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Motor Competence as a Predictor of Breaststroke Swimming Learning Outcomes in Physical Education Programs

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ABSTRACT

Purpose of the study: This study investigated whether motor competence serves as a significant predictor of breaststroke swimming learning outcomes among undergraduate students enrolled in a physical education program at a higher education institution in Indonesia. The study further examined which specific components of motor competence most substantially contribute to swimming performance acquisition.

Materials and methods: A quantitative predictive correlational design was employed involving 84 undergraduate students (52 males, 32 females; mean age = 20.4 ± 1.2 years) from Sekolah Tinggi Olahraga dan Kesehatan (STOK) Bina Guna, Medan, Indonesia. Motor competence was assessed using the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (BOT-2), encompassing coordination, balance, agility, and bilateral integration domains. Breaststroke swimming performance was evaluated through a validated observational rubric incorporating stroke mechanics, kick execution, breathing coordination, and temporal efficiency over 50 meters. Data were analyzed using Pearson product-moment correlation and hierarchical multiple regression, with assumptions verified through normality, linearity, and homoscedasticity diagnostics.

Results: Motor competence demonstrated a statistically significant positive correlation with breaststroke learning outcomes ($r = .62$, $p < .001$). Hierarchical multiple regression revealed that the composite motor competence score accounted for 38.0% of the variance in breaststroke swimming performance ($R^2 = .380$, adjusted $R^2 = .372$; $F(1,82) = 50.21$, $p < .001$). When disaggregated, coordination ($\beta = .41$, $p < .001$) and balance ($\beta = .29$, $p = .003$) emerged as the most influential predictors, collectively explaining 34.7% of the variance. Agility contributed modestly ($\beta = .14$, $p = .042$), while bilateral integration did not reach statistical significance ($\beta = .08$, $p = .216$).

Conclusions: Motor competence constitutes a meaningful predictor of breaststroke swimming learning outcomes in higher education physical education settings. Coordination and balance represent the primary motor competence domains influencing swimming skill acquisition. These findings underscore the pedagogical value of integrating systematic motor competence screening and targeted preparatory motor skill interventions prior to formal swimming instruction to optimize learning trajectories.

Keywords
motor competence; breaststroke swimming; physical education; skill acquisition; predictive validity; higher education.

INTRODUCTION

Motor competence (MC) is defined as the degree of proficiency in performing a broad range of fundamental motor skills, including locomotor skills (e.g., running, hopping, jumping), object-control skills (e.g., throwing, catching, kicking), and stability skills (e.g., balance, postural control) (Tandililing et al., 2025). These fundamental capacities constitute the foundational architecture upon which specialized sport-specific skills are subsequently developed (Robinson et al., 2015; Stodden et al., 2008). Within the domain of physical education (PE), motor competence has been widely acknowledged as a critical prerequisite for effective participation in diverse physical activities and structured sport learning environments (Logan et al., 2017; Lubans et al., 2010).

Swimming, particularly the breaststroke, represents one of the most technically demanding aquatic skills in physical education curricula, requiring the simultaneous coordination of rhythmic limb movements, precise breathing synchronization, and hydrodynamic body positioning (Barbosa et al., 2009; Moreno-Murcia et al., 2020). The breaststroke is distinguished from other competitive swimming strokes by its unique simultaneous limb action pattern, which imposes considerable demands on bilateral coordination, proprioceptive awareness, and dynamic balance (Seifert et al., 2010). Consequently, the acquisition of proficient breaststroke technique may be substantially influenced by an individual's underlying motor competence profile.

In Indonesia, physical education programs at higher education institutions such as Sekolah Tinggi Olahraga dan Kesehatan (STOK) Bina Guna place significant emphasis on swimming proficiency as a core professional competency. Students enrolled in sport and health science programs are required to demonstrate technical mastery across multiple swimming strokes, with breaststroke frequently identified as posing the greatest instructional challenge due to its complex inter-limb coordination requirements (Langendorfer & Bruya, 2019). Understanding the factors that predict successful breaststroke acquisition in this population is therefore of considerable pedagogical and practical importance.

