming performance. The urgency of this research lies in the need to identify the physical components that most significantly influence students' swimming ability. The results of this study are expected to provide a scientific foundation for developing more targeted training programs. Evidence-based training

programs can help students enhance their physical potential to achieve optimal swimming performance.

The research problems addressed in this study include: (1) What are the levels of arm muscle strength, cardiovascular endurance, and leg explosive power among students of the Elementary School Physical Education Study Program, Faculty of Sport and Health Sciences, Universitas Negeri Makassar? (2) Is there a significant correlation between these three physical components and 50-meter freestyle swimming ability? These questions are relevant to addressing the gap between academic requirements and the current physical condition of students.

This study employs a quantitative approach with a correlational design, which is appropriate for measuring the relationship between physical variables and swimming performance. The novelty of this research lies in the comprehensive analysis of physical components directly associated with student swimming performance. Previous studies have mostly focused on professional athletes, whereas this study examines physical education students who will become future sports educators. This contributes to the development of curriculum and teaching methods for swimming in higher education. Furthermore, this research aligns with the roadmap for the development of physical education in Indonesia, which emphasizes improving the physical quality and fundamental skills of future physical education teachers. In the long term, this study may serve as the foundation for developing science-based swimming training modules that can be implemented across universities.

Overall, this introduction highlights that physical components such as arm muscle strength, cardiovascular endurance, and leg explosive power are important determinants of 50-meter freestyle swimming performance. Therefore, an in-depth analysis of these three components is necessary to improve the competence of students in the Elementary School Physical Education Study Program, Faculty of Sport and Health Sciences, Universitas Negeri Makassar.

2. Research Method

This study employed a quantitative approach with a correlational design, which aimed to determine the relationship between the independent variables (arm muscle strength, cardiovascular endurance, and leg explosive power) and the dependent variable (50-meter freestyle swimming ability). According to Sugiyono [9], correlational research is a research method used to determine the degree of relationship between two or more variables without giving direct treatment to the research subjects. This design is appropriate for the purpose of this study, namely to analyze the extent to which physical components contribute to students' swimming performance.

The population of this study consisted of all students of the Elementary School Physical Education Study Program, Faculty of Sport and Health Sciences, Universitas Negeri Makassar, who were enrolled in the swimming course. The sampling technique used was purposive sampling, which is the selection of samples based on specific criteria relevant to the research objectives. In this study, the sampling criteria were students who had taken the swimming course for at least one semester and were in good physical condition. The total sample consisted of 30 participants.

The research instruments included three types of physical tests and one swimming performance measurement. Arm muscle strength was measured using the push-up test, which is a standardized method for assessing endurance and upper-arm strength [3]. Cardiovascular endurance was measured using the beep test to estimate VO_2 Max capacity, which has been validated as one of the best methods for measuring aerobic fitness [5]. Leg explosive power was measured using the vertical jump test, which has been widely used in sports research to assess lower-limb explosive strength [6]. The dependent variable, 50-meter freestyle swimming ability, was measured using both a manual stopwatch and an electronic timing system to enhance data validity and reliability.

The research procedure was carried out through several stages. First, the researcher prepared the instruments and validated the measurement tools with the assistance of swimming experts. Second, the physical tests (push-up, beep test, and vertical jump) were conducted following standard protocols to avoid measurement bias. Third, the 50-meter swimming performance data were collected in a standard swimming pool using start and finish techniques according to swimming regulations. All measurements were conducted by a competent research team to ensure data consistency and accuracy. According to Bompa and Buzzichelli [7], physical condition assessments must be conducted in a standardized manner so that the results can be interpreted scientifically.

The data analysis technique used the Pearson Product-Moment correlation test to determine the relationship between each physical component and the 50-meter swimming ability. Furthermore, multiple linear regression analysis was applied to determine the simultaneous contribution of the three independent variables to the dependent variable. The analysis was performed using SPSS version 22 at a significance level of $\alpha = 0.05$. The selection of these statistical techniques is consistent with Field [8], who stated that regression and correlation analyses are effective for predicting the influence of independent variables on dependent variables in sports research. The results of this analysis are expected to provide a scientific foundation for developing more effective training programs for students.

3. Results and Discussion

3.1 Results

Data analysis was carried out using the Pearson correlation test to examine the relationship between each physical component and the 50-meter freestyle swimming ability, as well as multiple linear regression analysis to determine the simultaneous contribution of the three components. The results are presented in the following table:

Table 1. Pearson Correlation Results between Physical Components and 50-Meter Freestyle Swimming Ability

Variable	r	p-value	Description
Arm Muscle Strength	0.36	0.041	Sig
Cardiovascular Endurance	0.61	0.001	Sig
Leg Explosive Power	0.54	0.002	Sig

The results in the table above show that all three physical variables have a significant positive relationship with the 50-meter freestyle swimming ability of students in the Elementary School Physical Education Study Program, Faculty of Sport and Health Sciences, Universitas Negeri Makassar, with cardiovascular endurance showing the strongest correlation.

