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REVIEW PAPER

Aquatic Interventions in Autism: A Dual-Lens Review of Clinical Efficacy and Community Implementation

Bryan V. Catama[1], Mark Constantine E. Villanueva[2]

[1]Professional Education Department, School of Teacher Education and Liberal Arts, Saint Louis University, Baguio City, Philippines 2600, [2]College of Teacher Education, Quirino State University, Dipintin, Maddela, Quirino, Philippines 3404

Abstract

Accidental drowning is a leading cause of death among children with Autism Spectrum Disorder (ASD), making aquatic interventions a public health priority. Although clinical benefits are well documented, the literature remains fragmented, often separating child-centered physiological and behavioral outcomes from the socioecological barriers faced by caregivers and instructors. To address this gap, this narrative review synthesizes 21 peer-reviewed empirical studies published between 2017 and 2025. Using a dual-lens framework, the review examines both clinical efficacy and community-based implementation. Quantitative evidence shows that structured aquatic programs improve water competence, gross motor skills, and executive functioning. Preliminary findings suggest that these gains may be linked to physiological mechanisms, including increased vagal tone and modulation of inflammatory cytokines [IL-6 and IL-10], which are associated with better sleep regulation and fewer stereotypic behaviors. In contrast, qualitative evidence reveals a serious implementation gap. Although families value aquatic participation as a meaningful activity that reduces parental stress, equitable access remains limited by sensory-challenging pool environments, high costs, and a shortage of autism-informed instructors. Bridging this efficacy-implementation divide requires scalable policy reforms, including task-sharing models in which therapists support mainstream instructors. Larger randomized controlled trials are also needed to strengthen the evidence base and help establish aquatic therapy as an equitably accessible standard of care.

Keywords: *Autism spectrum disorder, aquatic therapy, water safety, swimming interventions, caregiver perspectives*

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition marked by persistent difficulties in social communication, restricted patterns of behavior, and frequent gross motor impairments (American Psychiatric Association, 2013; Pusponegoro et al., 2016). Within this population, water safety is a major public health concern. Accidental drowning remains a leading cause of death among children with ASD, a risk commonly linked to attraction to water, limited danger awareness, and wandering or elopement behaviors (Carter & Koch, 2023; Cosart et al., 2025; Guan & Li, 2017; Kemp, Woodson, & Baldino, 2023; Rice et al., 2016). As a result, aquatic interventions should be viewed not only as recreational activities but also as potentially life-saving measures.

Although drowning prevention is often the main reason children with ASD are enrolled in swimming programs, recent research points to broader therapeutic benefits. The literature has moved beyond basic skill acquisition to emphasize the hydrostatic, thermodynamic, and sensory properties of water as forms of somatosensory input that may reduce nervous system hyperarousal (Bell, 2021; Güeita-Rodríguez et al., 2021). Empirical studies indicate that structured aquatic therapy can improve gross motor skills, dynamic balance, and executive functioning (Faraji et al., 2023; Marzouki et al., 2022). Emerging research also examines the neurophysiological and biological mechanisms underlying these outcomes. Aquatic interventions appear to

Correspondence:

Montenegro Sport

B.V. Catama
Saint Louis University, Professional Education Department, School of Teacher Education and Liberal Arts, Bonifacio St., Baguio City, Philippines 2600
E-mail: bvcatama@slu.edu.ph

increase vagal tone, which is associated with improved social behaviors such as eye contact, and to modulate inflammatory cytokines by lowering IL-6 and increasing IL-10 (AdibSaber et al., 2024; Bell, 2021). These changes may help explain reported reductions in restrictive and stereotypic behaviors, as well as improvements in sleep regulation (AdibSaber & Ansari, 2024; Lawson & Little, 2017). However, these mechanistic findings remain preliminary, as many studies rely on small samples and short intervention periods, underscoring the need for larger randomized controlled trials with objective clinical measures (Alecu & Onea, 2025; Kemp et al., 2024).

Beyond child outcomes, qualitative research highlights the wider effects of aquatic interventions on family life. Caregivers often seek swimming lessons because of intense fear that their child may drown (Carter & Koch, 2023; Cosart et al., 2025). Yet successful participation often develops into a meaningful and inclusive family activity. Studies report broader psychosocial benefits, including improved sibling interaction, reduced parental stress, and a stronger sense of community belonging (Alecu & Onea, 2025; Johnson et al., 2021). This shift from safety necessity to valued family occupation underscores the broader contribution of aquatic participation to family quality of life (Carter & Koch, 2023).

