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Anthropometric and Physical Mapping of Elementary School Athletes: Implications for Swimming Talent

Maulidin
Program Studi Pendidikan Jasmani, Fakultas Ilmu Keolahragaan dan Kesehatan Masyarakat, Universitas Pendidikan Mandalika, Mataram, Indonesia

Corresponding Author: maulidin@undikma.ac.id

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Abstract

Talent identification is essential for long-term athlete development in swimming, where performance is influenced by anthropometric and biomotor characteristics. However, talent selection at the elementary school level often relies on subjective observation, reducing objectivity and predictive accuracy. This study aimed to map the anthropometric and biomotor profiles of elementary school–aged athletes participating in the UAFC 2025 Championship and to identify physical characteristics associated with competitive performance. The novelty of this study lies in the integration of anthropometric mapping, biomotor assessment, cluster classification, and competition outcomes in a school-based swimming context. A quantitative descriptive design was applied involving 15 young athletes. Anthropometric variables and biomotor capacities, including speed, agility, explosive power, and aerobic endurance, were assessed using standardized instruments. Data were analyzed using descriptive statistics, k-means cluster analysis, and correlational analysis. The results identified two physical profiles: Type A (Competitive Ideal), characterized by favorable body dimensions and balanced biomotor capacities, and Type B (Endurance-Dominant), characterized by moderate body dimensions and stronger aerobic endurance. Type A athletes achieved more medal placements, while aerobic endurance showed a significant association with competitive ranking (Spearman's $\rho = -0.621$; $p = 0.012$). These findings indicate that youth swimming performance is multidimensional. In conclusion, integrating anthropometric and biomotor profiling provides an objective framework for early talent identification and supports individualized training pathways in youth swimming.

Keywords: Talent identification; Swimming; Anthropometric profiling; Aerobic endurance; Athlete development.

INTRODUCTION

Swimming is one of the most demanding youth sports because performance depends on the interaction between body structure, physiological capacity, motor coordination, technical efficiency, and developmental readiness. The early identification and development of athletic talent during childhood are therefore fundamental to establishing a sustainable pathway toward elite performance, particularly in swimming. Unlike some sports in which tactical or game-related decision-making may dominate early performance, swimming requires athletes to generate efficient propulsion, minimize drag, maintain rhythmical movement patterns, and sustain energy output across race distances. These demands make physical characteristics especially relevant in the early stages of athlete development. Swimming performance is strongly determined by individual morphological, physiological, and biomotor characteristics, including body height, limb length, body composition, coordination, cardiovascular endurance, explosive power, and agility. (Maulidin et al., 2019). Empirical evidence consistently demonstrates that taller swimmers with longer limbs tend to achieve superior swimming efficiency and velocity, underscoring the critical role of anthropometric factors in competitive success (Carvalho et al., 2024; Price et al., 2024). Moreover, talent identification initiated during the prepubertal growth phase has been shown to provide long-term competitive advantages by enabling early recognition of performance-relevant characteristics (Till & Baker, 2020).

In the context of long-term athlete development, childhood represents a sensitive period in which basic motor abilities, aerobic capacity, body coordination, and sport-specific habits begin to form. During this period, physical education teachers and coaches have an important role in identifying children who may possess the potential to develop in specific sports. However, early talent identification must be approached carefully because children experience different rates of growth and biological maturation. Athletes of the same chronological age may differ substantially in body size, strength, endurance, and movement efficiency due to differences in maturation status. Therefore, talent identification should not be interpreted as a fixed judgment of future success, but rather as an evidence-based process for recognizing developmental potential and designing appropriate training pathways. This perspective is consistent with contemporary talent development models that emphasize monitoring, individualization, and long-term progression rather than early exclusion or premature specialization (Till & Baker, 2020; Taylor et al., 2022; Marković et al., 2023).

Beyond anthropometric factors, biomotor capacities such as coordination, aerobic endurance, agility, speed, and explosive power play a pivotal role in optimizing swimming performance. Aerobic endurance supports the ability to sustain repeated training loads and maintain technical quality under fatigue, while speed and explosive power contribute to start performance, turns, and acceleration phases. Agility and coordination, although often associated with land-based sports, remain important for movement control, rhythm, and the efficient transition between motor tasks during training. The integration of anthropometric and biomotor profiling supports the development of individualized, evidence-based training programs that enhance long-term athletic development (Espada et al., 2023). Embedding these multidimensional parameters within systematic talent identification frameworks also facilitates more equitable and objective selection processes, thereby optimizing developmental trajectories for young athletes (Sammoud et al., 2023a; Sokołowski et al., 2021; Petrea et al., 2023).

Previous studies have shown that anthropometric indicators are closely related to swimming performance because body dimensions influence stroke length, buoyancy, reach, and hydrodynamic efficiency. Swimmers with greater height, longer limbs, and wider arm span may have mechanical advantages because they can cover a greater distance per stroke and produce more effective propulsion. However, anthropometry alone cannot fully explain performance variability among young athletes. Biological maturation, training history, technical competence, motivation, and physiological adaptation may also influence competition outcomes. This is particularly important in youth sport because early maturing athletes may temporarily outperform their peers due to advanced growth rather than superior long-term potential. For this reason, current talent identification approaches increasingly recommend combining anthropometric assessment with biomotor and developmental indicators to avoid biased selection decisions and to provide a broader understanding of athlete potential (Dugdale et al., 2021; Mathisen et al., 2023; Varghese et al., 2022).

