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ISSN: 0033-6297 (Print) 1543-2750 (Online) Journal homepage: www.tandfonline.com/journals/uqst20

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To cite this article: Dora M. Carolo, Dean Dudley, Ana Catarina Queiroga & João Martins (05 May 2026): Integrating Physical Literacy Into Blue Physical Activity Promotion, Drowning Prevention and Aquatic Education, *Quest*, DOI: [10.1080/00336297.2026.2655226](https://doi.org/10.1080/00336297.2026.2655226)

To link to this article: <https://doi.org/10.1080/00336297.2026.2655226>



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Integrating Physical Literacy Into Blue Physical Activity Promotion, Drowning Prevention and Aquatic Education

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ABSTRACT

Physical literacy (PL) is a foundational concept in physical education, physical activity, and long-term sports development. It is a human capability nurtured through learning processes and interactions with varied environments through movement and physical activity. Blue spaces can support the development of PL, health, quality of life, and environmental sustainability. However, PL research has centered on land-based PA settings. This critical review aims to provide a theoretical background and to reflect on expanding and integrating PL into blue physical activity promotion, drowning prevention, and aquatic education. It stresses the importance of pedagogical quality, professional training, and program design, calling for collaboration among practitioners, researchers, and policymakers to advance PL's value in aquatic settings.

KEYWORDS


Aquatic physical literacy; water competence; school; socioecological models; blue spaces

Introduction

Blue spaces – natural or built environments predominantly constituted of water (Olive & Wheaton, 2021) – have gained increasing interdisciplinary interest across health (Gascon et al., 2017; Pasanen et al., 2019), education (Eigenschenk et al., 2019; Rocher et al., 2020), sociology (McDougall et al., 2022; Olive, 2022) and environmental health (Brymer & Gray, 2010; Brymer et al., 2010). Research highlights the capacity of aquatic settings to offer relevant opportunities for adherence to physical activity (PA) behaviors and social cohesion (Gascon et al., 2017; Olive & Wheaton, 2021; Yen et al., 2021).

Blue physical activity (e.g., surfing, open water swimming, diving, sailing, rowing, canoeing, etc.) is understood within the scope of this paper as PA in, on, under, and near water, such as coastal, sea, river, lake, beach, waterway, and any facility with surface water (Foley, 2017; Pasanen et al., 2019). These activities are widely perceived as enjoyable and beneficial for physical, mental, educational, and social wellbeing (Georgiou et al., 2021;

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 Supplemental data for this article can be accessed online at <https://doi.org/10.1080/00336297.2026.2655226>.

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White et al., 2020). Evidence links blue PA to enhanced adaptive capacity (Wiesner & Rejman, 2014), physical fitness (Rocher et al., 2020), identity formation, social belonging (Waiti & Awatere, 2019), pro-social and pro-environmental behaviors (Eigenschenk et al., 2019; Olive & Wheaton, 2021). Although blue physical activity offers great potential for education, socialization, commitment to environmental protection and health promotion purposes, aquatic environments pose inherent risks, particularly drowning – the most prevalent and often fatal aquatic injury (Avramidis et al., 2007; World Health Organization [WHO], 2014, 2020a, 2024).

Quality aquatic education and injury prevention must underpin efforts to promote health and active engagement in blue spaces. Professionals in these settings are tasked with enabling safe, meaningful and pedagogically sound human-water interactions aiming to develop physical literacy (PL) as a foundation for active citizenship, sustainability, and wellbeing. Subsequently, conceptual clarity is needed regarding what PL entails in practice, its added value for aquatic education and research, and how it can be developed and assessed through aquatics.

The definition of PL remains debated after two decades (Martins et al., 2020). Two of the most widely cited definitions stem from the “Whiteheadian”/IPLA (International Physical Literacy Association [IPLA], 2017; Whitehead, 2019b) perspective and the PL framework proposed by Sport Australia (Keegan et al., 2019). The “Whiteheadian”/IPLA defines PL as “the motivation, confidence, physical competence, knowledge and understanding to value and take responsibility for engagement in physical activities for life.” On the other hand, based on the Sport Australia definition, PL can be defined as the skills, knowledge, and behaviors acquired through holistic learning processes during movement and PA to help all generations lead active, healthy, and fulfilling lives (Keegan et al., 2019). Despite the absence of a gold standard definition, PL is considered foundational in contemporary understandings of quality physical education (United Nations Educational, Scientific and Cultural Organization [UNESCO], 2015), PA promotion (World Health Organization [WHO], 2018), long-term development in sports (Higgs et al., 2019), public health (Cairney et al., 2019) and positive social development and active citizenship (Onofre, 2017).

While PL is gaining momentum globally across the mentioned sectors, the fields of aquatic education and drowning prevention have only recently begun to engage with the concept – even though interaction with diverse PA environments, including water and ice, is a core tenet of PL development (Keegan et al., 2019; Whitehead, 2001). Empirical research on the development and assessment of PL has focused on terrestrial environments and their inherent PA (Carl et al., 2022; Dudley, 2015, 2019). In parallel, aquatic education research has started to adopt expressions such as “aquatic literacy,” “aquatic physical literacy” or “physical literacy in aquatic environments” (cf. Albarracín & Moreno-Murcia, 2018; Dudley, 2019; Invernizzi et al., 2021; Mekkaoui et al., 2022; Pinto & Moreno Murcia, 2023; Scurati et al., 2019). However, these terms have not been accompanied by the necessary in-depth conceptual discussion to distinguish them from other well-established, analogous concepts in the field – aquatic competence, water competence, aquatic motor skills or aquatic locomotion skills (cf. Button, 2016; Button et al., 2020; Langendorfer & Bruya, 1995; Moran, 2013; Moreno-Murcia & Ruiz, 2019; Stallman et al., 2017, 2018; Szpilman et al., 2021). Clarifying PL’s distinct contribution to blue PA promotion, drowning prevention, and aquatic education is thus essential.

This critical review (Grant & Booth, 2009) theorizes PL as a conceptual bridge linking these fields or professional/research communities. It first addresses conceptual overlaps surrounding PL's emergence in aquatics, then explores its value for understanding of human-blue space interactions and mitigating drowning as a highly preventable injury (World Health Organization [WHO], 2017), as well as responding to the aquatic profession crisis identified by Stallman (2019). The paper concludes with implications for research, policy and practice.