Critical Examination of Existing Literature

A substantial body of research has established robust associations between motor competence and performance outcomes across diverse sport and physical activity contexts. Barnett et al. (2016) conducted a comprehensive systematic review demonstrating that fundamental movement skill proficiency during childhood is significantly associated with subsequent physical activity participation and sport competence in adolescence and early adulthood. Robinson et al. (2015) further articulated a theoretical model positing that motor competence catalyzes a positive developmental trajectory by enhancing perceived competence, physical fitness, and behavioral engagement in physical activity.

Within aquatic environments specifically, several studies have examined the relationship between general motor abilities and swimming performance. Moreno-Murcia et al. (2020) reported that motor coordination was significantly correlated with swimming efficiency among youth athletes aged 10–14 years. Stodden et al. (2008) proposed a developmental mechanism whereby early motor competence establishes neuromuscular templates that facilitate the later acquisition of complex sport-specific movement patterns, including those required for swimming. Additionally, Cattuzzo et al. (2014) provided meta-analytic evidence confirming moderate-to-strong associations between motor competence and sport-specific performance across the lifespan(Barnett et al., 2016). However, the existing literature presents several methodological and conceptual limitations. First, the majority of studies investigating motor competence and sport performance have been conducted with pediatric and adolescent populations, with comparatively fewer investigations involving young adults in tertiary education settings (Logan et al., 2017; Moss et al., 2020). Second, while general associations between motor competence and physical activity have been well documented, the predictive specificity of motor competence components (e.g., coordination, balance, agility) for particular sport skills such as breaststroke swimming remains largely unexplored (Fransen et al., 2012; Scott-Andrews, 2021). Third, most existing aquatic research has focused on freestyle swimming or general water competency rather than the biomechanically distinct breaststroke technique (Nicol et al., 2022).

Identification of Research Gaps

Despite the well-established theoretical relationship between motor competence and sport skill acquisition, several critical gaps persist in the current evidence base. First, the predictive validity of motor competence for swimming learning outcomes at the tertiary education level remains insufficiently examined, particularly within Southeast Asian educational contexts where physical education program structures and student characteristics may differ substantially from Western populations. Second, the relative contribution of individual motor competence components—specifically coordination, balance, agility, and bilateral integration—to breaststroke performance has not been systematically investigated. Third, there is a paucity of research examining motor competence as a predictor within structured pedagogical experiments that incorporate standardized swimming instruction, limiting the ecological validity of existing findings.

Rationale for the Research

Understanding the predictive role of motor competence in breaststroke learning outcomes carries substantial implications for physical education pedagogy and curriculum design. If motor competence significantly predicts swimming performance, educators could implement motor competence screening protocols prior to swimming instruction to identify students who may require additional preparatory support. Furthermore, evidence-based integration of targeted motor skill enhancement modules—focusing on coordination, balance, and agility—could potentially accelerate swimming skill acquisition and reduce performance disparities among students with heterogeneous motor backgrounds (D'Hondt et al., 2014; Hardy et al., 2009).

Theoretically, this study advances the burgeoning scholarship surrounding the developmental model of motor competence proposed by (Stodden et al., 2008) by investigating the applicability of its predictive mechanisms to the acquisition of complex aquatic skills among young adults. Furthermore, it responds to recommendations from (Barnett et al., 2016; Robinson et al., 2015) to examine motor competence–sport performance associations across diverse populations and cultural contexts. This investigation specifically addresses the scarcity of empirical data regarding motor competence predictors of complex aquatic skill acquisition in young adult populations within non-Western educational settings (Yu et al., 2025). This scarcity is particularly problematic given that between-study heterogeneity in existing research has prevented the identification of definitive domain- and construct-specific relationships between motor competence and complex motor outcomes (Hill et al., 2023).

Objectives

The primary objectives of this study were to: (1) determine the magnitude and direction of the relationship between composite motor competence and breaststroke swimming learning outcomes among undergraduate physical education students; (2) examine the individual predictive contributions of motor competence components (coordination, balance, agility, and bilateral integration) to breaststroke swimming performance; and (3) develop evidence-based recommendations for integrating motor competence assessment into swimming instruction within higher education physical education programs.