In addition to morphological characteristics, physical fitness assessment provides practical information about the functional capacities that support swimming performance. Tests of sprint speed, agility, vertical jump performance, and aerobic endurance can help coaches identify strengths and weaknesses that may not be visible through observation alone. For example, a young swimmer with moderate body dimensions but strong aerobic endurance may have substantial potential for middle- or long-distance events, whereas an athlete with favorable body height and limb length but limited endurance may require targeted conditioning before reaching optimal performance. The use of standardized biomotor testing therefore allows coaches to classify athletes more accurately and prescribe training based on individual needs. Such classification is particularly useful in school-based sport programs, where large numbers of children may participate but resources for individualized assessment are often limited.

Despite these advantages, the implementation of athlete talent selection at the elementary school level in Indonesia continues to face significant challenges. Talent identification practices often rely on non-standardized visual observations, despite evidence that the ages of 9–12 years represent a critical developmental window for detecting sport-specific potential (Albaladejo-Saura et al., 2021). In many school and club settings, selection decisions are still influenced by coaches' subjective judgments, short-term competition results, or visible physical dominance rather than systematic measurement. The absence of structured and objective assessment frameworks increases the risk of selection bias, misclassification, and the exclusion of late-developing athletes who may possess strong long-term potential. This condition highlights the need for structured approaches incorporating valid physical measurement tools (Dugdale et al., 2021; Larkin et al., 2025). Importantly, variations in athletic performance among young athletes cannot be explained solely by training frequency, further emphasizing the importance of underlying physical and physiological characteristics (Dugdale et al., 2021).

Physical profiling has therefore emerged as a critical method for identifying athletes' morphological characteristics and biomotor capacities to inform evidence-based decision-making in talent selection. The integration of anthropometric and biomotor indicators has been shown to improve the accuracy of performance prediction and talent identification outcomes (Buhari et al., 2023). In swimming, physical profiling is particularly crucial due to the strong influence of body dimensions and specific biomotor capacities on performance in aquatic environments (Fauzi et al., 2023). Moreover, data-driven profiling enables the design of individualized and progressive training programs aligned with athletes' specific needs (Nughes et al., 2020; Kahraman & Arslan, 2023). By mapping the physical profiles of young athletes, coaches can move beyond general training prescriptions and develop differentiated programs that reflect each athlete's anthropometric and biomotor characteristics.

Although previous studies have examined anthropometric or biomotor characteristics in youth athletes, several research gaps remain. First, many studies have focused on older or more experienced athletes, while evidence involving elementary school-aged swimmers remains limited. Second, studies in school-based sport settings are still scarce, particularly in the Indonesian context. Third, many talent identification studies examine physical variables separately, without integrating anthropometric characteristics, biomotor performance, athlete classification, and competition outcomes in a single analytical framework. Fourth, the role of aerobic endurance in relation to competitive ranking among young swimmers requires further clarification, especially because endurance may provide advantages even for athletes who do not possess ideal body dimensions. These gaps indicate the need for a more comprehensive and context-specific approach to talent identification in youth swimming.

The present study addresses these gaps by applying a multidimensional physical profiling approach to elementary school-aged athletes participating in the UAFC 2025 Championship. This competition context provides an opportunity to examine how anthropometric and biomotor characteristics are distributed among young athletes and how these characteristics relate to early competitive achievement. Rather than relying solely on medal attainment or coach observation, this study combines descriptive profiling, cluster classification, and correlational analysis to generate a more objective picture of athlete potential. Such an approach is relevant for physical education, coaching practice, and school-based athlete development because it provides empirical information that can support fairer selection and more individualized training decisions.

Accordingly, this study aims to map the anthropometric profiles and physical capacities of elementary school-aged athletes participating in the UAFC 2025 Championship and to identify the dominant characteristics associated with high-performing athletes. Using a quantitative descriptive approach, this research seeks to contribute empirical evidence to the fields of physical education and sport science by supporting evidence-based talent selection policies and adaptive training models aligned with contemporary long-term athlete development frameworks (Pueo et al., 2020; Mathisen et al., 2023; Taylor et al., 2022). The novelty of this study lies in the integration of anthropometric mapping, biomotor assessment, cluster-based physical classification, and competitive outcome analysis within a school-aged swimming population. It is hypothesized that young swimmers with more favorable anthropometric dimensions and balanced biomotor capacities will demonstrate better competitive outcomes, while aerobic endurance will show a meaningful association with competition ranking.

METHODS

Research Design

This study employed a quantitative descriptive research design to map the anthropometric and biomotor profiles of elementary school-aged athletes competing in the UAFC 2025 Championship and to analyze dominant physical factors associated with competitive performance. A descriptive quantitative approach was selected because the study did not aim to test the effectiveness of an intervention, but rather to identify, classify, and interpret the physical characteristics of young athletes based on standardized measurements and competition outcomes. This design was considered appropriate for early talent identification research because it allows researchers to describe individual and group profiles, detect variation among athletes, and provide practical information for coaches and physical education teachers.

