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Construct of 50-Meter Crawl Style Swimming Performance and The Determinant Physical Factors

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Abstract

This study aimed to achieve the following objectives, namely (1) develop a measurement construct model to evaluate performance of the 50-meter crawl style swimming, (2) establish a structural equation model to examine the relationship between physical factors and swimming technique performance, and (3) identify the determinant physical factors of performance. A total of 150 subjects were selected using the purposive random sampling technique, and the data were analyzed using SPSS 10.0 program and LISREL 8.71 for Windows. Analysis 1: The fit of the indicators used in explaining the latent variables in the study models was tested: (1) body proportion latent variable assessed through the manifests of the hip width, thigh rim, upper arm rim, forearm rim, shoulder width, elbow width, and arm length showed favorable results, with λ $t_{count} > t_{table}$ *of 1.979 (df =129.5), and construct reliability of 0.877 > 0.7, which indicated unidimensionality, (2) biomotor latent variable, represented by the manifests of strength, explosive capacity, speed, flexibility, dexterity, reaction time, balance, and coordination, also yielded positive outcomes with* λ $t_{count} > t_{table}$ *of 1.979 (df =129.5), and construct reliability of 0.987 > 0.7, which indicated unidimensionality, (3) the latent variable nutrition status, assessed through the manifests of body height and weight showed satisfactory results with* λ $t_{count} > t_{table}$ *of 1.979 (df =129.5), and construct reliability of 0.797 > 0.7, which demonstrated unidimensionality. Analysis 2: the testing of the model:* $\chi^2 = 201.89$ *at df = 176, p = 0.08810 (criterion > 0.005), RMSEA = 0.078 (criterion > 0.005), and GFI = 0.9174. These results confirmed the model fits the data. Analysis 3: The effects of the determinant physical factors on the 50-meter crawl style swimming performance were examined based on the obtained model: (1) biomotor was significantly influenced by body proportion (*$\gamma = 0.2727$*,* $t_{count} = 3.876$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*), (2) swimming technique was affected by body proportion (*$t_{count} = 5.1830$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*,* $\gamma = 0.1262$*), biomotor (*$\gamma = 0.0426$*,* $t_{count} = 2.4403$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*), nutrition status (*$\gamma = 0.1449$*,* $t_{count} = 4.3174$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*), and* VO_2Max *(*$\gamma = 0.7715$*,* $t_{count} = 13.1600$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*). Meanwhile, the contribution of lung volume was not significant (*$\gamma = -0.0219$*,* $t_{count} = 5.1830$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*), (3) performance was significantly influenced by body proportion (*$\gamma = 0.3153$*,* $t_{count} = 3.0275$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*) and swimming technique (*$\gamma = -0.7075$*,* $t_{count} = 2.0577$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*), while the contribution of endurance was insignificant (*$\gamma = 0.2474$*,* $t_{count} = 0.7548$*,* $t_{table\ (df=129,\ \alpha=0.05)} = 1.979$*).*

Keywords: *Swimming Performance, Body Proportion, Biomotor, Body Mass Index,* VO_2Max*, Lung Volume, Swimming Technique*

1. Introduction

Swimming is a prominent sport that requires adequate scientific intervention and investment to support efforts in improving performance based on the study of science and technology. According to Counsilman's book "*The Science of Swimming*" (Counsilman: 1968), swimming has evolved into a discipline. Also, the integration of science and technology is closely related to the development of tests and measurements, which necessitate a solid theoretical foundation for assessing performance. There are numerous factors impacting swimming (Falaahudin et al., 2021), namely internal factors, such as technique mastery, mental state, and physical condition (Nugroho et al., 2021), and external factors, such as the environment, nutrition, training programs, as well as facilities and infrastructure (Falaahudin & Sabillah, 2023). Therefore, comprehensive studies are imperative to investigate the relationship between various construct contributing to the theory of swimming performance. Among the requisite skills for fast swimmers in the 50-meter distance, crawl style was regarded as a highly effective performance method, alongside a good start and rotation (Gorgees, 2022).