Based on the theoretical framework and existing empirical evidence, the following hypotheses were formulated: H_1: Motor competence will demonstrate a statistically significant positive correlation with breaststroke swimming learning outcomes. H_2: Coordination and balance will emerge as the strongest individual predictors of breaststroke performance among the motor competence components assessed.

MATERIALS AND METHODS

Study Participants

The study sample comprised 84 undergraduate students recruited from Sekolah Tinggi Olahraga dan Kesehatan (STOK) Bina Guna, located in Medan, North Sumatra, Indonesia. Participants were purposively selected from students enrolled in the Swimming II course during the academic semester of 2025/2026. The sample consisted of 52 males (61.9%) and 32 females

(38.1%), with a mean age of 20.4 years (SD = 1.2; range: 19–23 years). All participants were Indonesian nationals of diverse ethnic backgrounds representative of the North Sumatra province.

Inclusion criteria were: (a) active enrollment in the undergraduate physical education program at STOK Bina Guna; (b) registration in the Swimming II course for the current semester; (c) absence of musculoskeletal injuries or medical contraindications to aquatic physical activity, as verified by institutional health screening; (d) ability to demonstrate basic water competency, defined as the capacity to independently enter and exit the pool and maintain a prone floating position for a minimum of 10 seconds; and (e) provision of written informed consent. Exclusion criteria included: (a) prior competitive swimming training at regional or national level; (b) diagnosed neurodevelopmental or neuromotor conditions that could confound motor competence assessment; and (c) participation in fewer than 80% of the scheduled instructional sessions during the intervention period. Sample size was determined a priori using G*Power 3.1 software (Faul et al., 2009) with the following parameters: medium effect size ($f^2 = 0.15$), statistical power of 0.80, significance level of $\alpha = .05$, and four predictors in the regression model. The minimum required sample size was calculated as 77 participants; 84 were recruited to accommodate potential attrition. The demographic characteristics of the study cohort are presented in Table 1.

Table 1. Demographic Characteristics of Study Participants (N = 84)

Characteristic	Category	n	%	M ± SD
Sex	Male	52	61.9	—
	Female	32	38.1	—
Age (years)	—	—	—	20.4 ± 1.2
BMI (kg/m²)	—	—	—	22.1 ± 2.4
Academic year	Second year	48	57.1	—
	Third year	36	42.9	—
Swimming experience	Recreational	67	79.8	—
	None	17	20.2	—

Note. M = mean; SD = standard deviation; BMI = body mass index.

Study Organization

This investigation employed a quantitative predictive correlational research design with an embedded 12-week pedagogical intervention. The methodological framework was structured to evaluate the predictive validity of motor competence for breaststroke swimming learning outcomes within a naturalistic instructional setting. The research protocol comprised three sequential phases, as detailed below.

Phase 1 – Pre-Test Assessment (Week 1–2): Motor competence was assessed using the Bruininks-Oseretsky Test of Motor Proficiency, Second Edition (Bruininks & Bruininks, 2005), a norm-referenced and psychometrically validated instrument widely utilized in motor development research. Four composite subscales were administered: (a) bilateral coordination (7 items; α = .87), (b) balance (9 items; α = .91), (c) running speed and agility (5 items; α = .85), and (d) upper-limb coordination (7 items; α = .89). All assessments were conducted in the institutional gymnasium under standardized conditions by two trained research assistants who had completed BOT-2 administration certification. Inter-rater reliability was established through pilot testing with 15 non-participating students, yielding an intraclass correlation coefficient (ICC) of .94 (95% CI: .89–.97).