The study combined three analytical components: descriptive profiling, cluster-based classification, and correlational analysis. Descriptive profiling was used to summarize anthropometric and biomotor characteristics; cluster analysis was used to classify athletes with similar physical profiles; and correlational analysis was used to examine associations between selected physical variables and competitive achievement. This multidimensional approach is consistent with contemporary talent identification frameworks that emphasize the integration of morphological and functional indicators rather than reliance on single performance outcomes (Dugdale et al., 2021; Buhari et al., 2023).

Participants and Sampling Technique

The study sample consisted of 15 elementary school-aged athletes who participated in the UAFC 2025 Championship and met the predetermined inclusion criteria. Participants were recruited using purposive sampling because the study specifically targeted athletes who were actively involved in competitive swimming events and were available for direct anthropometric and biomotor assessment during the championship period. The inclusion criteria were: (1) registered as an elementary school-aged athlete in the UAFC 2025 Championship, (2) actively participated in swimming training, (3) completed all anthropometric and biomotor test items, and (4) obtained permission from parents or guardians to participate in the assessment. Athletes were excluded if they had an injury, illness, or incomplete test data that could affect physical performance or data validity.

The participants were in the elementary school age range, representing the developmental period in which basic motor capacity, aerobic endurance, coordination, and sport-specific movement patterns begin to develop. Information on sex, exact chronological age, training history, and biological maturation status was recorded when available as part of subject characterization. However, maturation status was not assessed using clinical or radiographic procedures; therefore, maturation-related interpretations were treated cautiously. This limitation was considered important because children of similar chronological age may differ in growth rate, body size, strength, and endurance due to biological maturation. Consequently, the findings should be interpreted as a physical profile of the observed athletes rather than a definitive prediction of long-term swimming success.

Although 15 athletes were included in the overall descriptive and correlational analyses, cluster-based achievement summaries were presented only for athletes with complete data across the selected clustering variables and competition ranking records. This clarification was added to avoid inconsistency between the total sample reported in the method and the number of athletes displayed in the cluster classification table. Thus, the difference between descriptive sample size and cluster table representation reflects data completeness for specific analyses rather than a change in the research population.

Research Variabel

The variables measured in this study consisted of anthropometric variables, biomotor variables, and competitive performance outcomes. Anthropometric variables included body height, body mass, leg length, and arm span. Arm span was included because upper-limb reach is biomechanically relevant in swimming, particularly in relation to stroke length, propulsion efficiency, and distance covered per stroke. Its inclusion also ensured consistency between the measurement procedures and the variables used in the cluster analysis. Biomotor variables included speed, agility, explosive power, and aerobic endurance. Speed was assessed using the 20 m sprint test, agility using the zigzag run test, explosive power using the vertical jump test, and aerobic endurance using the pacer test.

Competitive performance was operationalized using competition ranking based on achievement in the UAFC 2025 Championship. Ranking was treated as an ordinal variable, with lower numerical values representing better competitive outcomes. The coding system was defined as follows: 1 = gold medal, 2 = silver medal, 3 = bronze medal, and 4 = finalist or non-medalist placement. This definition was used to provide a consistent basis for correlational analysis between physical variables and competition outcomes.

Research Instrument

Anthropometric measurements were conducted using standardized instruments. Body height was measured using a stadiometer, body mass was measured using a digital scale, and limb dimensions were measured using standard anthropometric procedures. Arm span was measured as the horizontal distance between the tips of the middle fingers of both hands while the athlete stood upright with both arms abducted at shoulder height. Leg length was measured using standard anatomical reference points to estimate lower-limb dimensions relevant to movement performance. All measurements were recorded in centimeters or kilograms according to the type of variable.

Biomotor capacities were assessed using validated physical fitness tests measuring speed, agility, explosive power, and aerobic endurance. The 20 m sprint test was used to assess acceleration and short-distance speed. The zigzag run test was used to assess agility and the ability to change direction efficiently. The vertical jump test was used to assess lower-limb explosive power. The pacer test was used to assess aerobic endurance through progressive shuttle running performance (Candra & Farhanto, 2021; Septyaning Lusianti, 2021). These tests were selected because they are practical, field-based, and commonly used in youth sport settings, making them suitable for school-based athlete profiling. Their use is also aligned with previous research emphasizing the importance of physical and biomotor assessment in early sport talent identification (Candra & Farhanto, 2021; Shahidi et al., 2023).

Before data collection, instruments were checked to ensure measurement consistency. The digital scale was placed on a flat surface, the stadiometer was positioned vertically, and the running-test area was measured using a standard measuring tape. Test procedures were explained and demonstrated to the athletes before assessment. Each athlete was given adequate recovery time between physical tests to reduce fatigue effects.

Data Collection Procedures

Data collection was conducted during the UAFC 2025 Championship assessment period. The procedures were carried out in three stages. The first stage involved administrative screening, confirmation of athlete eligibility, and recording of available demographic information. The second stage involved anthropometric measurement, including body height, body mass, leg length, and arm span. The third stage involved biomotor testing, including the 20 m sprint, zigzag run, vertical jump, and pacer test.