To achieve optimal swimming performance, several factors were considered. According to (Surahman, 2016), winning a competition necessitates swimming in the fastest possible time. Therefore, competitive swimmers are believed to possess specific anthropometrical features distinct from other athletes, but their performance is still contingent on physiological adaptations (Aspenes & Karlsen, 2012). These adaptations depend on psychological, morphological, physiological, and technical factors influenced by individual genetics and training. Although these factors are known to impact physical performance, the extent of their effect on adolescent swimmers' performance remains unclear (Aspenes & Karlsen, 2012). Study experts have continuously strived to identify and classify factors that precisely determine the highest precision in swimming performance (Kucia-Czyszczoń et al., 2013). Considerable emphasis has also been placed on energetic and biomechanical assessments as major determinant of swimming performance. Due to the progressively decreasing age in obtaining peak performance among swimmers, it is crucial to understand factors influencing performance of young boys and girls.

Swimming performance has been explained in terms of better control of stroke rate and stroke length, particularly with regard to race paces. Despite factors listed by Seifert as well as the considerable studies discussing the anthropometric and characteristics of performance among young swimmers (Jürimäe et al., 2007), further exploration is still needed (Duché et al., 1993). This is essential to comprehensively examine both internal and external determinant of swimming efficiency, encompassing factors such as technique, kinematics, age, and gender.

The following issues were addressed in this study: (1) the effect of manifests such as hip width, thigh rim, upper arm rim, forearm rim, shoulder width, elbow width, and arm length on body proportion, (2) the impact of muscle strength, leg muscle explosive capacity, speed, flexibility, dexterity, reaction time, balance, and coordination on biomotor, (3) the influence of body height and weight on swimmers' nutrition status, (4) a structural model of factors affecting the 50-meter crawl style swimming performance, (5) the direct and indirect effects of body proportion on performance through biomotor and swimming technique, (6) the effect of nutrition status on performance through technique, (7) the impact of endurance on performance through technique, (8) the influence of lung volume on performance, (9) the indirect effect of body proportion, biomotor, nutrition status, lung volume, and endurance on performance through technique. The direct effect of body proportion and endurance on performance was also explored.

The results are expected to be valuable in (1) creating opportunities to design instruments that can predict 50-meter crawl style swimming performance; (2) providing in-depth theoretical and practical discussions; (3) serving as a talent guide for coaches; and (4) encouraging other experts to investigate other swimming events or different sports disciplines.

2. Materials And Methods

This study used a quantitative method with a non-experimental design. The target population comprised swimmers who met the criteria for excellent proficiency in the 50-meter crawl style swimming (purposive sampling). Out of a total of 273 eligible students, 162 were randomly selected (randomized sampling). During the data quality selection stage, only 150 qualified data were included.

The variables in this study included (1) biomotor components, (2) body proportion components, (3) lung volume, (4) physical fitness, and (5) nutrition status. The Hypothetical Relationship Pattern of Factors Affecting 50-Meter Crawl Style Swimming Performance is shown in Figure 1.

Data analysis was conducted using the statistical program SPSS 10.00 and LISREL version 8.71 for Windows (Karl Joreskog and Dag Sorbom: 1996). Structural Equation Modeling (SEM) is a combination of 2 statistical methods, namely factors and path analyses (Ghozali, 2008). Therefore, LISREL was selected due to its accuracy, speed, and ease of use (Narimawati, 2007).