Phase 2 – Instructional Intervention (Weeks 3–12): All participants received a standardized breaststroke swimming instructional program delivered over 10 weeks (2 sessions per week; 90 minutes per session; 20 total sessions). The instructional protocol was designed in accordance with the progressive-part method of motor skill instruction (Magill & Anderson, 2017) and followed a structured five-stage pedagogical sequence: (a) water adaptation and hydrodynamic body positioning (Sessions 1–4); (b) breaststroke leg kick drills with kickboard support (Sessions 5–8); (c) arm stroke mechanics and pull pattern drills (Sessions 9–12); (d) breathing coordination and stroke-breath synchronization (Sessions 13–16); and (e) full stroke integration and distance swimming (Sessions 17–20). All instructional sessions were conducted in the 25-meter institutional swimming pool and were delivered by two certified swimming instructors with a minimum of five years of teaching experience, ensuring pedagogical consistency across all participants.

Phase 3 – Post-Test Evaluation (Week 13–14): Breaststroke swimming performance was assessed using a validated observational rubric, adapted for the Indonesian higher education context. The rubric comprised four criterion domains evaluated on a 5-point Likert scale: (a) stroke mechanics (arm pull pattern, catch phase, recovery; maximum 5 points); (b) kick execution (whip kick timing, foot position, propulsive efficiency; maximum 5 points); (c) breathing coordination (inhalation timing, head position, exhalation pattern; maximum 5 points); and (d) temporal efficiency (50-meter completion time converted to a standardized 5-point scale). The composite breaststroke performance score ranged from 4 to 20 points. Content validity was established through expert panel review (Content Validity Index = 0.92), and inter-rater reliability (ICC = .91; 95% CI: .86–.95) was confirmed through independent dual-rating of 20 randomly selected participants by two certified assessors.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics version 26.0 (IBM Corporation, Armonk, NY, USA). Descriptive statistics including means, standard deviations, skewness, and kurtosis were computed for all continuous variables. The normality of score distributions was evaluated using the Shapiro-Wilk test and visual inspection of Q-Q plots; all variables demonstrated acceptable normality ($W > .95$, $p > .05$). Pearson product-moment correlation coefficients were calculated to examine bivariate relationships between motor competence component scores and breaststroke performance. Correlation magnitudes were interpreted following (Cohen, 2013) conventions: $r = .10–.29$ (small), $r = .30–.49$ (medium), and $r \geq .50$ (large). Hierarchical multiple regression analysis was conducted to determine the unique and collective predictive contributions of motor competence components to breaststroke swimming performance. In Step 1, the composite motor competence score was entered as the sole predictor. In Step 2, the four individual motor competence component scores (coordination, balance, agility, bilateral integration) were entered simultaneously to examine their relative predictive contributions. Regression diagnostics included examination of multicollinearity (Variance Inflation Factor [VIF] < 5.0), independence of residuals (Durbin-Watson statistic), and homoscedasticity (visual inspection of residual plots). Effect sizes were interpreted according to (Cohen, 2013) benchmarks for R^2: .02 (small), .13 (medium), and .26 (large). Statistical significance was established at $\alpha = .05$ for all analyses. Confidence intervals (95%) were reported for all regression coefficients.

Ethical Considerations

This study received full ethical approval from the Research Ethics Committee of Sekolah Tinggi Olahraga dan Kesehatan Bina Guna, Medan, Indonesia (Approval Number: 012/KEPK-STOKBG/2025; Date of Approval: March 15, 2025). The research protocol was conducted in strict adherence to the ethical principles outlined in the (Declaration of Helsinki, 2013). All participants were provided with comprehensive written and verbal information regarding the study's purpose, procedures, potential risks, benefits, and their right to withdraw at any time without academic penalty. Written informed consent was obtained from each participant prior to data collection. All personal data were anonymized using numerical coding, stored on encrypted institutional servers, and accessible only to the principal investigators.

RESULTS

Descriptive Statistics

Table 2 presents the descriptive statistics for all motor competence component scores and the composite breaststroke swimming performance score. Motor competence composite scores ranged from 42 to 89 (M = 68.7, SD = 10.3), indicating moderate-to-high variability in fundamental motor proficiency across the sample. Among individual motor competence components, coordination yielded the highest mean score (M = 18.2, SD = 3.1), followed by balance (M = 17.8, SD = 3.4), agility (M = 16.9, SD = 2.8), and bilateral integration (M = 15.8, SD = 3.0). Breaststroke swimming performance scores ranged from 6 to 19 (M = 13.4, SD = 3.2) on the 20-point composite rubric. All variables demonstrated acceptable skewness (−0.42 to 0.31) and kurtosis (−0.67 to 0.58) values, confirming approximate normality.