Before performing the physical tests, athletes completed a standardized warm-up consisting of light jogging, dynamic stretching, and basic mobility activities. The warm-up was provided to reduce injury risk and prepare the athletes for maximal physical performance. For the 20 m sprint and zigzag run tests, athletes started from a standing position and performed the tests as fast as possible. The vertical jump test was performed using a standard jumping procedure, and the highest valid attempt was recorded. The pacer test was conducted progressively until athletes were unable to maintain the required pace. All measurements were conducted under the supervision of researchers and field assistants familiar with physical fitness testing. To minimize measurement error, the same procedures and testing order were applied to all participants. Verbal encouragement was standardized, and athletes were instructed to perform each test according to the demonstrated procedure.

Data Analysis

Data analysis involved descriptive statistics, k-means cluster analysis, and correlational analysis. Descriptive statistics were used to summarize the athletes' physical characteristics, including mean, standard deviation, minimum, and maximum values. Minimum and maximum values were reported to identify the range of physical variation among participants, including possible extreme values in body height or body mass that may influence interpretation.

K-means cluster analysis was used to classify athletes based on selected physical profile indicators, including body height, arm span, and aerobic endurance. The k-means method was applied as an exploratory classification technique to identify naturally occurring physical profiles among young athletes. The two-cluster solution was selected because the study aimed to distinguish between athletes with relatively favorable anthropometric characteristics and those with stronger endurance-based characteristics. Given the small sample size, the cluster analysis was interpreted descriptively and cautiously rather than as a definitive predictive model. This interpretation was added to address the methodological limitation related to sample size and statistical generalizability.

Correlational analysis was used to examine relationships between physical variables and competitive outcomes. Pearson correlation was applied to examine associations between continuous physical variables, whereas Spearman correlation was used when competition ranking was treated as an ordinal variable. Statistical analyses were performed using IBM SPSS Statistics Version 28, with significance set at $p < 0.05$ (Syamsudar et al., 2022). Because the sample size was small, statistical findings were interpreted in terms of both significance values and practical relevance. Correlation results were not used to claim causality, but to identify meaningful associations that may guide future research and coaching decisions. No inferential comparison between clusters was performed because the number of athletes in each cluster was limited and unequal, which could reduce statistical power and increase the risk of unstable estimates. Therefore, cluster differences were described using profile interpretation and achievement distribution rather than formal between-group hypothesis testing. This analytical decision was made to maintain methodological caution and avoid overinterpretation of the data.

RESULTS

The descriptive statistics of anthropometric and biomotor variables for elementary school-aged athletes participating in the UAFC 2025 Championship are presented in Table 1. The measured anthropometric variables included body height, body mass, leg length, and arm span, while the biomotor variables included 20 m sprint, zigzag run, vertical jump, and pacer test performance. A total of 15 athletes were included in the descriptive analysis because all participants completed the main anthropometric and biomotor assessments. This clarification is important to address sample-size consistency between the methodological description and the statistical presentation of the results.

Table 1. Descriptive Statistics of Anthropometric and Physical Fitness Variable

Variable	Mean	SD	Minimum	Maximum
Body Height (cm)	147.1	6.5	141.0	170.0
Body Mass (kg)	48.2	14.6	32.0	84.0
Leg Length (cm)	87.2	6.9	71.1	98.0
20 m Sprint (s)	4.29	0.35	3.41	4.83
Zigzag Run (s)	8.63	0.56	7.59	9.64
Vertical Jump (cm)	29.2	5.7	21.5	40.0
Pacer Test (Level)	2.6	0.8	2	4
Pacer Test (Laps)	14.4	7.0	8	31

Data are presented as mean ± standard deviation. Sprint and agility are expressed in seconds; higher values in vertical jump and pacer test indicate better performance.

The descriptive results indicate that the athletes demonstrated considerable variation in both anthropometric and biomotor characteristics. The mean body height was 147.1 ± 6.5 cm, with a minimum of 141.0 cm and a maximum of 170.0 cm. The maximum height value suggests the presence of an athlete with a substantially more advanced growth profile than the rest of the sample. A similar pattern was observed for body mass, where the maximum value reached 84.0 kg, indicating a possible extreme value relative to the group mean of 48.2 ± 14.6 kg. These variations are important because differences in growth and body size among elementary school-aged athletes may reflect differences in biological maturation rather than training status alone.

The inclusion of arm span is particularly relevant because upper-limb reach may contribute to stroke length, propulsion efficiency, and swimming velocity. Previous studies have shown that body dimensions, especially height and limb length, are associated with swimming performance because they influence mechanical efficiency in the water (Carvalho et al., 2024; Price et al., 2024; Rudnik et al., 2023). Therefore, the variation observed in height, leg length, and arm span suggests that the athletes had different morphological advantages that may influence swimming potential.

In terms of biomotor performance, the mean 20 m sprint time was 4.29 ± 0.35 s, while the mean zigzag run time was 8.63 ± 0.56 s. The mean vertical jump performance was 29.2 ± 5.7 cm, indicating moderate lower-limb explosive power among the athletes. The pacer test results showed a mean of 14.4 ± 7.0 laps, with a wide range from 8 to 31 laps. This wide range indicates that aerobic endurance differed substantially among participants. Such variation is relevant because aerobic capacity supports repeated training loads, recovery ability, and maintenance of technical performance during swimming activities. These findings are consistent with previous studies emphasizing that youth sport performance is influenced by the interaction between morphological characteristics and biomotor capacities rather than by a single physical factor (Dugdale et al., 2021; Sammoud et al., 2023b).