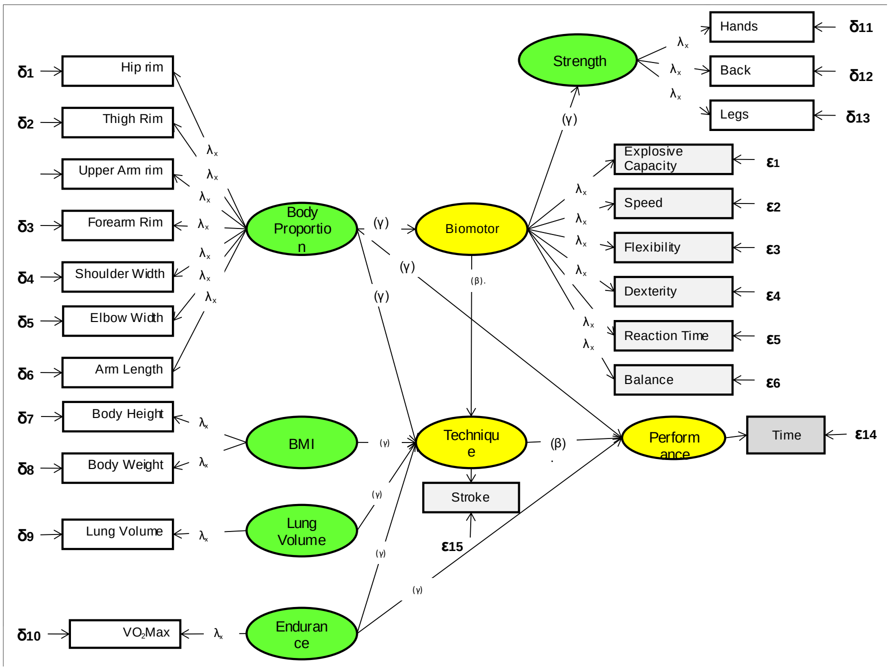

Figure 1: Hypothetical Relationship Pattern of Factors Affecting 50-Meter Crawl Style Swimming Performance

3. Results and Discussion

The data analysis results for body proportion, as measured from its manifests showed the following values: (1) hip width of 42.55 cm, (2) thigh rim of 49.44 cm, (3) upper arm rim of 26.10 cm, (4) forearm rim of 24.24 cm, (5) shoulder width of 43.03 cm, (6) elbow width of 5.82 cm, and (7) arm length of 5.12 cm for swimmers. Biomotor, as an exogenous construct (ζ), measured from its manifests, exhibited the following values: (1) strength of 229.42, (2) explosive capacity of 59.16, (3) speed of 5.63 seconds, (4) flexibility of 252.54, (5) dexterity of 25.21, (6) reaction time of 0.56, (7) balance of 25.44, and (8) coordination of 36.53. Nutrition status, as an exogenous construct (ζ), measured from its manifests, produced the following values: (1) body height of 1.66 and (2) body weight of 58.84. The average nutrition status index was 21.35, classified as normal. Meanwhile, endurance, as an exogenous construct (ζ), had a mean of 40.25 ml/kg.BW/minute for males and 36.51 ml/kg.BW/minute for females. Lung volume, as an exogenous construct (ζ), had a mean of 2.83 for males (recommended range: 3 to 6.1 liters) and 1.05 for females (recommended range: 2.5 to 4.5 liters).

To use SEM, it is necessary to ensure multivariate manifests adhere to the assumption of normal distribution. Failure to meet this assumption can increase the chi-square (χ^2) value, although in certain conditions, it may decrease. In essence, the test of the χ^2 goodness-of-fit is necessary when the overall model exhibits good fit (Narimawati, 2007). The normality test results for the multivariate manifests showed a value greater than 0.05, indicating a normal distribution.

Model Fit Test

The analysis of the hypothesized model fit with the collected empirical data showed the following markers for the GOF (goodness of fit index):

Table 1: The Goodness of Fit Index Results of Simulated Model

No	Index	*Cut of Value*	Result	Description*
1	Kai Square (p)	Small (less than 211.217) (p > 0.05)	201.89 (0.080)	Good
2	CFI	≥ 0.90 (max 1)	0.964	Good
3	GFI	≥ 0.95 (max 1)	0.917	Marginal
4	AGFI	≥ 0.95 (max 1)	0.854	Marginal
5	RMSEA	≤ 0.08 (min 0)	0.078	Good

Source: Data processing results

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After conducting simulations, the following structural model was proposed to explain factors influencing 50-meter crawl style swimming performance, namely body proportion, biomotor, nutrition status, VO_2Max, lung volume, and technique.