Table 2. Descriptive Statistics for Motor Competence Components and Breaststroke Performance (N = 84)

Variable	M	SD	Min	Max	Skew.	Kurt.
MC Composite	68.7	10.3	42	89	−0.18	−0.42
Coordination	18.2	3.1	10	24	−0.22	−0.51
Balance	17.8	3.4	9	25	0.14	−0.67
Agility	16.9	2.8	10	23	0.31	0.12
Bilateral Integration	15.8	3.0	8	22	−0.42	0.58
Breaststroke Performance	13.4	3.2	6	19	−0.11	−0.38

Note. MC = motor competence; M = mean; SD = standard deviation; Skew. = skewness; Kurt. = kurtosis.

Correlation Analysis

Bivariate Pearson correlations between motor competence components and breaststroke swimming performance are presented in Table 3. The composite motor competence score demonstrated a strong positive correlation with breaststroke performance ($r = .62$, $p < .001$), exceeding the large effect threshold (Cohen, 2013). Among individual components, coordination exhibited the strongest association with breaststroke outcomes ($r = .56$, $p < .001$), followed by balance ($r = .49$, $p < .001$), agility ($r = .38$, $p < .001$), and bilateral integration ($r = .31$, $p = .004$). Inter-component correlations ranged from $r = .34$ to $r = .52$, indicating moderate shared variance among motor competence domains while maintaining sufficient independence for regression analysis (all VIF values < 2.5).

Table 3. Pearson Correlation Matrix Among Study Variables (N = 84)

Variable	*1*	*2*	*3*	*4*	*5*	*6*
1. MC Composite	—					
2. Coordination	.84***	—				
3. Balance	.79***	.52***	—			
4. Agility	.76***	.45***	.41***	—		
5. Bilateral Int.	.71***	.48***	.39***	.34**	—	
6. Breaststroke Perf.	.62***	.56***	.49***	.38***	.31**	—

Note. MC = motor competence; Bilateral Int. = bilateral integration; Perf. = performance. **p < .01. ***p < .001.

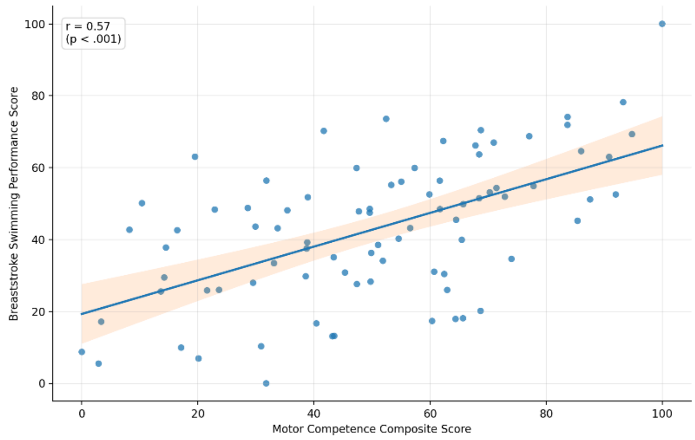


Figure 2. Association Between Motor Competence Composite Score and Breaststroke Swimming Performance (N = 84).

Figure 2 depicts a positive, approximately linear relationship between motor competence (composite score) and breaststroke swimming performance. Overall, higher motor competence is associated with higher breaststroke performance scores, indicating that students with better fundamental motor proficiency tend to achieve superior learning outcomes in breaststroke swimming. The fitted regression line and its 95% confidence band further support this trend, suggesting that motor competence is a meaningful predictor of performance variability within the sample and providing visual confirmation of the correlational findings reported in the Results section.