Methods

Theoretical and methodological approach

This study adopts a constructivist theoretical perspective, recognizing that authors actively co-construct knowledge through the interpretation and integration of diverse literature (Creswell, 2014). Following critical review principles, the process prioritized flexibility, reflexivity, and critical discernment over rigid methodological protocols (Grant & Booth, 2009; Kahlke et al., 2023)

Search strategy

A systematic search was conducted across Web of Science, PubMed, and Scopus, complemented by manual searches of reference lists, seminal works and gray literature (e.g., WHO, UNESCO and Organization for Economic Co-operation and Development [OECD] reports). The search included conceptual papers, studies, and reviews published between 2000 and April 2025 in English, Portuguese, and Spanish. Key search terms adapted for each database were combined across three conceptual areas: 1) PL; 2) Blue spaces and blue physical activity; 3) Aquatic education and water safety. Publications were considered for analysis if they (a) discussed PL, aquatic education, or water safety from a conceptual, pedagogical, or behavioral perspective; (b) presented frameworks, definitions, or models relevant to these topics; or (c) addressed blue spaces as settings for human development, learning, or PA.

Data analysis and quality assurance

This critical review employed interpretative qualitative research traditions, using the constructivist approach to judge the quality and relevance of the literature (Silverman, 2011). Titles, abstracts, and full texts were reviewed iteratively by the authors. Throughout the analysis, the authors utilized analytic memos and conceptual maps to document interpretative decisions and support reflexivity. Emphasis was placed on contrasting and integrating concepts across sources to construct meanings and theoretical linkages. The final Aquatic Physical Literacy (APL) framework emerged through this hermeneutical synthesis process. Quality assurance relied on the use of multiple sources and collective author deliberation on interpretive decisions to ensure coherence and transparency (Kahlke et al., 2023; Tracy, 2010).

From concept to practice: clarifying the concept and its applications for physical activity participation, safety, and learning in blue spaces

The original conceptualization of PL is grounded in philosophical principles framing movement and PA as part of the holistic and indivisible nature of human beings (monism), emphasizing the coupling of individuals and their environments (existentialism), and recognizing each person's unique potential and life journey (phenomenology) (Whitehead, 2001, 2010). These tenets underpin the central question: "What is the value of PL?" and are central to defining the concept itself, identifying the attributes individuals should aspire to (Whitehead, 2019b). Furthermore, they guide the methodological choices teachers, sport coaches, and other PA professionals make regarding activity planning, assessment, learning environment management, and pedagogical strategies (Carolo et al., 2024).

Over the last two decades, PL has garnered global traction across scholarship, policy, and practice, prompting definitional and theoretical debates (Edwards et al., 2017; Martins et al., 2020). Its growing relevance has inspired varied interpretations supported by governments, NGOs, and research partnerships to fit cultural and contextual realities (Shearer et al., 2018).

Among these, the Australian PL framework is one of the most comprehensive, influencing initiatives such as "Physical Literacy for Life" in Europe (Carolo et al., 2023). It identifies 30 elements across physical, psychological, social, and cognitive domains, defining PL as integrated learning, developed and expressed through movement across the lifespan (Keegan et al., 2019, p. 6). Differing from the "Whiteheadian" view of PL, the Australian approach conceptualizes PL as a socioculturally shaped learning construct, emphasizing the interdependent development of multidomain elements (Keegan et al., 2019). More recently, a global consortium (Carl, Mazzoli, Sum et al., 2024) focused on the consensual development of a Global Physical Literacy (GloPL) Action Framework aimed at advancing the field worldwide. This initiative seeks to articulate both forward-looking goals and guiding principles, as well as practical actions and strategies, exploring how these objectives can be achieved. This research group produced a comprehensive framework (GloPL Consortium, 2026) that both highlights and visually represents the unique challenges and potential solutions within physical literacy, while also promoting its dissemination across different sectors.

Ultimately, while researchers and practitioners work to clarify the meaning of PL and adapt it to diverse cultural contexts, there remains a collective responsibility to balance two priorities: respecting PL's philosophical foundations and ensuring its valid and practical implementation in research, policy, and practice.

Clarifying misunderstandings in physical literacy for application in blue physical activity, drowning prevention, and aquatic education

Although the absence of a universal definition is often criticized, scholars, including Whitehead, acknowledge that the non-existence of a gold standard definition of PL is not necessarily a weakness. While grounded in the pedagogical and philosophical tenets of PL, openness to varied interpretations can be essential for creating cultural relevance and meaning across different contexts (Edwards et al., 2018; Whitehead, 2019c). Despite

differences – such as the Australian model’s focus on social and learning domain or the New Zealand inclusion of the spiritual domain – the ontological and epistemological foundations of PL often remain consistent across definitions (Martins et al., 2020). Thus, debates over definitional clarity often obscure substantial consensus (Bailey, 2022). Examples are the PL emphasis on lifelong participation in PA; holistic development across affective, cognitive, and physical domains; and interaction with diverse environments to enhance competence, confidence and self-esteem (Martins et al., 2020). Nonetheless, persistent misunderstandings and overlaps (Carl et al., 2023; Whitehead, 2019a) continue to hinder collaborative research, policy adoption, and pedagogical practice, particularly in emerging contexts such as aquatic education (Carl et al., 2023; Carolo et al., 2023; Martins et al., 2020). Two major misconceptions and one conceptual overlap are particularly important.

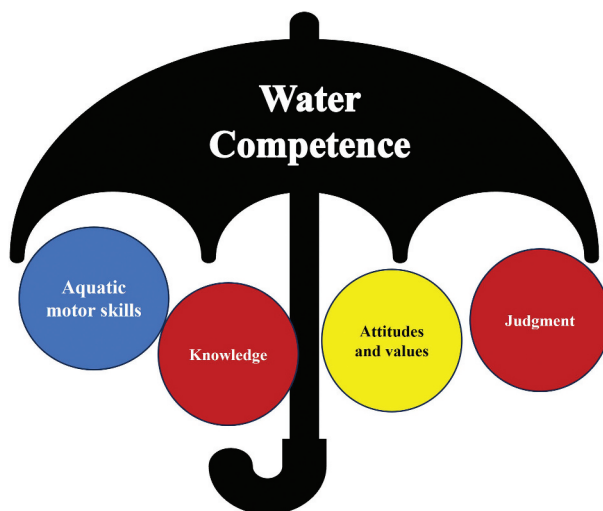
The first concerns Whitehead’s pairing of “physical” and “literacy” (Durden Myers et al., 2022a; Whitehead, 2019b), rooted in monism, existentialism and phenomenology (Pot et al., 2018; Whitehead, 2001, 2007, 2010, 2013, 2019b). Misinterpreting this philosophical grounding can lead to superficial or distorted applications that disconnect PL from its holistic and lifelong nature (Corbin, 2016; Durden Myers et al., 2022a; Edwards et al., 2017; Huang, 2024).