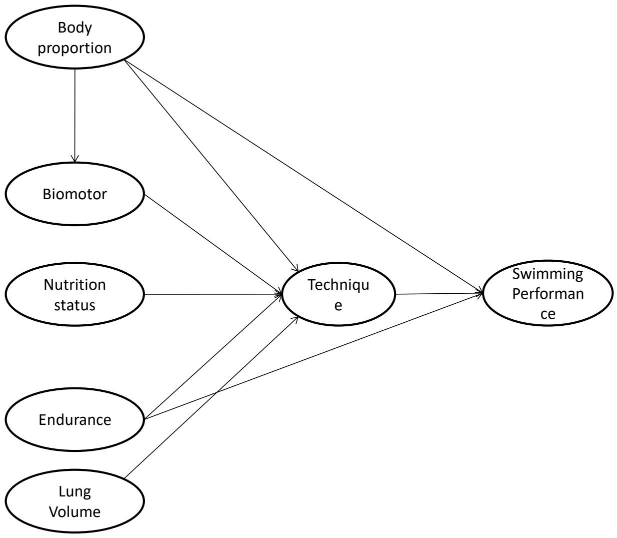

Figure 2: Path Diagram Model of the 50-Meter Crawl Style Swimming Performance After Simulation

Measurement Model Validation Test

Construct reliability method was used to assess the goodness of fit of the manifests used for depicting construct in the model. Body proportion was theoretically predicted to be influenced by 7 manifests, namely hip width (X_1), thigh rim (X_2), upper arm rim (X_3), forearm rim (X_4), shoulder width (X_5), elbow width (X_6), and arm length (X_7). The analysis of construct reliability for the latent variable of body proportion yielded a value of 0.87 > 0.7. This indicated body proportion exhibited significant reliability (Ferdinand August, 2002), and that all the manifests comprising construct were unidimensional. In addition, the significance test for the relationship between the manifests and body proportion showed a $t\text{-}_{count}$ greater than the $t\text{-}_{table}$ value, indicating statistical significance.

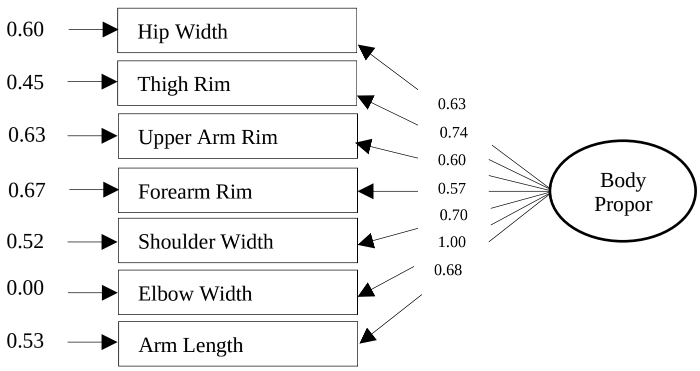

Figure 3: Factors Analysis of Body Proportion Construct

Biomotor construct was observed to be influenced by the following manifests: strength (X_8), explosive capacity (X_9), speed (X_{10}), flexibility (X_{11}), dexterity (X_{12}), reaction time (X_{13}), balance (X_{14}), and coordination (X_{15}). This result was supported by the t-count values exceeding both the standard lambda (λ) and the $t\text{-}_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. The analysis also revealed construct reliability of λ = 0.987, surpassing the threshold of 0.7. This indicated all manifests used to explain biomotor were unidimensional.

