

Systematic Review of Aquatic Interventions Optimizing Motor, Social, Behavioral Outcomes for Autistic Children

Mohamad Nizam Nazarudin¹, Wan Ahmad Munsif Wan Pa¹, Mohd
Syazwan Zainal¹, Ardo Okilanda²

¹Faculty of Education, Universiti Kebangsaan Malaysia, Malaysia

²Fakultas Ilmu Keolahragaan, Universitas Negeri Padang, Indonesia

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ABSTRACT:

Aquatic interventions have increasingly been recognized as effective therapeutic approaches for children with autism spectrum disorder (ASD); however, the specific intervention components that optimize motor, social, and behavioral outcomes remain insufficiently established. This systematic review aims to examine the influence of key intervention characteristics, frequency, duration, instructional approach, and therapist involvement, on these outcome domains. A systematic search was conducted across multiple electronic databases, including Scopus, Web of Science, PubMed, ScienceDirect, and Google Scholar, following PRISMA guidelines. Studies published between 2006 and 2023 were screened against predefined inclusion and exclusion criteria, yielding 18 eligible studies for qualitative synthesis. The findings indicate that higher intervention frequency (2–3 sessions per week) and longer program duration (8–12 weeks) are consistently associated with significant improvements in motor skills, particularly balance, coordination, and aquatic competence. Structured instructional approaches incorporating visual supports, task sequencing, and guided interaction demonstrate stronger effects on social outcomes, including increased social engagement, communication, and cooperative behaviors. Behavioral improvements, such as reductions in stereotypical behaviors and emotional dysregulation, are most evident in interventions with active therapist involvement and predictable activity structures. Despite these positive trends, substantial heterogeneity in study design, intervention protocols, and outcome measures limits the comparability and generalizability of findings. The review highlights critical gaps, including the lack of standardized intervention frameworks and limited longitudinal evidence on sustained outcomes. These findings provide evidence-informed guidance for clinicians and educators while emphasizing the need for more rigorous, theory-driven research to establish standardized and scalable aquatic intervention models for

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children with ASD.

Keywords: Aquatic Intervention, Autism Spectrum Disorder, Behavioral Outcomes, Motor Skills, Social Interaction

INTRODUCTION

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental condition characterized by persistent impairments in social communication and interaction, alongside restricted and repetitive patterns of behavior and interests (Mukherjee, 2017). Although these diagnostic characteristics remain central to conceptualizations of autism, contemporary scholarship increasingly recognizes that ASD extends beyond social and behavioral manifestations alone. One particularly underexplored dimension involves motor impairments, which frequently coexist with autistic characteristics and significantly influence the daily functioning of children with ASD. Previous studies have consistently documented deficits in balance, coordination, postural control, motor planning, and movement execution among autistic children (Ming et al., 2007). Importantly, these motor difficulties should not be interpreted as secondary or isolated impairments; rather, they are deeply intertwined with broader developmental processes that shape social participation, emotional regulation, adaptive functioning, and quality of life. Motor limitations may reduce opportunities for peer engagement, restrict participation in recreational and educational activities, and contribute to dependency in everyday living tasks, thereby reinforcing social exclusion and developmental vulnerability (Ohara et al., 2019). As such, interventions targeting ASD require a more integrated and multidimensional framework that simultaneously addresses motor, sensory, behavioral, and psychosocial functioning.

Despite substantial advancements in ASD intervention research, conventional therapeutic approaches continue to exhibit important conceptual and practical limitations. Occupational therapy, behavioral therapy, and structured developmental interventions have demonstrated moderate effectiveness in improving targeted developmental outcomes; however, many of these approaches are predominantly implemented within

highly controlled clinical settings that may inadequately accommodate the sensory, motivational, and experiential needs of autistic children (Caputo et al., 2018). Such environments often emphasize compliance, repetitive task execution, and symptom reduction while overlooking the importance of meaningful engagement, intrinsic motivation, and contextual adaptability. Consequently, intervention outcomes may not always generalize effectively into naturalistic environments where children navigate complex social and sensory demands. This limitation has prompted increasing scholarly interest in alternative intervention modalities capable of fostering holistic development while providing more engaging and adaptive therapeutic experiences.