The second misunderstanding is the flawed assumption that motor competence, fundamental movement skills and PL are synonyms as physical attributes (Whitehead, 2019a). From this perspective, PL is frequently and mistakenly reduced to the acquisition of a broad motor repertoire (Almond, 2014). This reductionist view limits pedagogical scope and underplays PL’s multidimensional character, which spans physical, cognitive, affective and social domains (Almond, 2014; Carolo et al., 2023).

A third conceptual issue concerns the potential overlap between *water competence* or *aquatic PL* concepts in literature. Empirical PL research has largely focused on land-based movement (Carl et al., 2022; Dudley, 2015) contradicting PL’s holistic emphasis on engagement across environments (Edwards et al., 2017; Keegan et al., 2019; Whitehead, 2001). This terrestrial bias underscores the need to expand PL frameworks into aquatic and icy contexts. It is therefore essential to uphold the principle of integration across domains and to better reflect the plural and relational engagements that shape human interaction with diverse PA landscapes.

Meanwhile, aquatic education and water safety literature and research have evolved in relative autonomy, with its own body of research on the motor skills, attitudes, and knowledge needed to engage safely and competently with aquatic environments (Guignard et al., 2020). From the authors’ perspective, integrating aquatic education and water safety within a PL framework not only addresses the current terrestrial bias on PL literature but also situates drowning prevention within a broader, holistic vision of embodied, lifelong movement. Therefore, understanding the conceptual field is key to bringing these strands of inquiry into dialogue.

Originally introduced by Langendorfer and Bruya (1995) as a gender-inclusive alternative to “watermanship,” *water competence* described the set of aquatic motor skills that define a swimmer who has acquired broad proficiency in moving in aquatic environments (Langendorfer, 2015). Over time, the definition evolved into a dynamic, holistic construct incorporating psychomotor, cognitive, and affective elements supporting safe aquatic behavior (Moran, 2013; Stallman et al., 2017, 2018; Szpilman et al., 2021) (Figure 1). Moreno-Murcia and Ruiz (2019) extended it to include environmental awareness, problem-



...that **facilitate safety** in, on and around water.
 (Stallman et al., 2017, 2018; Moran, 2013; Szpilman et al., 2021)

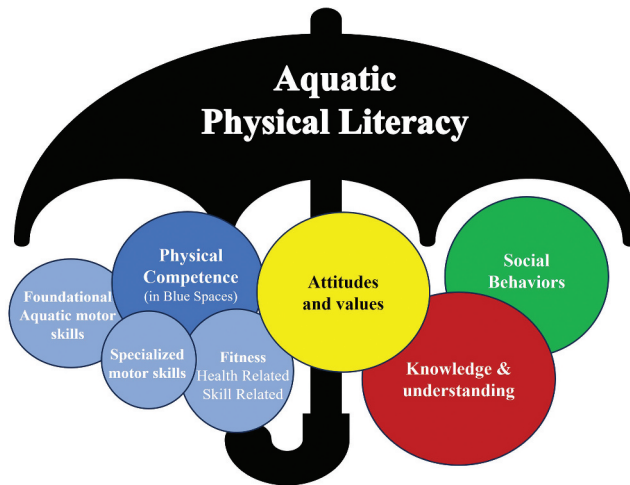
Figure 1. Water competence definition.

solving and social interaction. This shift has moved the concept beyond motor competence to encompass social and other types of attitudinal elements (Moreno-Murcia & Ruiz, 2019; Stallman et al., 2017, 2018). Such an expansion creates a semantic convergence with PL, whose conceptualization was initiated by Whitehead (2001). Given this overlap, a deep conceptual discussion is needed to avoid further misinterpretation and confusion in the fields of aquatic education and water safety. Without such clarity, theory-informed interventions, educational programs and research agendas could be hindered, ultimately affecting program quality, assessment (Leavy et al., 2016) and cross-sectoral collaborations. Key questions include:

- What are the conceptual differences between aquatic PL and water competence?
- What added value does PL bring to aquatic education, and water safety and policy?
- How can PL integration improve pedagogy, research and cross-sector collaboration (e. g., public health, education, recreation, sport)?

Figures 1 and 2 respectively depict the most recognized definition of *water competence* and the authors' proposed definition of aquatic *PL*, using color coding to represent physical (blue), cognitive (red), affective (yellow) and social (green) domains.

Developing PL through blue PA has emerged as a promising global research frontier for aquatic education and drowning prevention (Albarracín & Moreno-Murcia, 2018; Carolo et al., 2023; Dudley, 2019). While terms such as "Aquatic Literacy" and "Aquatic Physical Literacy" appear sporadically (Albarracín & Moreno-Murcia, 2018; Dudley, 2019; Invernizzi et al., 2021; Mekkaoui et al., 2022; Pinto & Moreno Murcia, 2023; Scurati et al., 2019), their conceptual implications remain underexplored.



...that enable individuals to **value** and **actively engage** in safe and **sustainable blue physical activities** across the **lifespan**.

Figure 2. Definition of Aquatic Physical Literacy.

Drawing from an integrative PL, motor competence, and water education/safety literature review, the authors define “aquatic physical literacy” as an applicable expression to translate “PL in aquatic environments”:

The development of attitudes, values, social behaviors, aquatic physical competence, knowledge and understanding that enable individuals to value and actively engage in safe and sustainable blue physical activities across the lifespan. (Figure 2)

This perspective addresses aquatic PL as a human capability (Durden Myers & Whitehead, 2019; Whitehead, 2019a) – and potentially a human right (Whitehead, 2019c) – cultivated (learned) through safe, meaningful, challenging and physically active experiences in aquatic environments. It integrates PL’s philosophical principles (Whitehead, 2001, 2010), the social and learning emphases of the Australian model (Keegan et al., 2019) and hydrocitizenship (Gearey et al., 2019) elements of safety and sustainability promotion.