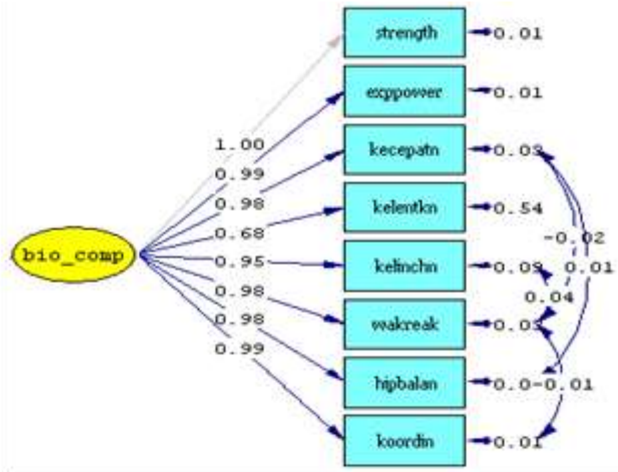

Figure 4: Factors analysis of biomotor construct

All manifests exhibited t-$_{count}$ greater than the t-$_{table}$ values, indicating statistical significance. Therefore, biomotor construct was significantly explained by muscle strength and leg muscle explosive capacity. The analysis also yielded a λ value resulting in construct reliability of 0.987 > 0.7, indicating all manifests were unidimensional.

Nutrition status, comprising the manifests of body height (X_{16}) and weight (X_{17}), had a t-count greater than the criteria, signifying statistical significance. The λ value resulted in construct reliability of 0.797 > 0.7, demonstrating all manifests were unidimensional.

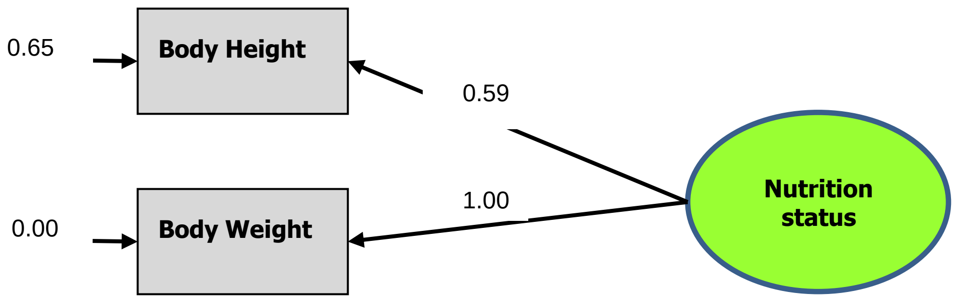

Figure 5: Measurement of Latent Variable Nutrition Status in Relation to Body Height and Weight

Endurance, lung volume, swimming technique, and performance were measured by a single manifest each, resulting in an error variance of 0 with a λ value of 1. Consequently, these 4 constructs were effectively reflected by their respective manifests, namely endurance by VO_2Max, lung volume by lung capacity, technique by stroke count, and performance by speed.

Structural Equation Model Test

The structural model test was conducted to determine whether the proposed theoretical model met the fit criteria of χ^2 with p>0.05, RMSEA, and GFI.

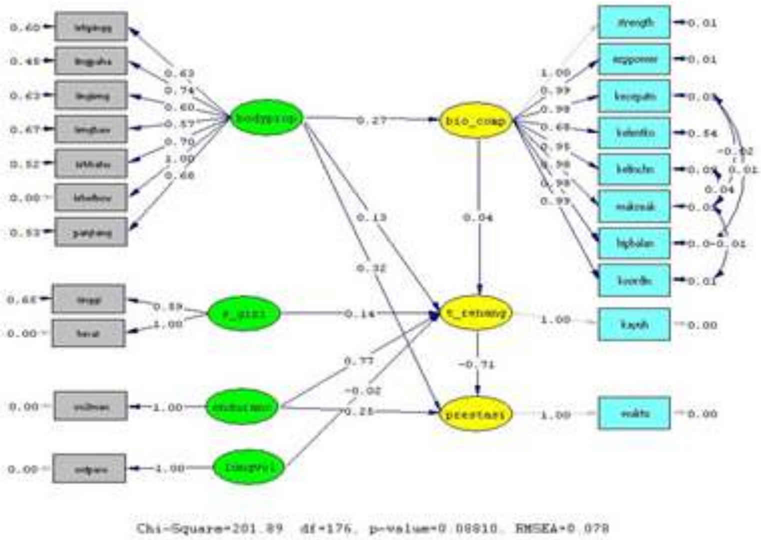

Figure 6: Structural Model of Factors Affecting the 50-Meter Crawl Style Swimming Performance

The model was tested using LISREL for Windows version 8.71, resulting in χ^2 = 201.89, with df = 176, p = 0.08810, RMSEA = 0.078, and GFI = 0.9174. These values satisfied the established criteria for a good fit, as p = 0.08810 > 0.005; RMSEA = 0.078 < 0.08; and GFI = 0.9174 > 0.9. Subsequently, a hypothesis test was conducted to assess the three main functions within the structural model, as supported by the theory.