Despite strong evidence of clinical and psychosocial benefits, major implementation barriers remain in community settings. Children with ASD are often excluded from mainstream swimming programs because public pools can be sensory-challenging and because autism-informed instructors remain scarce (Cosart et al., 2025; Kraft, 2019). Mainstream instructors frequently report feeling unprepared to address ASD-related behavioral and pedagogical needs, leaving families to depend on costly private lessons or forgo access altogether (Carter & Koch, 2023). This gap reflects a clear form of occupational injustice.

A further limitation is that the literature remains fragmented. Some studies focus narrowly on physiological and behavioral outcomes in controlled clinical settings (AdibSaber et al., 2024; Marzouki et al., 2022), while others examine the lived experiences of caregivers and instructors in community contexts (Carter & Koch, 2023; Cosart et al., 2025). Few reviews integrate both perspectives. This narrative review addresses that gap by synthesizing the dual impacts of aquatic interventions for children with ASD. Using a dual-lens framework, it examines both the clinical and neurobiological outcomes for children and the implementation experiences of caregivers and instructors. In doing so, it aims to clarify how aquatic programs can be optimized and made more equitably accessible, not only to protect children with ASD but also to support their families.

Methods

The aim of this narrative literature review is to critically synthesize the multidimensional effects of aquatic interventions for children with ASD, with attention to both child-centered clinical outcomes and the real-world implementation experiences of caregivers and instructors. To address this dual-lens objective, a comprehensive search was conducted in PubMed, Scopus, and Google Scholar for peer-reviewed empirical studies published between 2017 and 2025. The search strategy combined Medical Subject Headings (MeSH) and targeted free-text terms linked with Boolean operators (AND, OR, and truncation). The core search string was as follows: ("Autism Spectrum Disorder" OR "ASD" OR "autism") AND ("aquatic therapy" OR "swimming" OR "hydrotherapy" OR "water safety" OR "aquatic intervention*") AND ("caregiver*" OR "parent*" OR "motor skills" OR "social interaction" OR "efficacy" OR "implementation").

Initial screening, full-text eligibility assessment, and final article selection were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). The full study selection process is presented in the PRISMA flow diagram in Figure 1.

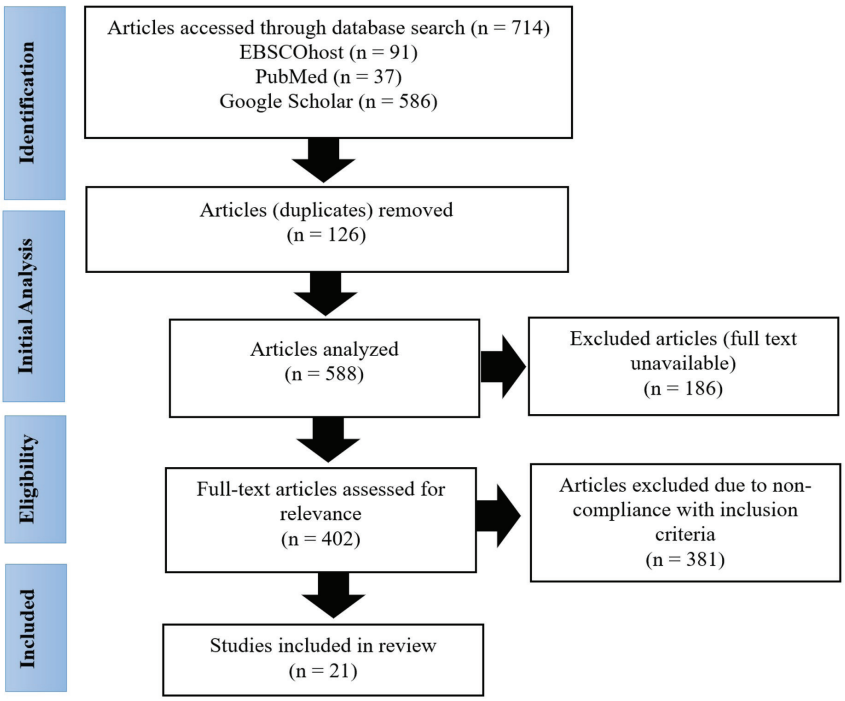

FIGURE 1. PRISMA flow chart of the article selection process

Inclusion Criteria

To ensure a rigorous synthesis, study eligibility was guided by a modified Population, Intervention, Comparison, Outcomes, and Study Design (PICOS) framework. Peer-reviewed empirical studies, including randomized controlled trials, quasi-experimental, observational, single-subject, mixed-methods, and qualitative designs, were included if they evaluated structured aquatic programs. The target population was children and adolescents aged 18 years