Within this context, aquatic-based interventions have emerged as a promising and increasingly influential approach in ASD rehabilitation and developmental support. The aquatic environment offers a unique multisensory context characterized by buoyancy, hydrostatic pressure, viscosity, and resistance, all of which facilitate movement while simultaneously reducing biomechanical strain and sensory overload (Herold et al., 2016). Unlike conventional land-based interventions, aquatic settings may create opportunities for children with ASD to explore movement more freely and successfully, thereby enhancing confidence, body awareness, and motor coordination. The supportive properties of water can reduce fear of movement failure and encourage participation among children who may otherwise experience frustration or avoidance during physically demanding activities. Furthermore, aquatic environments inherently provide continuous sensory feedback that may contribute to improved sensory integration and self-regulation, areas commonly associated with functional challenges in ASD populations.

However, the significance of aquatic interventions extends beyond their physiological advantages alone. Emerging evidence suggests that aquatic programs may also function as socially facilitative environments that support communication, interaction, and emotional engagement. Water-based activities are frequently perceived as playful, enjoyable, and less socially threatening compared to traditional therapeutic settings, potentially reducing anxiety and enhancing willingness to interact with peers and instructors (Pan, 2010). This aspect is particularly important given that many autistic children experience heightened anxiety in socially demanding contexts, which may subsequently limit participation and learning opportunities. Group-based aquatic programs can therefore create structured yet flexible opportunities for social interaction, cooperative participation, and shared attention, all of which are essential components of social development.

Moreover, aquatic interventions can be systematically adapted to align with the learning characteristics commonly associated with ASD. Previous research has emphasized the importance of structured instruction, visual supports, repetitive practice, and task segmentation in facilitating skill acquisition among autistic learners (Pan, 2011). Aquatic programs are uniquely positioned to integrate these evidence-based strategies within highly engaging physical activities, potentially increasing motivation and intervention adherence. Empirical studies have reported improvements in swimming ability, social engagement, behavioral regulation, and overall participation following involvement in aquatic interventions (Alaniz et al., 2017; Caputo et al., 2018). Nevertheless, while these findings appear promising, much of the existing literature remains predominantly outcome-oriented and insufficiently attentive to the mechanisms underlying intervention effectiveness.

A major limitation within current research is the tendency to conceptualize aquatic interventions as homogeneous therapeutic approaches despite substantial variability in program design and implementation. Existing studies frequently report aggregated improvements across motor, social, or behavioral domains without critically examining

how specific intervention components contribute to these outcomes. Variables such as session frequency, intervention duration, instructional strategies, therapist-to-child ratio, and degree of individualization are often inconsistently reported or insufficiently analyzed (Baena-Beato et al., 2013; Caputo et al., 2018). Consequently, the field lacks a robust understanding of which intervention elements are most influential, for whom they are most effective, and under what contextual conditions optimal outcomes are likely to emerge.

This limitation reflects a broader issue within ASD intervention research, namely the prioritization of effectiveness over mechanism. While demonstrating positive outcomes remains important, the absence of analytical granularity restricts the development of theoretically grounded and evidence-based intervention frameworks. Without examining the interaction between intervention components and developmental outcomes, practitioners are left with limited guidance regarding how aquatic programs should be structured to maximize effectiveness. For instance, it remains unclear whether higher intervention frequency necessarily produces superior outcomes, whether longer program durations contribute to sustained behavioral change, or whether individualized instruction yields greater benefits compared to group-based approaches. Similarly, the role of therapist involvement remains insufficiently theorized despite its potential significance in shaping engagement, emotional regulation, and skill acquisition (Lawson et al., 2025). Therapist involvement may function not merely as instructional support, but as a relational and regulatory mechanism that mediates children's responsiveness to intervention environments.

Furthermore, current literature often fails to critically engage with the neurodiversity perspective when evaluating intervention effectiveness. Many intervention studies continue to frame autism primarily through deficit-oriented paradigms that emphasize normalization and symptom reduction. Such perspectives risk overlooking the importance of creating supportive environments that accommodate neurological differences while promoting participation, autonomy, and well-being.