The first function can be expressed as follows: biomotor = 0.2727 body proportion. The positive γ coefficient of 0.2727 showed the contribution of body proportion to changes in biomotor was 0.2727^2 = 0.0744 or 7.44%. Therefore, 7.44% of the variation in swimmers' biomotor was directly influenced by body proportion. The analysis also revealed a t-count for body proportion, as evidenced by 3.876 > $t_{table\ (df=129,\ \alpha=5\%)}$ of 1.979. This indicated the contribution of body proportion to swimmers' biomotor was statistically significant.

The second function was represented by the equation: swimming technique = 0.1262 body proportion + 0.0426 biomotor + 0.1449 nutrition status – 0.0219 lung volume + 0.7715 endurance. The γ coefficient indicated swimmers with proportional body significantly contributed to the improvement of technique, as evidenced by a t_{count} of 5.1830 > $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. The positive γ coefficient for biomotor indicated swimmers' movement ability positively contributed to the improvement of technique in terms of stroke count. This contribution was statistically significant, as evidenced by t_{count} > $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979.

The positive γ coefficient for nutrition status indicated good nutrition significantly contributed to the improvement of the 50-meter crawl style swimming technique, as evidenced by a t_{count} of 4.3174 > t_{table} of 1.979 (df=129, α=5%). The negative γ coefficient for lung volume suggested an inverse relationship, where larger lung capacity was related to lower mastery of technique. However, this contribution was not statistically significant, as evidenced by a t_{count} of 1.2342 < $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. Endurance had a positive γ coefficient, which indicated that swimmers' endurance contributed positively to technique improvement. This contribution was statistically significant, with a t_{count} of 13.1600 > $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979.

Endurance had the largest γ coefficient among the four exogenous variables, indicating the highest contribution to improving swimming technique. In the model, endurance was measured by a manifest of VO_2Max, representing the amount of oxygen consumed by swimmers' body during submaximal to maximal muscle exertion.

The third function was expressed by the equation: Performance = 0.3153 body proportion – 0.7075 swimming technique + 0.2474 endurance. The positive γ coefficient indicated proportional body significantly contributed to improving the 50-meter crawl style swimming performance, as evidenced by a t_{count} of 3.0275 > $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. The negative γ coefficient for swimming technique suggested the stroke count significantly contributed to increased speed, as evidenced by a t_{count} of 2.0577 > $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. The positive γ coefficient for endurance indicated oxygen consumption contributed to improving performance. However, this contribution was not statistically significant, with t_{count} of 0.7548 < $t_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. Among the exogenous latent variables, swimming technique had a larger γ coefficient, contributing more significantly to the swimmers' performance compared to body proportion.

The structural test results demonstrated the magnitude of the effect of each exogenous variable in the model. The total effect of body proportion on performance decreased compared to its direct effect without going through swimming technique. This could be attributed to the positive relationship observed when body proportion explained technique, and the negative relationship when mediated by performance. Similarly, endurance had a positive direct effect on performance, becoming negative when mediated by technique.

Hypothesis Test

The first hypothesis posited that hip width, thigh rim, upper arm rim, forearm rim, shoulder width, elbow width, and arm length significantly explained body proportion. The analysis confirmed these factors significantly reflected body proportion. Moreover, construct reliability test showed all these factors were unidimensional, supporting the first hypothesis.

The second hypothesis stated that strength, leg muscle explosive capacity, speed, flexibility, dexterity, reaction time, balance, and coordination significantly explained biomotor. The analysis showed these factors significantly reflected biomotor. Subsequently, construct reliability test revealed all the analyzed manifests were unidimensional, validating the second hypothesis.