Table 1. Summary of included studies grouped by thematic clusters

Study (Author, Year)	Study Design	Participants (N, Age)	Intervention	Key Findings
PART A: Child-Centric Efficacy and Skill Acquisition				
Quraishi & Jarrar (2018)	Quasi-experimental	N=56; 5–8 years	6 months; aquatic therapy, 3 days/ week	Significant improvements were observed in both sensory modulation (Short Sensory Profile) and activities of daily living (WeeFIM).
Battaglia et al. (2019)	Case report/ Multi-method	N=3; 10–15 years	12 weeks; Multi-systemic Aquatic Therapy (CI-MAT)	Participants significantly improved gross motor proficiency (locomotor and object control skills). The highest social gains included eye contact and complying with turns.
Hubená (2021)	Observational	N=5 boys; 5–10 years	10 months; preparatory swimming lessons	Using the Štochl scale, all probands showed an overall improvement in basic aquatic skills, with the most significant gains in head dunking and starfish positions.
Shayakhmetova et al. (2021)	Quasi-experimental	N=5 boys; 9–10 years	6 months; swimming using visually associative boards	All children successfully mastered basic survival tasks, including immersion, exhalation in water, and sliding on the chest.
Vodakova et al. (2022)	Single-subject design	N=7; 7–12 years	7 weeks; Halliwick method	Participants improved aquatic skills (mental adjustment, breathing control) measured by the WOTA1, and gross motor function measured by the GMFM.
Marzouki et al. (2022)	Randomized controlled trial (RCT)	N=22; 6–7 years	8 weeks; Technical vs. Game-based aquatic training	Both experimental groups showed significant improvements in gross motor skills and reduced stereotypy compared to controls, with no significant differences between the two modalities.
Faraji et al. (2023)	Quasi-experimental	N=40; 7–10 years	8 weeks; Response-Oriented Aquatic (ROA) exercise	ROA exercise significantly improved gross motor skills (static/dynamic balance, throwing) and executive function (cognitive flexibility and working memory).
Sugiharto et al. (2023)	Research & Development (R&D)	N=70; 6–12 years	N/A (Developed a freestyle learning model)	The newly developed freestyle swimming learning model proved both feasible and highly effective in improving swimming skills for children with autism in special schools.
Kemp et al. (2024)	Randomized controlled trial (RCT)	N=37; 5–9 years	10 weeks; AquOTic intervention	Children receiving AquOTic demonstrated significant, large-effect-size improvements in water competency (measured by WOTA 1 & 2) and foundational swim skills.
PART B: Underlying Mechanisms of Action (Physiological & Sleep)				
Lawson & Little (2017)	Pre-post feasibility study	N=10 boys; 5–12 years	8 weeks; Sensory Enhanced Aquatics	Children with increased sensory sensitivity and decreased autism severity showed significantly decreased sleep disturbance following the intervention.
Bell (2021)	Quasi-experimental	N=64 (32 ASD, 32 TD); ~9–10 years	Single ~20-minute aquatic session	The aquatic intervention significantly increased vagal tone in participants with ASD. This increase positively correlated with social skills, including eye contact and laughing.
AdibSaber et al. (2024)	Randomized controlled trial (RCT)	N=40 boys; 6–14 years	10 weeks; Aquatic exercise + Vitamin D3	Only the combination of aquatic exercise and Vitamin D3 supplementation significantly reduced pro-inflammatory IL-6 and increased anti-inflammatory IL-10 serum levels.
AdibSaber & Ansari (2024)	Quasi-experimental	N=30 boys; 8–14 years	10 weeks; Aquatic vs. Kata techniques	Both modalities improved stereotypic behaviors. The aquatic exercise group achieved superior scores in reducing sleep anxiety and parasomnias compared to the Kata group.