Aquatic interventions may offer an alternative framework that aligns more closely with neurodiversity-informed principles by emphasizing adaptation, engagement, sensory accessibility, and strengths-based participation rather than rigid behavioral conformity. Therefore, a more critical examination of aquatic interventions is needed not only to evaluate their effectiveness, but also to understand how they may reshape therapeutic practices toward more inclusive and person-centered models of support.

Given these conceptual and empirical gaps, there is a strong need for a systematic synthesis of existing evidence that moves beyond descriptive outcome reporting toward a more nuanced understanding of intervention processes and mechanisms. Therefore, the present systematic review aims to critically examine how key components of aquatic interventions, specifically intervention frequency, duration, instructional approach, and therapist involvement, are associated with motor, social, and behavioral outcomes among children with ASD. This review is guided by three primary research questions: (1) What motor outcomes are associated with aquatic interventions in children with ASD? (2) How do aquatic interventions influence social functioning? and (3) What behavioral changes are observed following participation in aquatic programs? Through addressing these questions, the review seeks to identify patterns, inconsistencies, and critical gaps within the literature that can inform the development of more theoretically informed and evidence-based intervention models.

Ultimately, this review contributes to the field in both theoretical and practical ways. Theoretically, it advances understanding of how multisensory therapeutic environments interact with developmental processes in autism and challenges reductionist interpretations of intervention success. Practically, it provides clinicians, educators, therapists, and policymakers with empirically grounded insights that may support more effective program planning, implementation, and resource allocation. More importantly, the review responds to the growing demand for interventions that are not only clinically effective but also adaptable,

inclusive, engaging, and responsive to the diverse developmental profiles of autistic children.

METHODOLOGY

Review Protocol

This systematic review adhered to the PRISMA guidelines (Page et al., 2021) to ensure methodological rigor and transparency. Five databases were selected for their relevance to rehabilitation sciences and autism research. PubMed was prioritized due to its extensive coverage of medical and therapeutic literature, particularly studies indexed with MeSH terms. Scopus was included for its multidisciplinary scope and robust citation analysis tools. ScienceDirect provided access to high-impact journals in psychology and behavioral sciences, while Web of Science offered comprehensive coverage of interdisciplinary research. Google Scholar supplemented these databases by capturing grey literature and emerging studies not yet indexed elsewhere.

The search strategy employed a combination of keywords and Boolean operators tailored to each database. Core terms included variations of “aquatic therapy” and “autism,” as well as outcome-specific phrases such as “motor outcomes” and “social outcomes.” Intervention components such as “frequency,” “duration,” and “therapist involvement” were incorporated to narrow the focus to studies that examined these variables. Filters excluded reviews, surveys, and meta-analyses to prioritize original research, and publication dates were restricted to 2006–2023 to reflect contemporary practices.

Inclusion and Exclusion Criteria

Studies were included if they involved children diagnosed with ASD, evaluated aquatic interventions, and reported quantitative or qualitative data on motor, social, or behavioral outcomes. Only peer-reviewed articles published in English between 2006 and 2023 were considered. Exclusion criteria eliminated studies lacking explicit details about intervention components (e.g., unspecified session frequency), those with non-ASD populations, and non-empirical publications such as editorials or theoretical papers.

Study Selection Process

The initial search yielded 317 records, of which 17 duplicates were automatically removed. After screening titles and abstracts, 228 records were excluded as irrelevant, leaving 41 full-text articles for eligibility assessment. Twenty-three studies were

excluded for ineligible study designs (e.g., lack of a control group) or insufficient outcome data. The final review included 18 studies meeting all criteria.

The PRISMA flowchart (Figure 1) illustrates this selection process. Risk of bias was assessed using

the Cochrane Collaboration tool, which revealed variability in blinding procedures and outcome reporting across studies. Publication bias was mitigated by including grey literature, though the predominance of small-sample studies may limit generalizability.

