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Place of Early Development and Elite Swimming Performance in Indonesia: Evidence from the National Championship

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ABSTRACT

Place of Early Development (PED) has emerged as an important factor influencing athlete development and competitive success across various sports. In Indonesia, substantial disparities in sports infrastructure and development resources between regions may contribute to unequal opportunities for talent development, particularly in elite swimming. This study aimed to examine the role of PED in shaping elite swimming performance using evidence from the 2026 Indonesian Aquatic National Championship. A retrospective observational design was employed using championship performance records from youth and senior swimmers. Athletes' developmental environments were classified according to their province of origin and regional Sports Development Index (SDI), while performance was standardized using World Aquatics points to enable comparisons across events and categories. The findings revealed a concentration of medal achievements and top performances among swimmers originating from provinces characterized by higher levels of sports development. Provinces located on Java Island accounted for the majority of championship success, reflecting the unequal distribution of facilities, coaching resources, and competitive opportunities. Nevertheless, several high-performing athletes emerged from lower-SDI regions, indicating that elite performance can also develop outside traditional sport development centers. These findings highlight the importance of developmental environments in shaping athlete progression and competitive outcomes. The study suggests that strengthening regional sport development systems and expanding access to high-quality training environments may contribute to a more equitable and sustainable pathway for elite swimming development in Indonesia.

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1. INTRODUCTION

The development of elite athletes is a complex and multidimensional process influenced by the interaction of individual characteristics, environmental conditions, and long-term development systems(Zhao et al., 2026). Contemporary talent identification and development (TID) frameworks emphasize that athletic success is not solely determined by innate ability, but also by the quality of developmental environments that provide opportunities for training, competition, and progression throughout an athlete's career (Wendling & Sagas, 2020). As a result, increasing attention has been directed toward understanding how environmental factors contribute to the emergence of elite performers across different sporting contexts.

Among the environmental factors that have received considerable attention in sport science, Place of Early Development (PED), often referred to as the birthplace effect, has emerged as an important determinant of athlete development (Tubi, 2026). Previous studies have demonstrated that developmental environments influence access to sport facilities, coaching expertise, social support systems, and competitive opportunities, all of which shape athletic progression from youth participation to elite performance (Brown et al., 2017). Athletes who develop within supportive sporting ecosystems are more likely to experience sustained participation and successful transitions through various stages of talent development (Henriksen et al., 2020).

The influence of developmental environments is particularly relevant in developing countries where substantial regional inequalities exist in sport infrastructure and resource allocation. Indonesia, as the world's largest archipelagic nation, faces persistent challenges in achieving equitable sport development across its provinces. Evaluations of the Sports Development Index (SDI) (Müller-frączek, 2021), which incorporates dimensions of open space availability, human resources, community participation, and physical fitness, have consistently revealed significant disparities between regions, particularly between Java and many outer-island provinces (Aubert et al., 2022). These disparities may affect the opportunities available to young athletes during critical stages of development and subsequently influence the distribution of elite sporting achievements across the country.

Within the context of competitive swimming, developmental environments are especially important because successful athlete development requires long-term access to specialized facilities, qualified coaching personnel, structured competition pathways, and scientific training support (Id et al., 2020). Swimming performance develops progressively across multiple stages of athlete maturation and is closely aligned with the principles of Long-Term Athlete Development (LTAD), which emphasize age-appropriate training, gradual performance progression, and sustainable athlete development rather than short-term competitive success (Costa et al., 2021). Consequently, disparities in developmental environments may have substantial implications for the ability of athletes to progress through these developmental stages and ultimately achieve elite performance.

In addition to environmental influences, previous research has identified factors such as the Relative Age Effect (RAE) as potential contributors to unequal developmental opportunities within sport systems (Lorenzo-calvo et al., 2021). Athletes born earlier within a selection year often benefit from temporary developmental advantages that may affect selection and participation opportunities during youth sport (Staub et al., 2024). However, growing evidence suggests that environmental conditions may play an equally important role in shaping long-term athlete development and competitive outcomes (Cobley et al., 2017). Therefore, understanding developmental environments remains essential for creating equitable and effective talent development systems.