Aquatic PL is not a new literacy form but an expression of PL within aquatic environments, aligned with its holistic, environment-inclusive principles (Dudley, 2019; Jurbala, 2015; Keegan et al., 2019; Whitehead, 2001). Accordingly, when theorizing and applying aquatic PL, researchers and practitioners should operate within the established pedagogical and philosophical framework of PL, integrating its domains and elements. Simultaneously, they should incorporate evidence from key studies on aquatic motor skills, knowledge, and attitudes to shape safe and competent aquatic behaviors for design of more coherent, theory-informed programs that enhance learning quality, promote safety and advance drowning prevention.

An aquatic PL framework is proposed in this paper (Table 1) as a conceptual synthesis emerging directly from the clarification of misunderstandings and overlaps

Table 1. Aquatic physical literacy framework.

Component	Attributes	Indicators
<p>Attitudes and Values <i>Refers to the beliefs, dispositions, and moral values that guide how individuals engage with and experience physical activity in aquatic environments, including attitudes towards personal and community safety, social responsibility and care for blue spaces.</i></p>	<ul style="list-style-type: none"> ● Positive mindset about being physically active in blue spaces. ● Readiness to face challenges and new aquatic experiences. ● Willingness to learn and reflect on aquatic experiences. ● Respect and care for blue spaces, their biodiversity and those who use them. ● Valuing fairness and respect while regarding the use of shared spaces, rules, and cultural practices in, on, and around blue spaces. ● Valuing individual/community safety and sustainability. 	<p><i>While being physically active in blue spaces, a person demonstrates:</i></p> <ul style="list-style-type: none"> ● Enjoyment and motivation for active participation. ● Confidence in his/her ability to successfully perform a particular movement task, even in different or challenging conditions. ● Be willing to leave his/her comfort zone and tackle challenges that may require new skills, resilience, or adaptability while balancing curiosity and challenge-seeking with safe preparation and respect for the aquatic environment. ● Resilience by recovering from setbacks or difficulties and persevering in continuing the activity or working toward his/her goals. ● Willingness to learn and reflect on aquatic experiences by seeking feedback, supporting continuous improvement, adaptability and lifelong engagement. ● Valuing and prioritizing personal and community well-being/safety. ● Be willing to protect aquatic ecosystems for future generations.
<p>Social Behaviors <i>Refers to the ways individuals interact and engage with others while being physically active in aquatic environments, promoting cooperation, inclusion, mutual respect, and shared responsibility for safety and the sustainability of activities.</i></p>	<ul style="list-style-type: none"> ● Leadership and cooperation to support others. ● Clear, respectful, and supportive interaction with peers, instructors, and community members. ● Commitment to fairness and respect regarding the use of shared spaces, rules, and cultural practices through blue physical activity. ● Commitment to collaborate with others to assure safety and sustainable practices. ● Encouraging inclusion and participation for all, toward quality of life, health and achievements of one's full potential. 	<p><i>While being physically active in blue spaces, a person demonstrates:</i></p> <ul style="list-style-type: none"> ● Guiding, assisting, or working alongside people to help them participate safely, effectively, and enjoyably in blue physical activities. ● Communicating and behaving in ways that promote understanding, trust, and a positive environment for everyone involved. ● Acting in ways that ensure everyone can enjoy aquatic environments safely, harmoniously, and in line with personal and community values. ● Actively collaborating with others to promote safety and sustainable practices. ● Actively creating opportunities and a welcoming environment so that people of all ages, abilities, and backgrounds can enjoy and benefit from blue physical activities.

(Continued)

Table 1. (Continued).

Component	Attributes	Indicators
<p>Aquatic Physical Competence <i>Refers to the capacity to move effectively, efficiently, and safely in, on, and around aquatic environments, demonstrating adaptability across a range of conditions and activities.</i></p>	<ul style="list-style-type: none"> ● Foundational aquatic locomotor skills for safe movement and performance in aquatic environments: water entry and exit; buoyancy control; body position and alignment; kicking actions; arm propulsion patterns; breath control, directional movement; rotation and balance; transitions (float to swim, swim to stand). ● Specialized motor skills, including object manipulation skills and object locomotor skills that involve precision, efficiency, adaptation and task-specific performance. ● Health-related physical fitness: cardiovascular endurance, muscular strength, muscular endurance, flexibility, body composition. ● Performance-related physical fitness: speed, power, agility, balance, coordination, reaction time. ● Capability to adapt aquatic movement skills and fitness to different aquatic environments (e.g., pools, rivers, lakes, ocean) and conditions (e.g., depth, temperature, currents, waves, visibility), while maintaining safety, efficiency, and confidence. 	<p><i>While being physically active in blue spaces, a person demonstrates:</i></p> <ul style="list-style-type: none"> ● Mastery of foundational aquatic locomotor skills as safe entry and exit, breath control, float and treading water, roll and turn the body in different directions, propulsion in the front and back (basic swimming strokes). ● Capability to perform specialized aquatic movement skills that involve interacting with equipment, objects, or specific tools for sport, recreation, or work in water (e.g., guide the ball in water polo, using a pole or gun in spearfishing, using a surfboard to catch and ride waves). ● Cardiovascular endurance, muscular strength, muscular endurance and flexibility enabling sustained, efficient movement and healthy participation in blue physical activity for life. ● Speed, power, agility, balance, coordination and reaction time to move efficiently, perform skills effectively, adapt to environmental conditions, and ensure personal and collective safety. ● The ability to adjust movement techniques and energy expenditure to perform effectively and safely across diverse aquatic environments and conditions.
<p>Knowledge & Understanding <i>Refers to the awareness, comprehension, and application of information needed to engage safely, effectively, and responsibly in aquatic environments, including understanding of movement, environmental conditions, risks and sustainability.</i></p>	<ul style="list-style-type: none"> ● Contextual awareness to understand local aquatic dynamics such as tides, currents, weather patterns, seasonal changes. ● Understanding how to move and adapt effectively in different aquatic conditions (e.g., waves, temperature, depth). ● Capability to identify personal goals and plan progression in aquatic skills, physical fitness, knowledge, attitudes and social behaviors. ● Ability to recognize hazards, understand affordances and constraints to movement, and make informed decisions accordingly. ● Knowledge of environmental threats, their consequences, and understanding how to apply environmentally responsible practices to protect blue spaces, marine biodiversity, and human health. 	<p><i>While being physically active in blue spaces, a person demonstrates:</i></p> <ul style="list-style-type: none"> ● Understanding how natural, physical, and cultural factors influence safety, performance, and appropriate behavior in a specific blue space, enabling informed decision-making, respect for local customs and adaptation to environmental and cultural contexts. ● Knowledge of movement techniques and understanding of when and why to apply them to match the environmental demands and respond effectively and safely to changing aquatic conditions. ● Ability to set clear and achievable goals for aquatic participation and develop structured plans that support purposeful engagement, consistent improvement, and a balanced development of skill, fitness, knowledge, and mindset. ● Capacity to assess the aquatic environment, other people's aquatic behavior, identify risks, and determine safe and effective movement options before and during the activity, aligning decisions with environmental conditions and personal capabilities. ● Understanding how human actions and natural factors impact aquatic environments and how to support sustainable participation in blue physical activities while safeguarding ecosystems and community health.