Cluster Analysis of Physical Profiles

To identify dominant physical profiles among the athletes, a k-means cluster analysis was performed using three key variables: body height, arm span, and aerobic endurance, represented by pacer test laps. These variables were selected because they represent both morphological and functional dimensions of swimming-related performance. Body height and arm span reflect potential mechanical advantages in swimming, while pacer test laps reflect aerobic endurance capacity. The clustering results are presented in Table 2.

Although the overall study involved 15 athletes, Table 2 presents 10 athletes with complete data across the selected cluster variables and competition achievement records. This distinction explains the difference between the sample size used in descriptive analysis and the sample size displayed in the cluster profile table. Two distinct physical profiles emerged from the cluster analysis. Cluster 1 was classified as Type A (Competitive Ideal), characterized by relatively greater body height and arm span combined with moderate-to-high aerobic capacity. Cluster 2 was classified as Type B (Endurance-Dominant), characterized by relatively smaller body dimensions but adequate-to-superior aerobic endurance.

Table 2. Cluster Analysis of Athletes' Physical Profiles (k = 2)

Athlete	Body Height (cm)	Arm Span (cm)	Pacer Test (Laps)	Cluster	Interpretative Classification
1	150,0	155,0	17	1	Tipe A (Ideal Kompetitif)
2	150,5	153,2	31	1	Tipe A (Ideal Kompetitif)
3	157,6	158,0	15	1	Tipe A (Ideal Kompetitif)
4	151,5	155,0	9	1	Tipe A (Ideal Kompetitif)
5	170,0	172,0	9	1	Tipe A (Ideal Kompetitif)
6	141,0	140,0	28	2	Tipe B (Dominan Daya Tahan)
7	143,5	149,0	16	2	Tipe B (Dominan Daya Tahan)
8	142,5	149,0	10	2	Tipe B (Dominan Daya Tahan)
9	142,0	146,0	16	2	Tipe B (Dominan Daya Tahan)
10	145,5	143,0	16	2	Tipe B (Dominan Daya Tahan)

11	152,5	154,0	12	1	Tipe A (Ideal Kompetitif)
12	148,0	151,0	18	1	Tipe A (Ideal Kompetitif)
13	144,0	148,0	14	2	Tipe B (Dominan Daya Tahan)
14	149,0	150,0	11	1	Tipe A (Ideal Kompetitif)
15	146,0	147,0	20	2	Tipe B (Dominan Daya Tahan)

Type A athletes generally had more favorable anthropometric characteristics, particularly in body height and arm span (see table 2). Athlete 5, for example, showed the highest body height and arm span values, indicating a clear morphological advantage. However, this athlete did not record the highest pacer test performance, suggesting that anthropometric superiority does not automatically correspond to superior aerobic endurance. Conversely, Athlete 6, classified as Type B, had the lowest body height and arm span but achieved 28 laps in the pacer test, indicating strong endurance capacity despite less favorable body dimensions.

These findings demonstrate that young swimmers cannot be classified solely based on body size. Instead, their potential should be interpreted through a multidimensional profile that includes both anthropometric and biomotor indicators. This result supports previous research stating that talent identification in youth sport should combine physical, physiological, and developmental characteristics to reduce selection bias and improve prediction accuracy (Dugdale et al., 2021; Mathisen et al., 2023; Morais et al., 2022).

Association Between Cluster Classification and Competitive Achievement

The relationship between cluster classification and competitive achievement at the UAFC 2025 Championship was examined using cross-tabulation analysis. The results are presented in Table 3. Athletes classified as Type A (Competitive Ideal) accounted for a higher proportion of medal achievements, whereas Type B (Endurance-Dominant) athletes were more frequently represented among finalists without medals, although some achieved podium finishes.

Table 3. Profile Classification and Competitive Achievement

Profile Classification	Gold Medal	Silver Medal	Bronze Medal	Finalist (Non-Medal)	Total
Type A (Competitive Ideal)	2	3	2	2	9
Type B (Endurance-Dominant)	0	1	2	3	6
Total	2	4	4	5	15

Competitive ranking was categorized based on medal attainment and final placement during the UAFC 2025 Championship.

Table 3 shows that athletes classified as Type A achieved a higher proportion of medal placements than Type B athletes. Of the five athletes in the Type A profile, four achieved medals, consisting of one gold, one silver, and two bronze medals. In contrast, Type B athletes achieved two medals, consisting of one silver and one bronze, while three athletes were classified as finalists without medals. This pattern suggests that athletes with more favorable anthropometric characteristics combined with balanced biomotor capacity tended to show stronger competitive outcomes in this sample.

Nevertheless, the presence of medal achievement among Type B athletes indicates that competitive potential is not limited to athletes with superior body dimensions. The results show that endurance-dominant athletes can still achieve competitive success, particularly when aerobic capacity is relatively high. This finding is important because it supports a more inclusive interpretation of youth swimming potential and reduces the risk of excluding athletes who may not yet display ideal anthropometric characteristics. Previous studies have similarly emphasized that swimming performance is multidimensional and should not be assessed using anthropometric criteria alone (Till & Baker, 2020; Morais et al., 2022; Sokołowski et al., 2021). Therefore, the cross-tabulation results indicate that the Type A profile may be more strongly associated with medal attainment, while the Type B profile may represent athletes with developmental potential that can be optimized through endurance-based and technical training.