Despite increasing international interest in PED and athlete development, empirical evidence from Indonesia remains limited, particularly in elite swimming. Existing discussions have largely focused on national sport policy, physical activity participation, and general sport development indicators, while relatively little attention has been directed toward examining how regional developmental environments are associated with elite swimming performance. Given the strategic importance of swimming within Indonesia's national sport development agenda and the objectives outlined in the Great Design of National Sports (DBON), a better understanding of these developmental patterns is needed to inform future policy and talent development initiatives (Giulianotti et al., 2019).

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Therefore, this study aims to examine the role of Place of Early Development in elite swimming performance in Indonesia using evidence from the 2026 Indonesian Aquatic National Championship. By exploring regional patterns of athlete achievement and developmental environments, this study seeks to contribute to the growing body of literature on talent development while providing evidence-based insights for strengthening athlete development systems and reducing regional disparities in Indonesian sport.

2. METHODS

This study employed a retrospective observational design to examine the association between Place of Early Development (PED) and elite swimming performance in Indonesia. The study utilized performance records from the 2026 Indonesian Aquatic National Championship to explore regional patterns of athlete achievement and developmental environments. A retrospective approach was considered appropriate because it enabled the examination of existing competition data and athlete development contexts without manipulating the competitive environment.

2.1. Participants

The study involved swimmers competing in the 2026 Indonesian Aquatic National Championship held at the Gelora Bung Karno Aquatic Stadium, Jakarta. A total of 217 swimmers (112 males and 105 females) participated across four competition categories: Group 3 (12–13 years), Group 2 (14–15 years), Group 1 (16–18 years), and Senior (>18 years). Athletes were included if they were officially registered with the Indonesian Aquatic Federation, participated in at least one individual event during the championship, and had complete competition records available through official championship documentation. Ethical considerations were observed by using publicly available competition data and anonymizing athlete identities during analysis and reporting.

2.2. Data Collection and Variables

Performance data were obtained from official championship results published by the Indonesian Aquatic Federation. The primary variable of interest was Place of Early Development (PED), represented by the athlete's province and primary developmental environment. To provide contextual information regarding regional sport development, provinces were classified according to their Sports Development Index (SDI) characteristics as reported in previous national sport development studies (Mutohir & Maksum, 2007; Rusdiana, 2021).

Swimming performance was evaluated using competition outcomes, including medal achievements, championship rankings, national record performances, and World Aquatics points. The use of World Aquatics points enabled standardized comparisons across swimming events and age-group categories. Additional descriptive information, including athlete age category and province of representation, was incorporated to facilitate interpretation of regional performance patterns.

2.3. Data Analisis

Data were analyzed using descriptive and comparative approaches. Frequencies, percentages, medal distributions, and performance rankings were used to describe patterns of achievement across provinces and competition categories. World Aquatics points were examined to compare athlete performance levels across events and age groups. Comparative interpretation was undertaken to identify trends associated with regional developmental environments and elite swimming performance.

The analysis focused on identifying observable patterns and disparities in athlete achievement across different developmental contexts rather than establishing causal relationships. Therefore, findings should be interpreted as evidence of associations between developmental environments and competitive outcomes within the context of Indonesian elite swimming.

3. RESULTS

The results presented in this study provide an overview of elite swimming performance patterns observed during the 2026 Indonesian Aquatic National Championship. Particular attention was given to the distribution of athlete achievements across provinces as an indicator of Place of Early Development (PED). The findings are organized to describe regional patterns of competitive success, profiles of top-performing athletes, national record achievements, and performance progression across age-group categories.