(Continued)

Table 1. (Continued).

Component	Attributes	Indicators
Lifelong Journey <i>Refers to the ongoing commitment, adaptation and personal choice to engage in blue physical activities and sports across all stages of life.</i>	<ul style="list-style-type: none"> • Choose to be active daily and include blue physical activities in their routine. • Develop and refine water-specific skills, attitudes, social behaviors and knowledge across the different life stages (from childhood to older adulthood). • Adjust the type or intensity of activities to match changing capacities due to health conditions, aging and other circumstances. • Maintain and encourage lifelong participation in recreational, sport, and physical activities in or on water, fostering active citizenship through taking responsibility and initiative for personal and collective health, safety, and quality of life. 	<i>While being physically active in blue spaces, a person demonstrates:</i> <ul style="list-style-type: none"> • The ability to make conscious and consistent decisions to integrate movement in or on water as part of a healthy and active lifestyle. • Capacity to build, adapt and refine aquatic capabilities and understanding throughout life, while maintaining a positive mindset and healthy interactions in aquatic environments. • Ability to adapt participation in blue physical activity, so it remains safe, enjoyable and beneficial despite changes in physical ability, fitness level or personal circumstances (e.g., chronic disease diagnosis, aging, acquired impairment). • Consistent engagement with aquatic environments through physical activity over the years to support physical fitness, health, well-being, and social/place-based connection.

outlined above, offering a structured articulation of its core components, attributes and observable indicators describing individuals who maximize their aquatic PL potential. These capabilities emerge through the interaction of holistic learning, maturation and environment/cultural influences, emphasizing the pivotal roles of educators, coaches and ecological (external and internal) factors (Bauman et al., 2012; Sallis et al., 2000; Yen & Li, 2019).

Physical literacy: a call for an integrative understanding of human-blue spaces interaction

Can PL serve as a unifying concept to reconcile blue physical activity promotion with water-related injuries prevention? Addressing this question demands integration across disciplines – motor learning, psychology, sociology, blue space studies, aquatic education and safety, PA promotion, public health and injury prevention.

Although PL is well established in physical education and PA promotion, it is, however, largely absent from drowning prevention and blue spaces literature. An analysis of major international policy documents revealed this disconnection. WHO's global PA reports (WHO, 2018, 2020b, 2021b, 2022) contain no reference to blue spaces or PL in aquatic settings, aside from a brief mention in the *Global Action Plan on Physical Activity 2018–2030* (WHO, 2018), which indirectly notes natural environments as sites for sustainable PA and ecological stewardship. Similarly, WHO drowning prevention reports (WHO, 2014, 2017, 2021c, 2023b, 2024), make no mention to PL, PA, or blue spaces, with the sole exception of a reference to Greek sport science institutions as prevention partners (World Health Organization [WHO], 2024).

UNESCO's documents on quality physical education (UNESCO, 2015, 2021a, 2021b, 2021c), and OECD frameworks (Organisation for Economic Co-operation

and Development [OECD], 2019) position PL as a foundational educational concept but overlook aquatic education and drowning prevention. Yet, aquatic education – an essential component of quality PE and blue space engagement – shares responsibility for fostering PL and promoting lifelong, meaningful movement participation, consistent with UNESCO’s Quality Physical Education Framework principles.

In blue space literature, PL is never explicitly referenced, though several studies explore PA as a mediator between humans and aquatic environments (Eigenschenk et al., 2019; Gascon et al., 2017; Georgiou et al., 2021; Murrin et al., 2023; Olive, 2022; Pasanen et al., 2019; White et al., 2014, 2020, 2024; World Health Organization [WHO], 2021a, 2023a; Yen et al., 2021). Drowning is occasionally identified as a risk of such engagement (Foley, 2017; Smith et al., 2021; Vitale et al., 2022; White et al., 2016; WHO, 2021a). Notably, the mechanisms linking blue PA to well-being vary across settings (White et al., 2024), echoing a key PL principle – the importance of diverse movement environments (Jurbala, 2015; Whitehead, 2001).

Figure 3 illustrates the status of PL’s integration in policies and relevant international reports and standards on PA, physical education and drowning prevention.

Overall, PL features prominently in PA, PE, and sport development (green arrow), but is absent from blue spaces and drowning prevention policies and reports (red arrow). Blue spaces research only briefly mentions drowning or PA as mediator of human – blue spaces interaction (orange arrow). This gap underscores the need for stronger cross-sector collaboration to achieve inclusive, safe, and sustainable blue PA for all. For example, there is no intersection between PA and drowning prevention policies within the WHO, despite the organization’s strong initiatives regarding these two intervention sectors.

Embodying the blue: educational and health benefits of blue physical activity

Human experiences in blue spaces are shaped by cultural, social (Mahony et al., 2017; Moles, 2020; Wheaton et al., 2019), environmental factors (Araújo et al., 2019; White et al.,

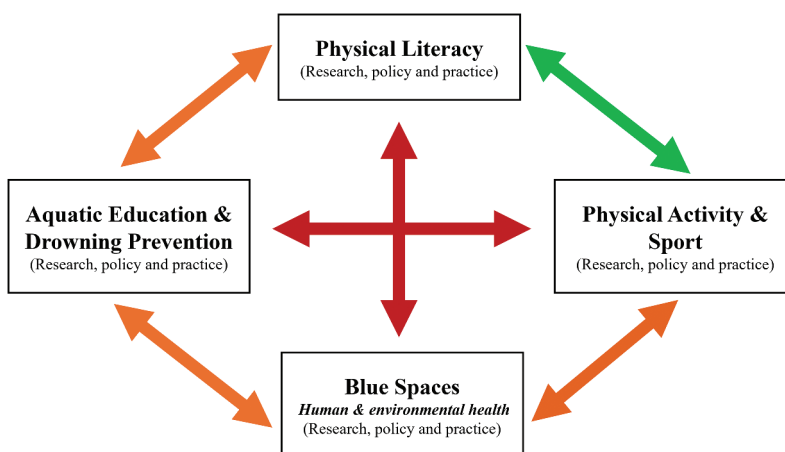


Figure 3. Presence of physical literacy, blue spaces, and drowning prevention in international policy documents from WHO, UNESCO, and OECD (2001–2024).