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Table 1. Summary of included studies grouped by thematic clusters

Study (Author, Year)	Study Design	Participants (N, Age)	Intervention	Key Findings
PART C: Real-World Implementation & Lived Experiences				
Kraft (2019)	Qualitative/ Phenomenological	N=2 (1 therapist, 1 instructor)	N/A (Explored instructor experiences)	Swimming fostered socialization, but instructors faced challenges with communication and sensory distractions, highlighting a need for physical assistance and relationship-building.
Johnson et al. (2021)	Mixed methods (Pilot/Feasibility)	N=10 dyads; 5.5–11 years	3 weeks (12 sessions); private swim program	Parents reported improved child sleep and decreased stress. Qualitative themes revealed major challenges regarding sibling integration and parental fear of drowning.
Güeita-Rodríguez et al. (2021)	Mixed methods	N=6; 6–12 years	7 months; Water Specific Therapy (Halliwick)	While quantitative metrics showed physical improvements, embedded qualitative data revealed parents placed highest value on unexpected gains in emotional reciprocity and non-verbal communication.
Carter & Koch (2023)	Qualitative/ Phenomenological	N=5 parents, 6 swimming teachers	N/A (Explored lived experiences)	Parents initially sought lessons for survival but found them to be a meaningful occupation. Teachers found lessons rewarding but faced a critical lack of knowledge and autism-specific training.
Kemp, Woodson, & Baldino (2023)	Mixed methods (Pilot/Feasibility)	N=8; 3–7 years	10 weeks; group-based aquatic OT	81% of individualized goals were met. Parents highly valued the occupational therapy (OT) approach, noting improved safety, tailored sensory adaptations, and decreased family stress.
Bekhet et al. (2023)	Qualitative evaluation	N=10 caregivers	12 sessions; Swimming Training Program	Caregivers found the program acceptable and highly valued instructor creativity. However, parents expressed a desire for instructors to utilize more firmness when managing behavioral issues.
Alecu & Onea (2025)	Mixed methods	N=36; 8–16 years	8 weeks; therapeutic swimming (post-ABA)	Using the PPQ-Autism-Swim, parents reported highly significant improvements in child well-being, learning, and self-confidence. Qualitative data reinforced benefits like calmer behavior and improved sleep.
Johnson et al. (2025)	Qualitative (Focus groups/ Interviews)	N=21 parents	N/A (Explored lived experiences)	Identified severe systemic barriers including autism traits increasing water safety risks, sensory overload in pools, financial constraints, and a critical lack of prepared instructors.

or younger with a medically confirmed diagnosis of ASD. To address real-world implementation, studies involving primary caregivers, parents, or aquatic instructors of these children were also included. Interventions included therapeutic swimming, aquatic occupational or physical therapy, and adapted recreational lessons using structured approaches such as the Halliwick concept, AquOTic, or sensory-enhanced aquatics. Studies were eligible regardless of control group type, including active controls, waitlist controls, and single-group pre-post designs. To capture both clinical efficacy and community implementation, studies had to report either quantitative child-centered outcomes, such as gross motor skills, water safety, sleep, vagal tone, and inflammatory cytokines (IL-6 and IL-10), or qualitative adult-centered outcomes related to feasibility, parental stress, and systemic or environmental barriers.

Exclusion Criteria

Studies were excluded if they focused only on adults with ASD (older than 18 years), as the literature primarily addresses childhood and adolescence. Studies involving other primary neurodevelopmental or physical disabilities were also excluded unless they reported separate data for an ASD subgroup. The review further excluded unstructured aquatic recreation, animal-assisted aquatic therapies, and land-based interventions without a direct aquatic comparison. Epidemiological studies on drowning rates without a preventive aquatic intervention, and studies limited to the biochemical properties of pool environments, were also excluded. To maintain methodological rigor, non-peer-reviewed sources, gray literature, opinion pieces, and conference abstracts without complete datasets were not included.

Results

Table 1 summarizes the 21 empirical studies included in this narrative review. To reflect the manuscript's dual-lens focus, the studies are organized into three thematic clusters: (A) child-centered efficacy and skill acquisition, (B) underlying mechanisms of action (physiological and sleep), and (C) real-world implementa-

tion and lived experiences. For each study, the table reports the authors and year, study design, participant characteristics, intervention parameters, and primary findings, providing a clear comparative overview of the current literature.

Discussion

This narrative literature review synthesizes the dual impacts of aquatic interventions for children with ASD, examining both direct clinical outcomes for children and the implementation experiences of caregivers and instructors. By linking clinical efficacy with community-based implementation, the review offers a holistic understanding of how aquatic programs can be optimized to support children with autism and their broader family ecosystem.