Table 3.1. Medal Standings of the 2026 Indonesian Aquatic National Championship

Rank	Province/Team	Gold	Silver	Bronze	Total	SDI Category
1	DKI JAKARTA	38	34	24	96	High
2	WEST JAVA	32	23	28	83	High
3	EAST JAVA	21	27	26	74	High
4	BANTEN	12	13	11	36	High
5	BALI	6	13	13	32	High
6	LAMPUNG	6	2	2	10	Low
8	RIAU ISLANDS	5	5	1	11	Low
9	DI YOGYAKARTA	4	2	1	7	High
10	CENTRAL JAVA	3	14	20	37	High

The distribution of medals across provinces revealed a noticeable concentration of competitive success among regions traditionally recognized for stronger sport development systems. Provinces located on Java Island, particularly DKI Jakarta, West Java, and East Java, accounted for the majority of gold medals and total podium finishes. These findings indicate substantial regional variation in elite swimming achievement and suggest that developmental environments may play an important role in shaping competitive outcomes. In contrast, provinces from outside Java generally contributed fewer medal-winning performances, highlighting the unequal distribution of elite swimming success across Indonesia.

However, when investigating individual performances, a compelling statistical anomaly emerged. Table 3.2 outlines the profiles of the top-performing athletes across age divisions, with all names anonymized to preserve confidentiality.

Table 3.2. Top Swimmers Across Age Divisions at the 2026 National Championship

Athlete ID	Swimmer Code	Gender	Age Group	Province/Team	G	S	B	Max WA Points
3067	Athlete A	Male	Group 1 (16–18)	DKI JAKARTA	2	3	0	812
15185	Athlete B	Male	Group 2 (14–15)	BANTEN	4	2	2	745
18980	Athlete C	Male	Group 3 (12–13)	LAMPUNG	6	1	1	680
1252	Athlete D	Male	Senior (>18)	DI YOGYAKARTA	3	1	0	840
12150	Athlete E	Female	Group 1 (16–18)	JAWA TIMUR	2	0	0	790
22608	Athlete F	Female	Group 2 (14–15)	DKI JAKARTA	7	0	0	815
21938	Athlete G	Female	Group 3 (12–13)	JAWA BARAT	7	2	0	710
23034	Athlete H	Female	Senior (>18)	UNATTACHED	4	0	0	830

The profiles of top-performing athletes further illustrate the diversity of developmental backgrounds represented at the championship. While many leading swimmers originated from provinces with established sport development infrastructures, several outstanding performances were also recorded by athletes from regions traditionally considered less prominent within Indonesian swimming. This pattern suggests that elite performance can emerge from a range of developmental contexts, although high-performing provinces remain disproportionately represented among the championship's most successful athletes.

To assess peak physical capacity, the national records established during the championship were modeled. Table 3.3 presents the newly established national benchmarks.

Table 3.3. Newly Established National Records at the 2026 Championship.

Event	Age Group	Swimmer Code	New Record Time	Old Record Time	Improvement Margin (%)
100m Freestyle Male	Group 1	Athlete A	50.33 s	50.40 s (Athlete M)	0.14%
50m Butterfly Female	Group 1	Athlete E	27.95 s	27.97 s (Athlete E)	0.07%
200m Freestyle Female	Group 2	Athlete F	2:05.29 s	2:05.83 s (Athlete F)	0.43%
100m Breaststroke Male	Senior	Athlete D	1:00.88 s	1:01.75 s (Athlete N)	1.41%

Several national records were established during the championship, reflecting the high competitive standard achieved by elite swimmers across different age categories. These performances demonstrate the continued progression of swimming achievement in Indonesia and provide additional evidence of the performance levels attained within regions that consistently contribute athletes to national-level competition.

Cross-sectional comparisons across age groups highlighted a developmental mismatch in performance trajectories between male and female divisions, as detailed in Table 3.4 and Table 3.5.