2016) and individual characteristics (Straughan, 2012; Volker & Kistemann, 2011). These interactions occur across multiple ecological levels (Georgiou et al., 2021; Haeffner et al., 2017), yet both blue space and aquatic education research seldom adopt socioecological perspectives (Gascon et al., 2017; Langendorfer, 1987; Löhmus et al., 2022).

While aquatic environments pose health risks – such as extreme weather, pollution, infectious disease and drowning (Brown & Murray, 2013; Kouadio et al., 2012; Meddings et al., 2021; Sindall et al., 2022; United Nations, 2021; Vos et al., 2020) – are well documented, their specific educational, psychological and social benefits remain comparatively underexplored (White et al., 2020). Emerging evidence links blue spaces with identity foundation and belonging (Bates & Moles, 2022; Foley, 2017; Olive, 2022; Waiti & Awatere, 2019), social connectedness (Gaspar de Matos, 2017; Hignett et al., 2017; Pereira et al., 2020; Rocher et al., 2020), emotional restoration (Bell et al., 2015; Volker & Kistemann, 2011; White et al., 2010), and physical and mental health (Britton et al., 2018; Gascon et al., 2017; Gaspar de Matos, 2017; Massey et al., 2020; McDougall et al., 2022; Volker & Kistemann, 2011).

Programs fostering blue PA improve health indicators, motor competence, and prosocial behaviors in vulnerable populations (Devine-Wright & Cath, 2020; Gaspar de Matos, 2017; Hignett et al., 2017) and in children with disabilities (Clapham et al., 2020). Engaging with aquatic environments can also enhance environmental stewardship. Interactions with nature build belonging and ecological responsibility, particularly when modeled socially (Brymer et al., 2010; Larson et al., 2017). However, most research on blue PA focuses on near-water land-based activities such as walking, running, or cycling, rather than immersive ones such as surfing, swimming, sailing, or canoeing (Caddick et al., 2015; Foley, 2017; Foley & Kistemann, 2015; McDougall et al., 2022; Pasanen et al., 2019; Rocher et al., 2020), limiting understanding of direct aquatic engagement and its role fostering hydrocitizenship – collective responsibility for water safety and sustainability (Dudley, 2019; Gaspar de Matos, 2017; Gearey et al., 2019; Georgiou et al., 2021; Larson et al., 2017; Smith et al., 2021).

This proposed perspective on aquatic PL offers a lens to bridge these gaps by integrating physical, cognitive, affective and social dimensions of learning and behavior in aquatic environments. Beyond skill acquisition, it emphasizes environmental awareness, safety, sustainability, and community stewardship. From this perspective, blue PA becomes not merely movement in water but meaningful interaction with it – promoting lifelong human development alongside environmental health.

Physical literacy as a lifesaving internal resource: an integrated approach to drowning prevention

Facilitating safe, meaningful interaction with aquatic environments promotes personal growth, active citizenship, and environmental stewardship (Carolo, 2022), yet water-related injury remains a major concern (Avramidis et al., 2007). Historically, this risk has driven prescriptive swimming programs that, while valuable, often promote a narrow, fear-based narrative – “learn to swim so you don’t drown” – overlooking the broader competencies required for confident, lifelong participation in diverse aquatic environments (Dudley, 2019).

Drowning remains among the most serious aquatic injuries, causing an estimated 300,000 unintentional deaths globally each year (WHO, 2024). Mortality disproportionately

affects males, young children (under 5 years), adolescents, rural populations, and those in low socioeconomic groups (Franklin et al., 2020; Meddings et al., 2021; Taylor et al., 2020; WHO, 2014). In the European and Eastern Mediterranean Regions, it is the second leading cause of accidental death among children aged 5–14 (WHO, 2024) and the sixth among 1–24 (Meddings et al., 2021). Over half of drowning victims worldwide are under 30 years old (WHO, 2024).

Drowning arises from the interaction of biological, socio-demographic, behavioral, environmental, and geopolitical factors (Davey et al., 2019; Denny et al., 2021; Koon et al., 2021; Rahman et al., 2021). Accordingly, prevention requires multisectoral partnerships and coordinated interventions (United Nations, 2021; WHO, 2024) informed by robust research (Peden & Franklin, 2021; WHO, 2017).

The WHO Global Status Report on Drowning Prevention identifies five central domains for action: (1) governance and coordination; (2) policy and legislation; (3) community-level interventions; (4) awareness raising; and (5) data and research (WHO, 2024). While “*community-level interventions*” show promise, progress remains uneven – only 22% of countries integrate swimming and water safety into school curricula. Moreover, swimming skills learned in pools often fail to transfer effectively to open-water contexts (Guignard et al., 2020; Kjendlie et al., 2013; Langendorfer, 2015; Sundan, 2025).

From an aquatic education perspective, preventing aquatic accidents thus requires more than motor proficiency: it depends equally on knowledge, attitudes, decision-making and social competence across individual, task and environment dimensions (Haddon, 1980). Integrating PL frameworks into aquatic education can help public health interventions move beyond fragmented, skill-focused approaches toward a holistic model that develops capable, confident, safety-aware, and environmentally responsible participants. This dual emphasis – fostering safe, lifelong engagement with aquatic environments while reducing the risk of water-related injuries – provides a sustainable pathway for advancing both health promotion and drowning prevention.

The authors’ perspective on Aquatic PL incorporates the attitudes and knowledge central to water safety (Moran, 2006, 2008; Pidgeon-Willcox et al., 2017; Terzidis et al., 2007), including hazard recognition, risk assessment, decision-making, use of flotation devices and emotional/physical self-regulation. It also expands into the social domain – often overlooked in both PL and drowning prevention research (Dudley, 2019) – by integrating social determinants of safety behavior and participation. Enhancing ethical conduct, interpersonal relationships, leadership and communication strengthen *hydro-citizenship*: collective commitment to drowning prevention and sustainability (e.g. appropriate behavior during mass water accidents, during floods or aquatic emergencies). This aligns with Australian PL framework and Dean Dudley’s conceptualization of PL as a “drowning vaccine” (Dudley, 2019).