The third hypothesis stated that body height and weight significantly reflected nutrition status. The statistical analysis confirmed these factors significantly reflected nutritional status. Meanwhile, construct reliability test revealed all factors involved in the model were unidimensional, supporting the third hypothesis.

The fourth hypothesis stated that body proportion had a significant direct and indirect effect on performance through biomotor and swimming technique. The γ coefficient of 0.1262 indicated that body proportion contributed significantly to technique, as evidenced by a $t\text{-}_{count}$ of 5.1830 > $t\text{-}_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. This validated the fourth hypothesis.

The fifth hypothesis posited that biomotor had a significant indirect effect on performance through swimming technique. The analysis results yielded a γ coefficient of 0.0426 and a $t\text{-}_{count}$ of 2.4403 > $t\text{-}_{table\ (df=129,\ \alpha=0.05)}$ of 1.979, indicating a significant contribution of biomotor to technique. This validated the fifth hypothesis.

The sixth hypothesis stated nutrition status significantly affected performance through the 50-meter crawl style swimming technique. The analysis results yielded a γ coefficient of 0.1449, indicating nutrition status significantly contributed to technique improvement, as evidenced by a $t\text{-}_{count}$ of 4.3174 > $t\text{-}_{table\ (df=129,\ \alpha=0.05)}$ of 1.979. This validated the sixth hypothesis.

The seventh hypothesis stated that lung volume significantly affected performance through swimming technique. The analysis yielded a γ coefficient of -0.019, suggesting an inverse relationship. However, this contribution was not statistically significant, as evidenced by a $t\text{-}_{count}$ of 1.2342 < $t\text{-}_{table\ (df=129,\ \alpha=0.05)}$ of 1.979.

The eighth hypothesis stated endurance significantly affected performance through swimming technique. The analysis yielded a γ coefficient of 0.1775, indicating that endurance significantly contributed to performance through technique, with a $t\text{-}_{count}$ of 13.1600 > $t\text{-}_{table\ (df=129,\ \alpha\ =\ 0.05)}$ of 1.979. This validated the eighth hypothesis.

The ninth hypothesis stated body proportion significantly affected 50-meter crawl style swimming performance. The analysis yielded a positive γ coefficient, indicating body proportion contributed to performance, with a $t\text{-}_{count}$ of 3.0275 > $t\text{-}_{table\ (df=129,\ \alpha\ =\ 5)}$ of 1.979. This validated the ninth hypothesis.

The tenth hypothesis stated that swimming technique affected performance. The analysis yielded a γ coefficient of -0.7075, indicating the 50-meter crawl style swimming technique contributed with a negative direction. This contribution was statistically significant, as evidenced by a $t\text{-}_{count}$ of -2.0577 > $t\text{-}_{table\ (df=129,\ \alpha\ =\ 0.05)}$ of 1.979, validating the tenth hypothesis.

The eleventh hypothesis stated endurance significantly affected 50-meter crawl style swimming performance. The analysis yielded a γ coefficient of 0.2474, indicating endurance significantly contributed to performance, with a $t\text{-}_{count}$ of 0.7548 > $t\text{-}_{table\ (df=129,\ \alpha\ =\ 0.05)}$ of 1.979. This validated the eleventh hypothesis.

The function of the 50-meter crawl style swimming technique with coefficients of body proportion at 0.1262, biomotor at 0.0426, nutrition status at 0.1449, and endurance at 0.7715, was significant. This implied technique could significantly explain swimming technique while supporting the hypothesis regarding the direct effect of body proportion, biomotor, nutrition status, and endurance on technique. However, lung volume with a coefficient of -0.0219 was insignificant, thereby not supporting the hypothesis.

The structural function of performance with body proportion (coefficient of 0.3153) and swimming technique (-0.7075) was significant. Both variables supported the hypothesis stating their significant effects on performance. However, endurance did not have a significant effect, indicating the hypothesis was not supported.