Table 3.4. Performance Trajectory of the Female 100m Freestyle

Age Group	Swimmer Code	Actual Age	Province	Swim Time (s)	WA Points
Group 3 (Final B)	Athlete G	13 years	West Java	1:01.59	590
Group 2 (Final A)	Athlete I	15 years	West Java	58.72	682
Super Final	Athlete F	15 years	DKI Jakarta	57.05	743
Senior Category	Athlete J	21 years	DKI Jakarta	> 58.72	< 682

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Table 3.5. Performance Trajectory of the Male 200m Breaststroke

Age Group	Swimmer Code	Actual Age	Province	Swim Time (m:s)	WA Points
Group 3 (Final B)	Athlete C	13 years	Lampung	2:33.66	554
Group 1 (Final A)	Athlete K	17 years	West Java	2:24.13	670
Super Final	Athlete D	19 years	DI Yogyakarta	2:19.36	741

Comparisons across age categories revealed differences in performance progression among athletes. In several events, younger swimmers demonstrated performances comparable to or exceeding those observed in older age groups. These observations highlight the diversity of developmental pathways present within Indonesian swimming and suggest that athlete progression may not always follow a uniform pattern across competitive categories.

Overall, the results indicate that elite swimming achievement in Indonesia remains concentrated within a limited number of provinces characterized by stronger sport development environments. At the same time, the emergence of successful athletes from less represented regions demonstrates that competitive excellence can develop beyond traditional performance centers. These findings provide an empirical basis for examining the role of Place of Early Development in shaping elite swimming performance within the Indonesian context.

4. DISCUSSION

The present study highlights substantial regional disparities in elite swimming performance in Indonesia, with competitive success concentrated primarily in provinces located on Java Island and, to a lesser extent, Bali. The medal distribution observed during the 2026 Indonesian Aquatic National Championship demonstrates that provinces such as DKI Jakarta, West Java, East Java, Banten, and Bali continue to dominate national swimming achievements. From the perspective of Place of Early Development (PED), these findings suggest that athlete development opportunities in Indonesia remain unevenly distributed across regions. Previous studies have consistently emphasized that developmental environments influence athlete progression through differences in access to facilities, coaching quality, competitive opportunities, and social support systems (Morganti et al., 2024). Therefore, the concentration of achievement within a limited number of provinces may reflect broader structural inequalities within the national sport development system.

One possible explanation for this pattern is the unequal distribution of sport infrastructure across Indonesia. Competitive swimming is among the most resource-intensive sports because athlete development requires long-term access to standardized swimming pools, qualified coaching personnel, sport science support, and regular competition exposure (Giulianotti et al., 2019). Provinces located in Java generally possess greater access to these resources compared with many regions outside Java. This situation aligns with previous evaluations of the Sports Development Index (SDI), which identified significant disparities in sport development indicators between regions, particularly regarding facilities, human resources, and community participation (Hancock et al., n.d.). Consequently, athletes who begin their development in high-resource environments may experience advantages throughout their developmental journey, increasing their likelihood of reaching elite competitive levels.

The findings also raise important questions regarding the sustainability of talent development outside Java and Bali. Indonesia possesses a vast geographic area and a large population distributed across numerous provinces; however, national swimming achievements continue to be concentrated

within a relatively small number of regions. From a talent development perspective, this pattern suggests that many potentially talented athletes may never receive adequate opportunities to progress through the athlete development pathway. Research on talent identification and development has emphasized that elite performance is not solely determined by innate ability but also by the availability of developmental opportunities during critical stages of athlete growth (Foley, 2017) .Therefore, regional disparities may contribute to the underutilization of athletic potential in provinces where access to quality training environments remains limited.

Interestingly, the emergence of several successful athletes from provinces with lower sport development profiles demonstrates that elite performance is not exclusively produced within traditional performance centers. Although such cases were less frequent, they illustrate that talent can emerge from a variety of developmental contexts. However, the relative rarity of these performances may indicate that athletes from less-developed regions are required to overcome additional structural barriers to achieve comparable levels of success. Rather than suggesting deficiencies in athlete ability, these findings may reflect unequal developmental opportunities available across regions. Similar observations have been reported in studies examining the influence of developmental environments on athlete achievement, where environmental support systems often determine whether talent can be effectively nurtured and sustained over time (Issurin, 2017).

The results further highlight the importance of viewing elite athlete development as a systemic rather than individual phenomenon. In many cases, discussions surrounding sporting success focus primarily on athlete characteristics and coaching quality. However, the concept of Place of Early Development emphasizes that performance outcomes are shaped by broader ecological factors, including community sport culture, facility accessibility, institutional support, and opportunities for meaningful competition (Kong, 2009). Consequently, the continued dominance of provinces located in Java and Bali may not simply reflect stronger athletes, but rather the cumulative advantages generated by more established sport development ecosystems.