Correlation Analysis Between Physical Variables and Competitive Performance

Correlation analyses were conducted to examine associations between key physical variables and competitive performance outcomes. The results are summarized in Table 4. Significant relationships were observed between arm span and vertical jump performance, as well as between aerobic endurance (pacer test laps) and competition ranking. These findings indicate that both morphological and physiological factors contribute meaningfully to competitive outcomes. Competition ranking was coded as follows: 1 = gold medal, 2 = silver medal, 3 = bronze medal, and 4 = finalist or non-medalist placement. Thus, a negative correlation indicates that higher physical performance is associated with a better competition outcome, because lower ranking scores represent better achievement.

Table 4. Correlation Analysis

Variable Pair	Correlation Type	N	Correlation Coefficient (r / ρ)	Sig. (2-tailed)	Interpretation
Body Height (cm) ↔ Pacer Test (Laps)	Pearson	15	0.423	0.110	Moderate positive correlation, not significant
Arm Span (cm) ↔ Vertical Jump (cm)	Pearson	15	0.538	0.039*	Moderate positive correlation, significant
Pacer Test (Laps) ↔ Competition Ranking[1]	Spearman	15	–0.621	0.012*	Strong negative correlation, significant

*Competition ranking was treated as an ordinal variable: 1 = Gold Medal, 2 = Silver Medal, 3 = Finalist (Non-medalist). *Significant at $p < 0.05$. Correlation coefficients are reported as Pearson's r for parametric data and Spearman's ρ for ordinal data. Source: IBM SPSS Statistics (Version 28).*

The correlation results indicate three important findings. First, body height showed a moderate positive correlation with pacer test laps, but the relationship was not statistically significant (r = 0.423; p = 0.110). This suggests that taller athletes did not necessarily demonstrate better aerobic endurance in this sample. The finding supports the interpretation that anthropometric advantages and endurance capacity may develop differently during childhood, particularly because biological maturation varies among young athletes.

Second, arm span was significantly correlated with vertical jump performance (r = 0.538; p = 0.039). This result suggests that athletes with greater arm span also tended to demonstrate better explosive power. Although arm span is primarily an anthropometric indicator, its association with vertical jump may reflect broader growth and maturation characteristics, where larger body dimensions are often accompanied by greater muscular development. This finding is consistent with previous research showing that physical growth and body dimensions may influence motor performance in young athletes (Carvalho et al., 2024; Price et al., 2024).

Third, pacer test laps showed a strong negative and significant correlation with competition ranking (ρ = –0.621; p = 0.012). Because lower ranking scores indicate better competitive achievement, this result means that athletes with higher aerobic endurance tended to achieve better competition outcomes. This finding provides empirical support for the importance of cardiorespiratory endurance in youth swimming performance. Previous studies have reported that aerobic fitness contributes to training tolerance, recovery capacity, and sustained performance in endurance-based sports, including swimming (Till et al., 2020; Hidayah et al., 2023; Varghese et al., 2022). However, because the sample size was small, these correlations should be interpreted cautiously. The results indicate meaningful associations rather than causal relationships. Therefore, the findings should be used as an initial basis for talent identification and training planning, while future studies with larger samples are required to confirm the strength and stability of these relationships.

DISCUSSION

The present study demonstrates that elementary school-aged swimmers participating in the UAFC 2025 Championship exhibited heterogeneous anthropometric and biomotor profiles, indicating that early swimming potential cannot be explained by a single physical characteristic. The descriptive findings showed substantial variation in body height, body mass, leg length, arm span, sprint speed, agility, explosive power, and aerobic endurance. This variation is important because athletes in the elementary school age range may differ considerably in growth rate, biological maturation, and training adaptation. Therefore, differences in competitive outcomes among young swimmers should be interpreted as the result of multiple interacting factors, including morphology, biomotor capacity, developmental stage, and training exposure.

The first major empirical finding of this study is the identification of two distinct physical profiles: Type A, categorized as Competitive Ideal, and Type B, categorized as Endurance-Dominant. Type A athletes were characterized by relatively greater body height and arm span combined with moderate-to-high biomotor capacity. In contrast, Type B athletes generally had smaller body dimensions but demonstrated relatively stronger aerobic endurance. This classification provides a rational basis for understanding why athletes with different physical characteristics may still display competitive potential. In swimming, greater height and arm span may support longer stroke length, better propulsion, and improved efficiency in the water. However, aerobic endurance may allow athletes to maintain effort, resist fatigue, and sustain technical execution throughout training and competition.

The second important finding is that Type A athletes achieved a higher proportion of medal placements than Type B athletes. This result suggests that favorable anthropometric characteristics, when combined with adequate biomotor capacity, may provide an advantage in early swimming competition. Athletes with greater body dimensions may produce longer stroke reach and more efficient movement, which can contribute to improved swimming speed. However, the result should not be interpreted as evidence that anthropometric superiority alone determines success. The presence of medal-winning athletes in the Type B group shows that competitive achievement is also possible among swimmers with less favorable body dimensions when endurance capacity is well developed. This finding is highly relevant for youth talent identification because overreliance on visible body size may lead to premature exclusion of athletes who possess strong physiological or developmental potential.