A socioecological approach to aquatic education and drowning prevention across the lifespan

Comprehensive aquatic education should develop physical, cognitive, affective (Langendorfer, 2015; Quan et al., 2015; Stallman et al., 2017) and social skills to support safe and competent participation – distinct from the misleading goal of being “drowning proof.” The UN Resolution for Drowning Prevention (United Nations, 2021) highlights

equitable access to aquatic education but also underscores the need for broader competencies beyond skill acquisition. Building such a comprehensive set of competencies requires acknowledging that individual abilities do not develop in isolation but are shaped by, in turn shape, the broader social and environmental systems in which an individual lives.

A socioecological approach to aquatic education and drowning prevention across the lifespan is essentially about recognizing that water safety, aquatic participation, and drowning risk are shaped by multiple, interconnected layers of influence – from the individual’s competencies to broad policy environments – and that these influences evolve as people move through different life stages. Therefore, it is essential to recognize the diverse and authentic ways in which humans interact with and experience aquatic environments (WHO, 2021a). From a PL perspective, this means integrating multiple dimensions: motor learning (Button et al., 2020; Guignard et al., 2020; Langendorfer, 2009; Rocher et al., 2020; Stallman, 2017); the development of psychological capabilities such as intrinsic motivation, confidence, and self-efficacy (Vitale et al., 2022; Willcox-Pidgeon et al., 2018); relevant knowledge (Moran, 2008; Wilks et al., 2017); social capabilities; and external determinants of active living in aquatic settings, including social and cultural influences (Mahony et al., 2017) and environmental characteristics/conditions (Löhmus et al., 2022) factors.

Socioecological models (McLeroy et al., 1988; Sallis & Owen, 2015), grounded in Bronfenbrenner’s systems theory, may illustrate how drowning risk and aquatic behavior emerge from reciprocal influences across different ecological levels. The indicators presented in Supplementary Table primarily represent the intrapersonal dimension of Aquatic PL, conceptualizing it as an individual human capability encompassing physical, cognitive, affective and social attributes. When situated within a sociological framework, however, these capabilities are understood as dynamically shaped by, and interacting with, influences across interpersonal, community, organizational, and policy levels. Thus, integrating PL within the intrapersonal level informs quality practice in schools, clubs and communities (Carolo et al., 2023) while shaping and being shaped by broader cultural, policy (Dudley et al., 2017) and organizational level changes (Dudley, 2019).

To further operationalize this multilevel framing, the specific roles of Aquatic PL across sociological levels are outlined below. At the **individual/intrapersonal** level, PL is identified as one of the capabilities of a person. This level encompasses also biological factors, personal and emotional characteristics, competencies, identity, age, socioeconomic status, etc. The **interpersonal level** involves family, peers and mentors, who transmit knowledge and model behavior. Here educators and coaches play a mediating role, and their interventions on an interpersonal level should remain consistent with PL’s philosophical principles, respecting the individuality of each PL journey. This requires teaching strategies that align with the student’s social agenda, and incorporate pedagogical principles of inclusion, task adequacy, and differentiation (Carolo et al., 2023). **Community level** influences include access to safe aquatic spaces, culturally relevant programs and local water safety initiatives. The **organizational level** covers schools, workplaces and sport systems embedding PL frameworks in curricula and professional development. **Policy-level** strategies include national drowning prevention plans, curriculum mandates, facility regulations and environmental design standards. Finally, the **broader environment** – cultural values, traditions and norms – shapes safety practices and collective stewardship of blue spaces.

Positioning PL within this socioecological framework underscores its potential to strengthen both individual capability and systemic resilience. Schools, in particular, serve as pivotal microsystems for aquatic education and drowning prevention, offering equitable opportunities to develop motor, emotional, cognitive and social competences essential for lifelong engagement in blue PA. When embedded into curricula and teacher training, aquatic PL can extend its impact beyond individuals to communities, fostering partnerships with aquatic clubs, safety organizations, and local stakeholders that reinforce and diversify student learning opportunities and promote local companies and organizations' services/local impact. At the organizational and policy levels, aligning aquatic PL with national policy and legislation ensures scalable, sustainable progress and facilitates collaboration with national institutions (e.g., sport federations, national education directorate, ministries). This tiered, socioecological integration – from individual learning to policy reform – provides a coherent pathway for reducing drowning risk while cultivating safe, confident, and environmentally responsible engagement in aquatic environments across the lifespan.

Reframing aquatic education and drowning prevention through physical literacy and socioecological models

Although PL has generated extensive research, its translation into policy and practice requires stronger knowledge production and cross-sector collaboration (Carl et al., 2023). Since 2022, the authors have explored how integrating insights from aquatic education, safety, blue spaces, and PL can advance drowning prevention, health promotion and *hydrocitizenship* through movement in, on and around water. A main set of four broader questions were foundational to this academic work and emerged from the authors' professional experiences and reflections:

- Why do people drown?
- How can positive relationships with aquatic environments be fostered?
- How can PA in blue spaces be encouraged?
- How can we prevent drowning while actively engaging in aquatic settings?

Building on these reflections, a series of research directions were identified to guide future inquiry, policy and practice:

- What is PL's added value for aquatic safety, education and blue physical activity promotion?
- How can PL inform research, policy, and interventions for drowning prevention and aquatic education?
- What are the practical and policy implications of viewing PL as a “vaccine against drowning” (Dudley, 2019)?
- How can aquatic PL development and assessment be conceptualized using valid, reliable and authentic approaches?
- Which elements across the physical, psychological, cognitive and social domains best predict blue physical activity and water safety behavior?

- How do aquatic professionals' levels and perceptions of aquatic PL influence teaching confidence and pedagogical quality?
- How can researchers, practitioners, and policymakers collaborate to design integrated, domain-inclusive aquatic education and blue PA programs that?
- How can PL frameworks help reimagine traditional learning approaches in aquatic contexts (Dudley, 2019)?

Synthesizing insights from diverse fields, the authors identified knowledge gaps and opportunities with direct implications for future research, policy development and professional practice.