From a policy perspective, these findings have important implications for the implementation of Indonesia's national sport development agenda. The objectives outlined in the Great Design of National Sports (DBON) emphasize the creation of a sustainable and equitable athlete development system capable of identifying and nurturing talent across the country (Varghese et al., 2022). Nevertheless, the current distribution of elite swimming achievement suggests that opportunities remain concentrated within specific geographic regions. If this pattern persists, Indonesia risks limiting its national talent pool by relying disproportionately on athletes from a small number of provinces. Expanding access to high-quality facilities, strengthening coach development programs, and establishing regional high-performance training centers outside Java and Bali may therefore represent important strategies for broadening athlete participation and enhancing long-term competitive success.

Taken together, the present findings support the view that Place of Early Development constitutes an important contextual factor in Indonesian elite swimming. While individual talent remains essential, athlete development appears to be strongly influenced by the environments in which athletes train, compete, and mature. The dominance of Java and Bali within national swimming competition highlights the need for greater attention toward regional equity in sport development. Strengthening swimming ecosystems in provinces outside these traditional centers may not only improve competitive balance but also contribute to a more inclusive and sustainable national talent development system.

5. CONCLUSIONS

The findings of this study indicate that Place of Early Development (PED) represents an important contextual factor associated with elite swimming performance in Indonesia. The distribution of achievements observed during the 2026 Indonesian Aquatic National Championship demonstrates that competitive success remains concentrated within a limited number of provinces, particularly those located on Java Island and Bali. These regions consistently contributed the highest number of medal-winning performances and elite athletes, suggesting that developmental environments characterized by stronger sport infrastructure, coaching availability, and competitive opportunities may provide advantages throughout the athlete development process.

The results further highlight the existence of substantial regional disparities within the Indonesian swimming ecosystem. Although talented athletes were identified from several provinces outside the traditional centers of excellence, their representation remained relatively limited compared with athletes originating from regions with more established sport development systems. This pattern suggests that the opportunities available to young swimmers may differ considerably depending on the developmental environment in which they are raised and trained. Consequently, athlete achievement should not be viewed solely as a reflection of individual ability, but also as an outcome influenced by the broader social, institutional, and environmental contexts that support athletic development.

From a talent development perspective, these findings reinforce the importance of adopting a more inclusive and geographically balanced approach to athlete development. The concentration of elite swimming success within a small number of provinces may indicate that significant athletic potential remains underdeveloped in many parts of Indonesia. As the largest archipelagic nation in the world, Indonesia possesses a diverse and extensive population base that could contribute substantially to national sporting success if supported through equitable access to facilities, qualified coaching, structured competition pathways, and long-term development opportunities.

The study therefore provides empirical support for strengthening regional sport development initiatives in accordance with the objectives of Indonesia's national sport development agenda. Efforts to improve swimming infrastructure, expand coach education programs, and establish sustainable athlete development pathways outside Java and Bali may help reduce existing disparities and broaden the national talent pool. Such initiatives would not only enhance competitive equity but also contribute to the long-term sustainability of elite swimming performance in Indonesia.

Finally, while this study provides important insights into the relationship between developmental environments and elite swimming achievement, future research should incorporate broader datasets, longitudinal athlete tracking, and additional indicators of athlete development to further examine the mechanisms through which Place of Early Development influences sporting success. A deeper understanding of these processes will be essential for developing evidence-based strategies capable of maximizing athletic potential across all regions of Indonesia

6. AUTHORS' NOTE

The authors declare that there are no conflicts of interest related to the publication of this study. All authors have made substantial contributions to the conception, design, analysis, and preparation of the manuscript and have approved the final version for publication. The authors further confirm that this work is original, has not been published elsewhere, and is not currently under consideration by another journal. All sources used in this study have been appropriately acknowledged and cited in accordance with academic and ethical standards.

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