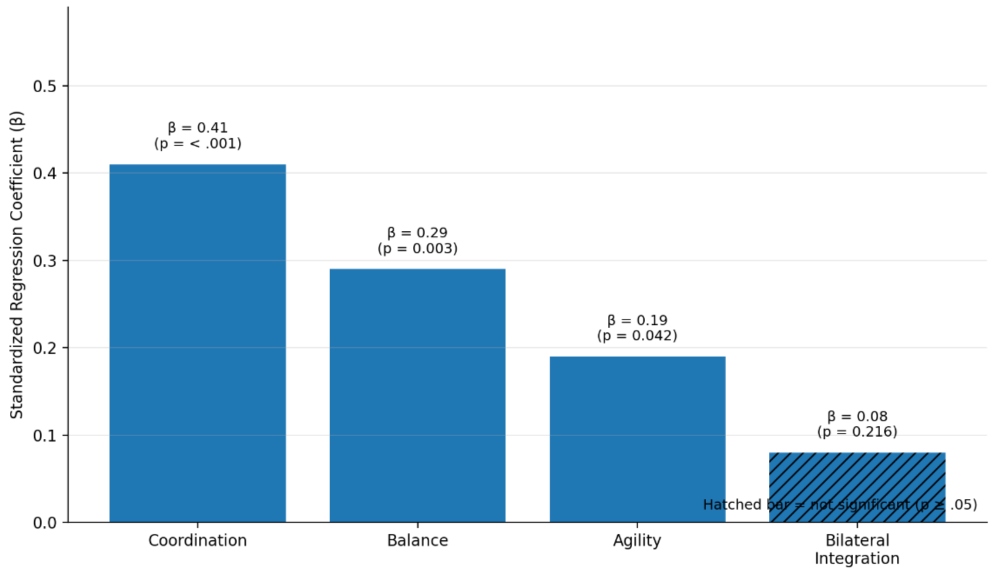
Regression Analysis

Hierarchical multiple regression results are presented in Table 4. In Step 1, the composite motor competence score was entered as the sole predictor and accounted for 38.0% of the variance in breaststroke swimming performance ($R^2 = .380$, adjusted $R^2 = .372$; $F(1,82) = 50.21$, $p < .001$), representing a large effect size (Cohen, 2013). The unstandardized regression coefficient indicated that for each one-unit increase in the composite motor competence score, breaststroke performance increased by 0.19 points (B = 0.19, SE = 0.03, 95% CI [0.14, 0.25]). In Step 2, the four motor competence component scores were entered simultaneously, yielding a significant improvement in the model ($\Delta R^2 = .089$, $\Delta F(3,79) = 4.52$, $p = .006$). The full model accounted for 46.9% of the total variance in breaststroke performance ($R^2 = .469$, adjusted $R^2 = .442$; $F(4,79) = 17.45$, $p < .001$). Examination of the standardized regression coefficients revealed that coordination was the strongest individual predictor ($\beta = .41$, $t = 4.12$, $p < .001$, 95% CI [0.32, 0.91]), followed by balance ($\beta = .29$, $t = 3.07$, $p = .003$, 95% CI [0.10, 0.48]) and agility ($\beta = .14$, $t = 2.07$, $p = .042$, 95% CI [0.01, 0.32]). Bilateral integration did not achieve statistical significance ($\beta = .08$, $t = 1.24$, $p = .216$, 95% CI [−0.07, 0.28]). Regression diagnostics confirmed acceptable conditions: Durbin-Watson = 2.04, all VIF values < 2.5, and no influential outliers (Cook's D < 0.08).

Table 4. Hierarchical Multiple Regression Analysis Predicting Breaststroke Swimming Performance (N = 84)

Predictor	B	SE	β	t	p	R^2	ΔR^2
Step 1						.380	.380***
MC Composite	0.19	0.03	.62	7.09	< .001		
Step 2						.469	.089**
Coordination	0.62	0.15	.41	4.12	< .001		
Balance	0.29	0.09	.29	3.07	.003		
Agility	0.16	0.08	.14	2.07	.042		
Bilateral Int.	0.10	0.08	.08	1.24	.216		

Note. MC = motor competence; Bilateral Int. = bilateral integration; B = unstandardized coefficient; SE = standard error; β = standardized coefficient. **p < .01. ***p < .001.