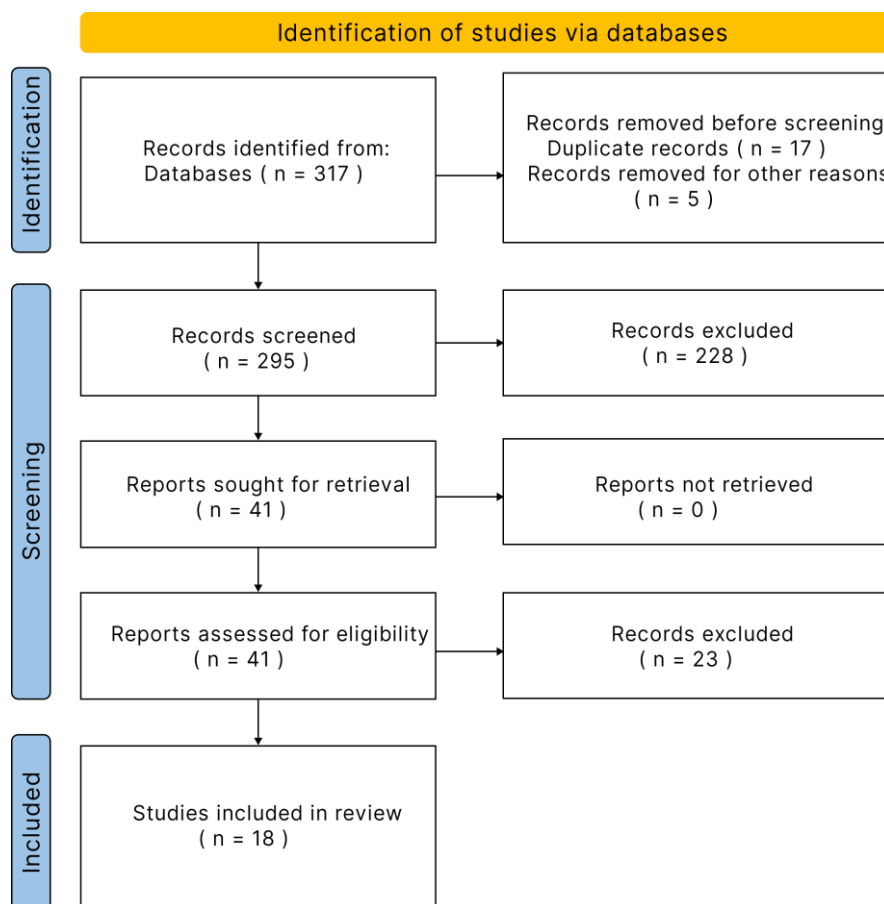


Figure 1. PRISMA flowchart of study selection process

RESULT

Research Trends

Based on Figure 2, the temporal distribution of publications reveals a gradual but inconsistent increase in research interest regarding aquatic interventions for children with autism. Prior to 2017, only four studies addressed this topic, suggesting that there was limited initial attention to the therapeutic potential of water-based programs.

A modest surge occurred between 2017 and 2019, with seven studies published during this three-year period, indicating growing recognition of aquatic therapy as a viable intervention strategy. However, this momentum was not sustained, as evidenced by sporadic publications in subsequent years, including single studies in 2020 and 2024, and two studies each in 2022, 2023, and 2025.