Child-centered efficacy and clinical outcomes

The literature consistently shows that structured aquatic environments support physical, cognitive, and psychosocial development in children with ASD. Water safety is especially critical, as drowning is a leading cause of accidental death among children with autism, largely due to wandering and attraction to water without a clear sense of danger (Cosart et al., 2025; Kemp et al., 2023). Interventions based on the Halliwick concept and occupational therapy programs such as AquOTic effectively build foundational water competence, survival skills, and breath control, thereby reducing drowning risk (Güeita-Rodríguez et al., 2021; Kemp et al., 2024; Vodakova et al., 2022).

Beyond safety, the physical properties of water, including hydrostatic pressure, resistance, and buoyancy, make it an effective setting for addressing common motor deficits in ASD, particularly poor balance and coordination (Quraishi & Jarrar, 2018; Sugiharto et al., 2023). Evidence suggests that aquatic therapies, whether technical, game-based, or response-oriented, improve gross motor skills such as object control, dynamic balance, and locomotion (Battaglia et al., 2019; Faraji et al., 2023; Marzouki et al., 2022). These physical benefits also appear to extend to executive functioning, with response-oriented aquatic exercises improving cognitive flexibility and working memory (Faraji et al., 2023).

Aquatic settings also promote psychosocial development. Children in swimming interventions show gains in joint attention, peer acceptance, and emotional reciprocity, along with reductions in hyperactivity, aggression, and stereotypic behaviors (AdibSaber & Ansari, 2024; Alecu & Onea, 2025; Marzouki et al., 2022). Regular aquatic therapy is also associated with longer sleep duration and lower levels of sleep anxiety and parasomnias, particularly among children with high sensory avoidance profiles (AdibSaber & Ansari, 2024; Johnson et al., 2021; Lawson & Little, 2017).

Underlying mechanisms of action

The literature identifies several biological, neurological, and sensory mechanisms that may explain the broad benefits of aquatic therapy. From a sensory perspective, hydrostatic pressure provides continuous proprioceptive and tactile input, often described as a "massive hug," which may reduce hyperarousal and regulate sensory processing difficulties (Alecu & Onea, 2025; Quraishi & Jarrar, 2018).

Neurologically, Polyvagal Theory offers one explanation for improved social engagement. Swimming practices such as breath control and submersion may induce meditative states and increase vagal tone, a physiological change associated with better eye contact, laughter, and cooperative play (Bell, 2021). Biologically, aquatic exercise may also reduce systemic inflammation. Aerobic swimming depletes muscle glycogen stores, which may lower the pro-inflammatory cytokine interleukin-6 (IL-6). When combined with vitamin D3 supplementation, aquatic exercise appears to further decrease IL-6 and increase the anti-inflammatory cytokine IL-10, with corresponding improvements in social interaction deficits (AdibSaber et al., 2024). Finally, the neurotrophic hypothesis suggests that the metabolic demands of aquatic exercise increase cerebral blood flow and stimulate brain-derived neurotrophic factor (BDNF), thereby supporting neuroplasticity and executive functioning (Faraji et al., 2023).

Real-world implementation and lived experiences

Although clinical outcomes are largely positive, translating aquatic interventions into community programs reveals substantial systemic and logistical barriers. Qualitative syntheses show that many parents initially seek swimming lessons out of an intense fear of drowning but later come to view swimming as a meaningful and inclusive family activity that reduces stress and fosters a sense of achievement (Carter & Koch, 2023; Cosart et al., 2025; Kemp et al., 2023).

These experiences also expose major implementation challenges. Parents and mainstream instructors alike report frustration over the lack of autism-specific training. Instructors often feel unprepared and rely on trial and error because they lack formal preparation for ASD-related behavioral and sensory needs (Carter & Koch, 2023; Kraft, 2019). Public pools can also create serious sensory barriers, as echoing acoustics and splashing may trigger sensory overload and meltdowns (Cosart et al., 2025). Parents face additional logistical strain in managing neurotypical siblings during specialized one-to-one lessons, often without access to concurrent childcare (Bekhet et al., 2023; Johnson et al., 2021). Financial, geographic, and systemic inequities, including high costs and long waitlists, further limit access for marginalized communities, making inclusive water safety an urgent issue of occupational justice (Carter & Koch, 2023; Cosart et al., 2025).