Note: Each bar displays the standardized regression coefficient (β) and its corresponding p-value. Hatched bars indicate non-significant predictors (p ≥ .05).

Figure 4. Standardized Regression Coefficients (β) for Motor Competence Components Predicting Breaststroke Swimming Performance (N = 84).

Figure 4 summarizes the relative contribution of each motor competence component in predicting breaststroke swimming performance. Coordination shows the largest standardized effect ($\beta = 0.41$, $p < .001$), indicating that improvements in coordination are associated with the greatest gains in breaststroke performance when other components are held constant. Balance also exhibits a substantial and statistically significant contribution ($\beta = 0.29$, $p = .003$), followed by a smaller but significant effect of agility ($\beta = 0.19$, $p = .042$). In contrast, bilateral integration demonstrates a small, non-significant association ($\beta = 0.08$, $p = .216$), suggesting it does not explain additional unique variance in performance beyond the other predictors included in the model.

Summary of Key Findings

The principal findings of this investigation can be summarized as follows. Motor competence demonstrated a strong positive association with breaststroke swimming performance ($r = .62$), supporting Hypothesis 1. The composite motor competence score significantly predicted breaststroke outcomes, accounting for 38.0% of the performance variance. When disaggregated into component scores, coordination and balance emerged as the dominant predictors, collectively explaining an additional 8.9% of

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variance beyond the composite score, thereby supporting Hypothesis 2. Agility contributed a small but statistically significant predictive increment, while bilateral integration did not independently predict breaststroke performance after accounting for the other components.

DISCUSSION

This study investigated the predictive validity of motor competence in relation to breaststroke swimming proficiency among undergraduate physical education students at Sekolah Tinggi Olahraga dan Kesehatan Bina Guna, Indonesia. The findings furnish robust evidence that motor competence represents a substantive and statistically significant determinant of breaststroke performance, as the composite motor competence score accounted for 38.0% of the variance in swimming outcomes. This observation accords with the theoretical model advanced by Stodden et al. (2008), which asserts that motor competence forms the indispensable neuromuscular groundwork for mastering intricate, sport-specific motor patterns.

The magnitude of the observed relationship (r = .62) is consistent with and extends previous research. Barnett et al. (2016) reported moderate-to-strong associations between fundamental movement skills and subsequent sport performance in their systematic review, though their analysis primarily encompassed land-based physical activities. Moreno-Murcia et al. (2020) documented significant correlations between motor coordination and swimming performance in youth athletes (r = .47–.55), and the present study's somewhat stronger association may reflect the greater biomechanical complexity of breaststroke compared to the freestyle strokes examined in their investigation. The breaststroke's unique requirement for simultaneous bilateral limb coordination, rhythmic timing, and dynamic postural control likely amplifies the relevance of underlying motor competence (Rezki et al., 2025; Seifert et al., 2010).

The hierarchical regression analysis revealed that coordination (β = .41) and balance (β = .29) emerged as the most influential individual predictors of breaststroke performance, collectively explaining a substantial proportion of outcome variance. This finding is theoretically coherent, as breaststroke technique demands precise inter-limb coordination for the synchronization of arm pull, whip kick, and glide phases, as well as continuous dynamic balance maintenance during the cyclical body position changes inherent in the stroke (Nicol et al., 2022; Sinaga et al., 2025). The primacy of coordination as a predictor corroborates the work of Mostaert et al. (2022), who demonstrated that coordination-intensive motor competence domains exhibit the strongest associations with complex sport skill performance.

Agility contributed a smaller but statistically significant predictive increment (β = .14, p = .042), suggesting that rapid directional control and neuromuscular responsiveness play a supporting role in the execution of the breaststroke's multi-planar movement pattern. In contrast, bilateral integration did not independently predict breaststroke performance after accounting for the other motor competence components (β = .08, p = .216). This null finding may reflect the substantial shared variance between bilateral integration and coordination (r = .48), indicating that the unique predictive information captured by bilateral integration is largely subsumed within the coordination construct.