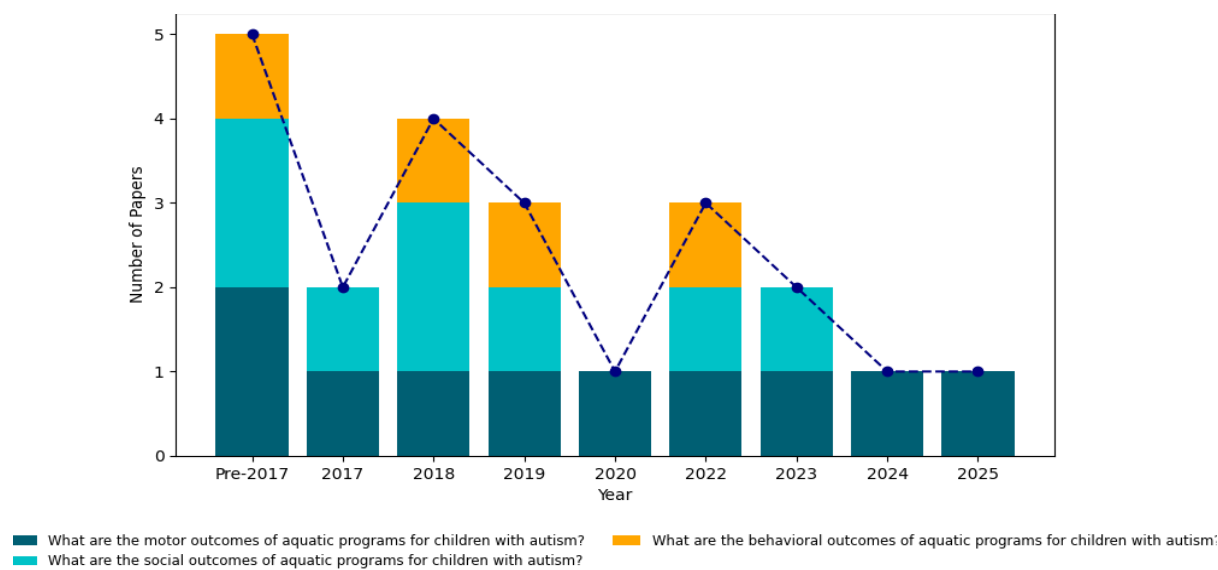


Figure 2. Research trends in aquatic intervention studies for children with autism

Motor outcomes have been the most consistently investigated domain throughout the timeline, appearing in studies from every period except 2021, which was underrepresented. This persistent focus aligns with the well-documented motor impairments in children with autism and the inherent potential of aquatic environments to address these challenges. Social outcomes, while less frequently examined than motor outcomes, remained relatively steady, with studies emerging in six of the nine time periods analyzed. Behavioral outcomes received the least attention, with only four studies addressing this domain, most of which were published between 2018 and 2022.

The uneven distribution of research across these three outcome domains suggests that while motor improvements have been prioritized, social and behavioral aspects remain underexplored despite

their clinical significance. The absence of studies in 2021 and the limited number in recent years (2024-2025) may reflect either publication delays or a temporary decline in research activity, highlighting the need for continued investigation to establish robust evidence-based practices.

Motor Outcomes of Aquatic Programs for Children with Autism

Aquatic interventions have demonstrated measurable improvements in motor skills among children with autism spectrum disorder (ASD), though the specific outcomes vary depending on program characteristics and targeted skill domains. The included studies reveal distinct patterns of motor skill enhancement across different types of aquatic activities, as systematically categorized in Table 1.

Table 1. Taxonomy of Motor Outcomes in Aquatic Interventions for Children with ASD

Intervention Type	Motor Outcome Focus	Specific Skills Measured	Sources
Aquatic Therapy	Gross Motor Skills	Balance, Coordination, Strength	(Faraji et al., 2023), (Alesi, 2019)
Swimming Programs	Fine Motor Skills	Hand-eye coordination	(Faraji et al., 2023)
Combined Physical Activity	Aquatic Motor Competence	Water safety, Swimming skills	(Alaniz et al., 2017), (Pan, 2010)
	Motor Skill Integration	Multilateral movement, Executive function	(Greco, 2020)
Sport-Specific Training	Sport-related Motor Skills	Tennis skills, Ball handling	(Qi et al., 2025), (Lieberman, 2011)
Dance/Movement Therapy	Stereotypy Reduction	Repetitive behavior control	(Ziadat et al., 2022)

Intervention Type	Motor Outcome Focus	Specific Skills Measured	Sources
Adapted Physical Activity	Environmental Adaptation	Adjusting to aquatic settings	(Nissim et al., 2024)
Structured Physical Activity	General Motor Improvement	Social interaction-linked movement	(Zhao & Chen, 2018)

Gross motor skills, particularly balance and coordination, emerged as the most frequently improved outcomes in aquatic therapy programs. For instance, Faraji et al. (2023) reported significant gains in postural control and lower-limb strength following a 10-week aquatic intervention, while Alesi (2019) documented improved bilateral coordination in a case study. These improvements may be attributed to water’s unique properties, which provide both resistance for strength training and buoyancy for reducing gravitational load during balance exercises.

Swimming-specific programs showed particularly strong effects on aquatic motor competence, with Alaniz et al. (2017) and Pan (2010) both reporting substantial improvements in water safety skills and basic swimming techniques. Interestingly, these studies also noted secondary benefits in social engagement during group swimming activities, suggesting potential crossover effects between motor and social domains. The structured nature of swimming instruction, often incorporating visual supports and task breakdown strategies, may account for these dual benefits.