Table 2. Multiple Linear Regression Analysis Results

Independent Variables	Contribution (%)
Arm Muscle Strength, Cardiovascular Endurance, and Leg Explosive Power	56,9%

Based on the table above, the three variables simultaneously contributed 56.9% to the variance in 50-meter freestyle swimming ability. The remaining 43.1% is likely influenced by other factors such as technique, flexibility, swimming experience, and psychological aspects.

3.2 Discussion

The correlation results indicate that arm muscle strength has a positive effect on swimming performance. Physiologically, this can be explained by the fact that arm muscle strength influences the pulling and pushing phases of the stroke, which generate propulsive force in the water. According to Rhea et al. [3], an increase in arm muscle strength through resistance training can improve propulsive power, thereby enhancing swimming speed. Students with stronger arm muscles are able to produce more efficient strokes, reduce water resistance, and achieve faster 50-meter times.

Cardiovascular endurance showed the strongest correlation ($r = 0.61$). A high VO_2 Max capacity supports optimal oxygen distribution to the muscles during high-intensity activities such as sprint swimming. Although the 50-meter distance is short, an efficient cardiovascular system helps reduce early fatigue and facilitates rapid recovery. This finding aligns with Mujika et al. [2], who emphasized that aerobic fitness still plays a role in sprint events as it supports energy metabolism and performance stability.

Leg explosive power also demonstrated a significant positive correlation ($r = 0.54$). This ability is particularly crucial during the start and wall push-off phases. Markovic et al. [6] explained that swimmers with greater leg explosive power are able to generate higher initial momentum, which accelerates start velocity—an essential factor in sprint events. In the context of students, plyometric and squat jump exercises are recommended to develop this component.

The combined contribution of the three variables, amounting to 56.9%, indicates that physical aspects are highly influential in determining swimming performance. This finding supports the theory of Bompa and Buzzichelli [1], which states that optimal performance can only be achieved through a combination of technical training and the development of sport-specific physical conditioning.

This discussion also highlights the importance of integrating physical training into the swimming curriculum for physical education students. Many students tend to focus on swimming techniques while neglecting structured physical training. However, according

to the principle of training specificity, physiological adaptations occur in accordance with the type of exercise performed. Therefore, improving relevant physical components is essential to support efficient swimming technique.

From a practical perspective, this research provides direct implications for the design of swimming training programs for students. Arm strength can be improved through push-up and resistance training, cardiovascular endurance through interval swimming and VO_2 Max exercises, and leg explosive power through plyometric training. These exercises should be implemented following the principles of periodization to achieve optimal physiological adaptation [4].

The results of this study are consistent with previous research on professional swimmers but offer novelty by focusing on non-athlete university students. This approach is important because physical education students are future sports educators who must possess swimming proficiency and a scientific understanding of physical components. The findings also provide a scientific basis for developing swimming instruction policies in higher education. The curriculum can incorporate specific physical training components, not merely technical practice. Thus, students can achieve optimal competency standards both as educators and as sports practitioners.

Overall, the findings of this study reaffirm that success in the 50-meter freestyle swimming event is determined not only by technical skills but also by measurable and well-trained physical conditions. Therefore, the integration of a science-based approach with practical instruction is essential for improving the quality of graduates in the Physical Education, Sports, and Recreation Study Program.

4. Conclusion

Based on the results of data analysis and discussion, this study produces several important conclusions as follows: 1) Arm muscle strength has a significant positive relationship with 50-meter freestyle swimming ability. The correlation value obtained was $r = 0.36$ with $p = 0.041$. This indicates that students with greater arm muscle strength tend to achieve faster swimming times because they can generate greater propulsive force during the pull and push phases. 2) Cardiovascular endurance (VO_2 Max) showed the highest correlation with swimming performance. The correlation value obtained was $r = 0.61$ with $p = 0.001$. Students with higher VO_2 Max values are able to distribute oxygen to the muscles more efficiently, allowing their performance to remain stable during high-intensity activities such as 50-meter sprint swimming. 3) Leg explosive power also demonstrated a significant correlation with swimming ability. The correlation value obtained was $r = 0.54$ with $p = 0.002$. This component greatly contributes to the start and wall push-off phases, providing significant initial acceleration in short-distance events. 4) The combined contribution of the three physical components to the variance in swimming performance reached 56.9%, based on the results of multiple linear regression analysis. Meanwhile, the remaining 43.1% is influenced by other factors such as swimming technique, flexibility, experience, and psychological aspects. The swimming learning program in the Physical Education, Sports, and Recreation Study Program, Faculty of Sport and Health Sciences, Universitas Negeri Makassar, requires an emphasis on specific training for these three physical components. This approach aligns with the

principle of training specificity and can be directly implemented in the swimming curriculum to enhance students' physical competence and overall performance.

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