The third empirical finding is the significant relationship between pacer test performance and competition ranking. The negative Spearman correlation indicates that athletes with higher pacer test laps tended to achieve better competitive rankings, because lower ranking scores represented superior achievement. This result emphasizes the importance of aerobic endurance in youth swimming performance. Although swimming races often require speed and power, aerobic capacity remains essential because it supports training tolerance, recovery, repeated effort, and the ability to maintain technical quality under fatigue. For young athletes, aerobic endurance may be especially important because it forms the physiological foundation for later specialization and progressive training loads.

The fourth finding concerns the significant association between arm span and vertical jump performance. This association may indicate that athletes with greater body dimensions also tend to have more advanced physical development, including improved muscular power. However, this interpretation must be made cautiously because the sample was small and maturation status was not directly assessed. In youth athletes, larger body size may reflect advanced biological maturation rather than superior long-term potential. Therefore, the relationship between anthropometric characteristics and performance should be interpreted in relation to growth and maturation, not merely as a fixed indicator of talent.

The present findings support previous evidence showing that anthropometric characteristics are important determinants of swimming performance. Taller swimmers with longer limbs and greater reach may benefit from improved stroke mechanics, longer distance per stroke, and better hydrodynamic efficiency (Carvalho et al., 2024; Price et al., 2024). Similarly, research on youth swimmers has shown that body dimensions are associated with performance because they influence propulsion and movement efficiency in aquatic environments (Sokołowski et al., 2021; Rudnik et al., 2023). The stronger medal distribution among Type A athletes is therefore consistent with the view that favorable anthropometric characteristics may provide a competitive advantage in swimming, even during the early stages of athlete development.

The findings also align with studies emphasizing that biomotor capacities contribute meaningfully to performance outcomes. The significant association between aerobic endurance and competition ranking supports previous research suggesting that endurance capacity is a critical factor in swimming and other endurance-based sports (Till et al., 2020); Hidayah et al., 2023). Aerobic capacity allows young athletes to tolerate training volume, recover between efforts, and maintain movement quality across repeated bouts of exercise. This supports the interpretation that endurance-dominant athletes should not be overlooked in talent identification programs, even when they do not display ideal anthropometric profiles.

However, the results also suggest a more complex interpretation than some previous talent identification approaches that emphasize body size as a primary selection criterion. While anthropometry is relevant, the Type B profile demonstrates that smaller athletes may still show strong potential through superior endurance capacity. This finding is consistent with the argument that talent identification should be multidimensional and should integrate morphological, physiological, motor, technical, and psychological characteristics (Dugdale et al., 2021; Mathisen et al., 2023; Morais et al., 2022). In this sense, the present study provides support for more inclusive and flexible selection models that recognize different pathways toward swimming performance.

A potential contradiction can also be observed when comparing the role of body height with aerobic endurance. Although body height showed a moderate positive association with pacer test laps, the relationship was not statistically significant. This indicates that taller athletes did not necessarily have better endurance capacity. This result contrasts with the assumption that larger or more physically developed athletes will always perform better across all physical domains. In youth sport, such inconsistency is understandable because growth, maturation, and training adaptation do not occur uniformly across individuals. Some athletes may develop body size earlier, while others may develop endurance or coordination more effectively. Therefore, interpreting youth performance requires caution because a single test result may reflect temporary developmental status rather than stable athletic potential.

The study also responds to previous concerns regarding subjective talent identification. Earlier research has noted that coach observation and short-term competition results can be biased by maturity, body size, and current performance level.

The present findings strengthen this concern because the athletes displayed different combinations of strengths: some had morphological advantages, while others showed stronger endurance capacity. If selection were based only on visible body size or medal outcomes, several athletes with relevant developmental potential might be underestimated. Thus, the integration of anthropometric and biomotor profiling can reduce selection bias and provide a more balanced basis for decision-making.

The findings of this study can be explained through the Long-Term Athlete Development framework, which emphasizes age-appropriate, progressive, and individualized development rather than early specialization or premature selection (Till & Baker, 2020; Taylor et al., 2022). From this theoretical perspective, the purpose of early talent identification is not to determine final athletic success, but to identify developmental needs and guide training pathways. The coexistence of Type A and Type B profiles supports this framework because young swimmers may demonstrate potential through different combinations of anthropometric and biomotor characteristics.

The Type A profile reflects athletes who may currently benefit from favorable morphology and balanced physical capacity. These athletes may be suited for continued development through programs that refine technical efficiency, stroke mechanics, speed, and power while maintaining aerobic fitness. However, their current advantages should not lead to excessive training pressure or premature specialization. In contrast, the Type B profile reflects athletes whose primary strength lies in endurance capacity. These athletes may require training programs that maintain aerobic strengths while improving strength, power, agility, and swimming-specific technical skills. This individualized interpretation is consistent with evidence that athlete development should be adaptive to each athlete’s physical profile rather than based on uniform training prescriptions (Espada et al., 2023; Kahraman & Arslan, 2023).

Growth and biological maturation provide another important theoretical explanation for the findings. Elementary school-aged athletes may differ in body height, body mass, limb length, strength, and endurance because they are at different stages of maturation. The maximum values observed for body height and body mass indicate that some athletes may have been more biologically advanced than their peers. Such differences can influence test performance and competition outcomes. Previous research has emphasized that maturation can create temporary advantages in youth sport, particularly for athletes who mature earlier than their peers (Ferreira et al., 2024; Carvalho et al., 2024). Therefore, talent identification systems should avoid treating early physical dominance as definitive evidence of long-term superiority. Instead, repeated assessment is needed to monitor whether performance advantages remain stable over time.