Methodological quality and gaps in the literature

Research on aquatic interventions is marked by a tension between individualized clinical observation and the demand for stronger statistical rigor. Much of the foundational literature relies on small convenience samples, single-subject designs, or quasi-experimental pre-post studies without active control groups (Lawson & Little, 2017; Vodakova et al., 2022). Although more recent work reflects a needed shift toward large-scale mixed-methods studies and randomized controlled trials (RCTs) (Alecu & Onea, 2025; Kemp et al., 2024; Marzouki et al., 2022), the independent effects of aquatic therapy often remain difficult to isolate because of confounding factors such as concurrent Applied Behavior Analysis (ABA) or natural maturation (Alecu & Onea, 2025).

Measurement validity also remains contested. Standardized tools such as WOTA and GMFM are important for objective assessment, but they may produce ceiling effects in higher-functioning children or fail to capture small gains in beginners, which has led to the use of modified measures such as the Štochl assessment (Hubená, 2021; Kemp et al., 2024; Vodakova et al., 2022). At the same time, many studies depend on custom parent-report questionnaires to assess broader psychosocial outcomes such as sleep and behavior. Although these measures improve ecological validity, they also introduce expectancy bias and halo effects (Alecu & Onea, 2025).

The literature also shows clear demographic selection bias. Studies often require participants to follow verbal instructions or to have received prior behavioral therapy, which systematically excludes minimally verbal children and those with profound cognitive impairments. Representation is also limited for females, fathers, and non-English-speaking minority families (Alecu & Onea, 2025; Cosart et al., 2025; Kemp et al., 2024).

Implications for practice and policy

To address these gaps and advance occupational justice, the literature offers several practical recommendations for practitioners and policymakers. A key strategy is task-sharing. Rather than fully medicalizing service delivery, healthcare professionals, including occupational therapists, can support community programs by training mainstream instructors or supervising university therapy students as one-to-one "swim buddies," creating a more scalable and cost-effective model (Carter & Koch, 2023; Kemp et al., 2023). Practice should also adopt a whole-family approach by providing sibling childcare or allowing parents to join sessions in the water, which may reduce child anxiety and strengthen parent confidence (Bekhet et al., 2023; Johnson et al., 2021).

Pedagogical adaptations in the pool are equally important. Instructors should use autism-specific strategies such as predictable routines, visual schedules, and sensory-adapted equipment, including visually engaging swim boards shaped like rockets or animals, to reduce tactile aversion and support participation (Kraft, 2019; Shayakhmetova et al., 2021). At the policy level, the inequities identified by caregivers call for stronger structural support. Recommended reforms include insurance coverage for adapted swimming lessons, integration of water safety goals into Individualized Education Programs (IEPs), and proactive distribution of drowning-prevention resources in pediatric clinics to better protect this vulnerable population (Cosart et al., 2025).

Conclusion

This dual-lens narrative review indicates that aquatic interventions for children with ASD may offer benefits that extend beyond the prevention of accidental drowning. Across the literature, structured aquatic therapy is associated with improvements in gross motor skills, executive functioning, and social-emotional regulation, suggesting its potential value as a multidimensional therapeutic modality. These outcomes may be partly explained by neurophysiological and biological mechanisms, as the sensory characteristics of water have been linked to reduced hyperarousal, enhanced vagal regulation, and modulation of inflammatory markers such as IL-6 and IL-10, which may, in turn, support sleep quality and social engagement.

At the same time, the review highlights a persistent gap between therapeutic promise and community-based accessibility. Caregivers and instructors consistently identify structural barriers, including the limited availability of autism-informed instructors, sensory demands within public aquatic environments, and financial constraints, all of which restrict equitable participation. Addressing these barriers will require coordinated action at both practice and policy levels. Scalable, family-centered task-sharing approaches, in which healthcare professionals equip mainstream swimming instructors with autism-relevant knowledge and strategies, may represent a feasible pathway for broader implementation. Framed in this way, equitable access to aquatic interventions is not solely a service delivery issue but also a question of occupational justice with important implications for the safety and well-being of children with ASD and their families.

Directions for Future Research

Future research should strengthen the evidence base by moving beyond small-scale exploratory studies toward adequately powered randomized controlled trials that incorporate standardized outcome measures and longitudinal follow-up. Greater consistency in intervention design is also needed to clarify dose-response relationships and identify the conditions under which aquatic therapy is most effective. In addition, further investigation is warranted into the potential synergistic effects of combining aquatic interventions with other behavioral, developmental, or neurobiological supports. Finally, implementation research should be prioritized to examine the scalability, feasibility, and equity of community-based delivery models, with particular attention to demographic and socioeconomic disparities that may shape access across diverse populations.

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Conflict of Interest

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