A particularly noteworthy contribution of this study is its extension of the motor competence–sport performance relationship to a higher education context within Southeast Asia. Previous investigations have predominantly examined pediatric and adolescent samples in Western educational settings (Karkada et al., 2022; Suud et al., 2024). The present findings demonstrate that motor competence retains substantial predictive validity for complex sport skill acquisition in young adulthood, supporting the developmental continuity hypothesis articulated by (Stodden et al., 2008). This has important implications for physical education programs at the tertiary level, where students are expected to acquire professional-level sport competencies.

From a pedagogical standpoint, the results suggest that implementing systematic motor competence screening prior to formal swimming instruction could enable educators to identify students who may benefit from supplementary motor skill preparatory programs. Targeted interventions focusing on coordination and balance enhancement—such as structured dryland exercises incorporating dynamic balance challenges, agility ladder drills, and bilateral coordination tasks—could potentially improve subsequent swimming skill acquisition efficiency (D'Hondt et al., 2014; Hardy et al., 2009). Furthermore, differentiated instructional approaches based on motor competence profiles may reduce performance disparities and promote more equitable learning outcomes.

Several limitations should be acknowledged when interpreting these findings. First, the study employed a single-institution, purposive sample from STOK Bina Guna, which may constrain the generalizability of results to other higher education settings, demographic populations, or cultural contexts. Second, the cross-sectional predictive design precludes definitive causal inferences regarding the motor competence–swimming performance relationship; prospective longitudinal designs would strengthen causal interpretations. Third, the absence of biomechanical analysis (e.g., kinematic or kinetic assessment) limited the capacity to identify the precise movement mechanisms through which motor competence influences breaststroke execution. Fourth, potential confounding variables such as water anxiety, prior informal aquatic experience, and motivational factors were not systematically controlled, though inclusion/exclusion criteria partially mitigated these concerns. Finally, the observational assessment of breaststroke performance, while psychometrically validated, is inherently subject to subjective evaluator judgment, despite the high inter-rater reliability coefficients obtained.

CONCLUSION

This study provides robust empirical evidence that motor competence serves as a significant and meaningful predictor of breaststroke swimming learning outcomes among undergraduate physical education students. The composite motor competence score accounted for 38.0% of the variance in breaststroke performance, representing a large effect size with clear practical significance for physical education pedagogy. Among the constituent motor competence domains, coordination and balance emerged as the primary predictors, highlighting their critical roles in the acquisition of the biomechanically complex breaststroke technique.

These findings reinforce the theoretical proposition that fundamental motor competence constitutes a prerequisite scaffold for the efficient learning of specialized sport skills and extend its empirical validation to the aquatic learning domain within higher education settings. The results carry direct implications for curriculum design in physical education programs, specifically supporting the integration of motor competence assessment and targeted preparatory motor skill training as antecedent components of swimming instruction.

Based on the findings, the following recommendations are proposed: (1) Physical education programs at higher education institutions should incorporate systematic motor competence screening prior to advanced swimming courses to identify students requiring additional preparatory support. (2) Curriculum designers should integrate structured dryland motor skill enhancement modules—emphasizing coordination, balance, and agility—as a preparatory phase preceding formal swimming instruction. (3) Future research should employ multi-center, longitudinal designs with biomechanical instrumentation to elucidate the mechanistic pathways linking motor competence to swimming skill acquisition. (4) Comparative studies across diverse swimming strokes (freestyle, backstroke, butterfly) are warranted to determine whether the predictive pattern observed for breaststroke generalizes to other aquatic skills. (5) Intervention studies evaluating the efficacy of motor competence enhancement programs for improving swimming learning outcomes should be prioritized as a subsequent research direction.

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CONFLICT OF INTEREST

The authors declare that no competing financial interests, personal relationships, or institutional affiliations exist that could have influenced the design, execution, analysis, or reporting of this research.

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