Implications for future research, policymaking and practice

PL offers a framework to address deficits in aquatic professional preparation identified by Stallman (2019), extending beyond swimming instruction to broader aquatic and nautical sports. Inadequate training quality, inconsistent curricula and limited evaluation hinder sector-wide development. Integrating PL principles – already central to quality physical education and PA promotion – can strengthen science-based pedagogy, curriculum design, and professional practice in aquatic education and safety. Embedding these principles in teacher and coach education may enhance instructional quality and resilience within the sector.

Existing PL frameworks, such as the Australian model (Keegan et al., 2019), can help bridge theoretical and empirical gaps in aquatic education and drowning prevention research (Leavy et al., 2016; Stallman, 2017). Combining aquatic education scholarship (Button et al., 2022; Guignard et al., 2020; Langendorfer, 2015; Langendorfer et al., 2018; Moran et al., 2012; Quan et al., 2015; Stallman, 2017) with ecological dynamics (Durden Myers et al., 2022b; Rudd et al., 2020), socioecological approaches (Carolo et al., 2024; Sallis & Owen, 2015), and philosophical foundations (Pot et al., 2018; Whitehead, 2001, 2007, 2010) can advance research, practice and policy coherence in this field. Three policy priorities emerge:

- (1) Integrate aquatic PL into national PA, physical education, and drowning prevention strategies, and training frameworks.
- (2) Ensure equitable access to aquatic environments, particularly for high-risk groups such as children, migrants and rural populations.
- (3) Promote and fund cross-sectoral collaborations.

As for research, it is considered the following priorities:

- (1) Identifying PL elements linked to blue PA engagement and drowning prevention.
- (2) Developing aquatic PL-specific assessment tools for ecological program evaluation.
- (3) Designing and testing interventions that integrate PL principles into aquatic education, drowning prevention and blue PA promotion.

Adopting a socioecological perspective is essential to integrate PL across blue space, education and health promotion policies. Such collaboration among international, national and

community organizations can strengthen responses to insufficient PA levels (Guthold et al., 2020; World Health Organization [WHO], 2022), high drowning rates (WHO, 2014, 2020a) and threats to aquatic environmental health through the promotion of pro-environmental behaviors (Brymer & Gray, 2010; Larson et al., 2017; Waiti & Awatere, 2019).

PL promotes a holistic understanding of factors shaping lifelong engagement in aquatic activities, countering narrow, skill- or performance-focused sport models (Dudley, 2019; Higgs et al., 2019). Schools – through whole-school approaches to PA promotion – are key contexts for implementing PL-informed aquatic programs that offer equitable, safe, and challenging learning experiences. Collaborative partnerships and high-quality professional training are crucial to ensure accessible, sustainable, and educationally rich blue physical activity opportunities for all.

Strengths and limitations

While this work carries limitations – namely potential subjectivity and the absence of a pre-registered protocol – it is grounded in evidence and supported by clear philosophical assumptions. These foundations informed the proposed definition and core attributes of aquatic PL. The synthesis reflects both scientific knowledge and the authors’ professional perspectives in aquatic education, safety, and PL. Given the limited empirical research on PL in aquatic contexts, some arguments remain theoretically based. Nonetheless, the paper’s conceptual depth, critical analysis, and innovative outlook offer valuable insights that stimulate scholarly debate, and advance understanding and practice in this emerging area.

Conclusion

This critical review underscores the urgent need for coordinated collaboration among aquatic education, safety research, policymaking, and allied fields – including sport, education and environmental sustainability – to advance safe and high-quality engagement in blue PA. Sustained interdisciplinary dialogue is essential to refine PL’s philosophical and practical foundations and to inform inclusive, context-sensitive programs (Carl et al., 2023; Dudley et al., 2017; Higgs et al., 2019).

As a foundational construct across physical education, sport and recreation, PL seeks to cultivate competent, responsible and resilient individuals who contribute to personal well-being, and community health through lifelong, meaningful participation in PA.

Although concepts such as “aquatic literacy” and “physical literacy in aquatic environments” have recently surfaced in aquatic education research, comprehensive discussions of PL’s pedagogical and conceptual value in this context remain scarce. In response, the authors define “aquatic PL” as “the development of attitudes, values, social behaviors, aquatic physical competence, knowledge and understanding that enable individuals to value and actively engage in safe and sustainable blue physical activities across the lifespan.” This multidimensional framing extends beyond motor proficiency to include cognitive, psychological, and social dimensions, linking individual development with environmental and social responsibility.

Positioned as a unifying framework, PL can address key challenges in aquatic education and professional practice by fostering intersectoral partnerships among sport, education, health, and environmental agencies; enhancing public health through safer, lifelong

engagement in blue PA and reduction of drowning risk factors; and strengthening pedagogical quality through evidence-informed curriculum design and professional development.

Because lifelong engagement in PA is shaped by interaction between individual, and cultural/environmental influences, socioecological models offer a robust basis for designing PL-oriented interventions. Schools are uniquely positioned to translate this rationale into practice – providing equitable, developmentally appropriate aquatic education and professional development that simultaneously promotes active living, strengthens drowning prevention, and fosters sustainable relationships with blue spaces.

Acknowledgements

DC conceived the idea for this review article. DC drafted the versions of the manuscript. JM, DD, and ACQ critically reviewed the manuscript and provided suggestions for improvement. All the authors have read and approved the final submitted version of the manuscript.

Author contributions

CRediT: **Dora M. Carolo:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft; **Dean Dudley:** Supervision, Writing – review & editing; **Ana Catarina Queiroga:** Supervision, Writing – review & editing; **João Martins:** Supervision, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

DC work was supported by the National Funds through FCT-Portuguese Foundation for Science and Technology, I.P. under the Grant 2021.06516. BD. DC and JM work was supported by National Funds through FCT-Portuguese Foundation for Science and Technology, I.P., under the scope of UIDEF - Unidade de Investigação e Desenvolvimento em Educação e Formação, UID/04107/2025, <https://doi.org/10.54499/UID/04107/2025>. ACQ work was supported by FCT-Portuguese Foundation for Science and Technology, I.P. through the projects with references UID/4750/2025 and LA/P/0064/2020 and DOI identifiers <https://doi.org/10.54499/UID/04750/2025> and <https://doi.org/10.54499/LA/P/0064/2020>.

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AI disclosure

We used ChatGPT 5.2 (OpenAI; accessed December 26th) for language editing and reference – format consistency checks. All changes were reviewed and approved by the authors.

Abbreviations

PL	Physical literacy
PA	Physical activity
Aquatic PL	Aquatic Physical Literacy

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