The structural model depicted swimming technique as a mediating variable for body proportion, biomotor, nutrition status, lung volume, and endurance on performance. The significant effects indicated the function of technique as a mediating variable on performance was supported. However, the mediating function of lung volume diminished because it was not significant in relation to technique.

The significant effect of body proportion on biomotor, swimming technique, and performance could be attributed to arm length, elbow width, shoulder width, forearm rim, upper arm rim, and thigh rim. In real-life situations, these aspects mutually complemented each other to collectively influence biomotor, technique, and performance. Arm length, supported by elbow width, shoulder width, forearm rim, and upper arm rim had a significant impact. Barbosa emphasized that swimmers spend a substantial amount of time in swimming phase during any swimming in event (Barbosa et al., 2011).

Lauder (2003) found that the arms, hands, shoulders, and joint angles played a role in generating hydrodynamic force in 50-meter crawl style swimmers. Shoulder rotation at various angles were also proven to generate hydrodynamic force. Adams (2001) further examined that superior swimming technique could enhance speed in swimmers. Technique improved when swimmers possesed body proportion naturally developed or attained through specific training. Michael (2007) demonstrated that body proportion played a significant role in heat generation during movement, where good body proportion enhanced movement efficiency and reduced fatigue.

The 50-meter crawl style swimming technique could essentially be considered the output of a unified process involving body proportion and biomotor. Swimmers with favorable body proportion had the potential for good biomotor, which could impact stroke count when combined with resources like strength, explosive capacity, speed, flexibility, dexterity, reaction time, hip balance, and tight coordination. Stefanon (2005) stated that 15%-25% of the speed in 50-meter crawl style swimmers was determined by body fitness/condition, while the remaining 75%-85% by swimming technique and movement efficiency. Since swimming is a multi-factorial sport, performance improvement should not be solely attributed to a single domain, such as anthropometrics (Morais et al., 2013).

In addition to body proportion and biomotor, nutrition status, lung volume, and endurance also influenced the 50-meter crawl style swimming technique. This was because technique was affected by body proportion and biomotor, and its training required adequate nutrition intake and sufficient oxygen supply from lung. Although the study did not aim to prove the effect of VO_2Max on technique, Kimura et al. (1998) and Marten (1987) conducted swimming simulations to measure VO_2Max and found a correlation. The importance of endurance for swimmers had also been highlighted by Stephen (1986), while the significance of nutrition in the world of sports had been established by Burke (2006).

There was insignificant effect of lung volume on swimming technique and endurance on performance, with a significant effect on only swimming technique. This suggested that (1) empirically, the data had not been able to demonstrate the role of lung volume in technique or the impact of endurance on performance, (2) the assumption showed the study subjects had relatively homogeneous (suboptimal) lung capacity, which did not determine technique, (3) further test involving trained swimmers was required to ensure the validity of the theoretical foundation used in building the model.

The swimmers' ability to consume oxygen still played a role in biomotor, providing a significant impact on swimming technique. However, performance was not directly influenced since the predominant energy system was anaerobic without the support of technique.

4. Conclusion

In conclusion, (1) Body proportion was significantly reflected by hip width, thigh rim, upper arm rim, forearm rim, shoulder width, elbow width, and arm length; (2) Biomotor was significantly reflected by strength, leg muscle explosive capacity, speed, flexibility, dexterity, reaction time, balance, and coordination; (3) Nutritional status was significantly reflected by body height and weight; (4) The model was considered fit according to the established criteria; (5) Body proportion had a significant direct and indirect effect on 50-meter crawl style swimming performance through biomotor and swimming technique; (6) Nutrition status significantly influenced performance through technique; (7) Endurance had a significant effect on performance through technique; (8) Lung volume did not have a significant effect on performance; (9) Body proportion, biomotor, nutrition status, lung volume, and endurance indirectly (through technique) had a significant effect on performance. Body proportion significantly and directly influenced performance, while endurance had no significant direct effect; (10) The model provided an explanation for the direct and indirect effects of body proportion, biomotor, nutrition status, lung volume, and endurance on performance through technique.

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