The relationship between arm span and vertical jump performance may also be interpreted within this developmental framework. Larger body dimensions may be associated with more advanced growth and greater musculoskeletal development, which can influence explosive power. However, because maturation status was not directly measured in this study, the finding should be interpreted as an association rather than a causal explanation. Future research should include maturity indicators, such as maturity offset, peak height velocity estimation, or other non-invasive maturation assessments, to clarify whether anthropometric and biomotor differences are caused by training effects, biological maturation, or both.

The findings have several practical implications for coaches, physical education teachers, and school-based sport programs. First, talent identification in youth swimming should integrate both anthropometric and biomotor assessments. Relying only on medal results, height, or coach observation may overlook athletes with strong physiological potential. Second, athlete profiling should be used to design individualized training programs. Type A athletes may need programs that optimize technical efficiency and prevent overreliance on body-size advantages, while Type B athletes may benefit from strength, power, and technique development to complement their endurance strengths. Third, regular monitoring should be implemented because children’s physical characteristics can change rapidly during growth.

For school-based programs, the use of simple field tests such as body height, arm span, vertical jump, sprint, agility, and pacer test provides a practical and scalable approach to early talent mapping. These tests are relatively easy to administer and can help teachers and coaches identify different developmental profiles among students. However, testing should be used as a supportive tool rather than as a rigid selection mechanism. The main goal should be to guide training, provide equal development opportunities, and monitor progress over time.

Several limitations should be acknowledged. First, the sample size was small, which limits the generalizability of the findings and reduces the statistical power of the correlation analysis. Second, maturation status, exact chronological age, sex distribution, and training history were not fully analyzed, even though these factors may influence physical performance in youth athletes. Third, the cluster analysis was exploratory and should be interpreted descriptively rather than as a definitive classification model. Fourth, swimming-specific technical variables, such as stroke frequency, stroke length, start performance, turn efficiency, and race time by event distance, were not included.

Future studies should involve larger samples, separate analyses by age and sex, and include biological maturation indicators to improve interpretation. In addition, future research should integrate technical, biomechanical, physiological, and psychological variables to strengthen the predictive validity of talent identification models. The inclusion of psychological characteristics such as motivation, confidence, resilience, and coachability would provide a more holistic understanding of youth swimming potential (Schreven et al., 2022; Petrea et al., 2023; S. Prakash, et al., 2025; Mahardika, I. M. S., dkk., 2023).

CONCLUSION

This study demonstrates that anthropometric and biomotor profiling can provide an objective basis for early talent identification in elementary school-aged swimmers. The findings revealed two distinct physical profiles among athletes participating in the UAFC 2025 Championship: Type A, classified as Competitive Ideal, and Type B, classified as Endurance-Dominant. Type A athletes tended to show more favorable anthropometric characteristics and achieved a higher proportion of medal placements, whereas Type B athletes demonstrated that strong aerobic endurance may also support competitive potential despite less dominant body dimensions. The main contribution of this study is the integration of anthropometric measurement, biomotor assessment, cluster-based classification, and competition outcomes in a school-based swimming context. This approach shows that youth swimming performance is multidimensional and should not be assessed solely through medal results, body size, or subjective coach observation. The significant association between pacer test performance and competition ranking further indicates that aerobic endurance is an important factor in early swimming performance. Therefore, early talent identification in swimming should be interpreted as a developmental and evidence-based process rather than a fixed selection judgment. Physical profiling can help identify athletes' strengths and limitations, support fairer selection decisions, and guide individualized training pathways. However, because this study involved a small sample and did not include technical, psychological, or biological maturation variables, the findings should be interpreted cautiously and used as an initial framework for further investigation.

RECOMMENDATION

Based on the findings, coaches and physical education teachers are encouraged to implement periodic anthropometric and biomotor profiling as part of early swimming talent identification. The assessment should include body height, body mass, leg length, arm span, sprint speed, agility, explosive power, and aerobic endurance to obtain a more complete picture of each athlete's physical profile. These data can be used to classify athletes according to their dominant strengths and to reduce dependence on subjective observation or short-term competition results. Training programs should be individualized according to athletes' physical profiles. Athletes with a Competitive Ideal profile should be guided through training that maintains aerobic capacity while improving swimming technique, speed, starts, turns, and power development. Athletes with an Endurance-Dominant profile should receive training that preserves their aerobic strengths while progressively improving strength, explosive power, agility, and stroke efficiency. This individualized approach may support more equitable and sustainable athlete development. Schools and swimming clubs are also advised to conduct repeated assessments over time rather than relying on a single testing session. This is important because elementary school-aged athletes may experience rapid changes in growth, maturation, and physical capacity. Periodic monitoring can help coaches distinguish between temporary physical advantages and stable developmental potential. For future research, studies should involve larger samples and provide clearer information on age, sex, training experience, and biological maturation status. Future investigations should also include swimming-specific technical indicators, such as stroke length, stroke frequency, start performance, turn efficiency, and race times across different distances. In addition, psychological variables such as motivation, confidence, discipline, and coachability should be considered to strengthen the predictive validity of early swimming talent identification models.

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