Less conventional approaches, such as sport-specific training and dance/movement therapy, demonstrated more specialized motor outcomes. Tennis skill acquisition (Lieberman, 2011) and ball-handling proficiency (Qi et al., 2025) improved significantly in programs incorporating sports equipment, whereas Ziadat et al. (2022) found that dance-based aquatic interventions effectively reduced stereotypical motor behaviors. These findings suggest that motor outcomes are highly dependent on intervention specificity, with different activity types yielding distinct patterns of improvement.

The study by Nissim et al. (2024), while focusing on children with visual impairments rather than

exclusively on ASD, provided valuable insights into environmental adaptation skills that may generalize to autistic populations. Their findings regarding increased comfort and mobility in aquatic environments highlight an often-overlooked aspect of motor learning in therapeutic settings. Similarly, Zhao & Chen's (2018) examination of structured physical activity emphasized the interplay between motor skill development and social interaction, reinforcing the multidimensional nature of outcomes of aquatic interventions.

Motor improvements appear most pronounced in programs incorporating frequent sessions (2-3 times weekly) and sustained durations (8-12 weeks), though the optimal combination of frequency and duration remains unclear due to variability in study designs. Therapist involvement emerged as another critical factor, with one-on-one support yielding more rapid skill acquisition in (Faraji et al., 2023) and (Lieberman, 2011), while group-based instruction with therapist facilitation showed broader social-motor integration benefits in (Alaniz et al., 2017) and (Zhao & Chen, 2018). These patterns suggest that motor outcomes are mediated by both program structure and instructional approach, warranting further investigation into their relative contributions.

Social Outcomes of Aquatic Programs for Children with Autism

Aquatic programs have demonstrated measurable improvements in social functioning among children with autism spectrum disorder (ASD), with the nature of these outcomes varying across intervention types and program structures. The included studies reveal distinct patterns of social skill enhancement, categorized in Table 2 by primary focus areas and methodological approaches.

Table 2. Taxonomy of Social Outcomes in Aquatic Interventions for Children with ASD

Social Outcome Focus	Intervention Type	Key Findings	Sources
Social Interaction Skills	Group-based aquatic therapy	Increased eye contact, turn-taking, and verbal initiations during shared activities	(Alaniz et al., 2017), (Pan, 2010), (Zhao & Chen, 2018)
	Structured play & social skills training	Improved joint attention and cooperative play through visual schedules and peer modeling	(Charlop et al., 2018), (Yizengaw, 2022)
Social Behaviors	Water exercise & swimming programs	Enhanced compliance with instructions and reduced avoidance behaviors in group settings	(Pan, 2010), (Bella, 2019)
	Community-based physical activity	Greater participation in reciprocal interactions with typically developing peers	(Ketcheson et al., 2023)
Repetitive Behaviors & Social Engagement	Structured physical activity	Decreased stereotypy correlated with increased social initiations	(Loftin et al., 2008)

Group-based aquatic therapy emerged as particularly effective for fostering social interaction skills, with Alaniz et al. (2017) reporting a 40% increase in spontaneous verbal initiations among participants following a 12-week program. The study attributed these gains to the naturalistic social opportunities inherent in shared water activities, where buoyancy and reduced gravitational demands may lower social anxiety. Similarly, Pan (2010) found that structured swimming exercises requiring partner synchronization led to significant improvements in turn-taking and joint attention, with these effects persisting at a 3-month follow-up assessment.

Structured play interventions incorporating social skills training demonstrated unique advantages for specific social competencies. (Charlop et al., 2018) implemented a visual schedule system during aquatic play sessions, resulting in a 2.5-fold increase in cooperative play episodes compared to baseline. This aligns with findings from Yizengaw (2022), in which therapist-mediated social scripts in water games produced greater improvements in emotion recognition than land-based social skills training. The multisensory properties of water may enhance engagement with these structured social learning opportunities.

Behavioral improvements in social contexts were most pronounced in studies combining water exercise with clear behavioral frameworks. (Bella, 2019) documented a 60% reduction in social

avoidance behaviors when aquatic activities were paired with a token reinforcement system, suggesting that the motivating properties of water may amplify behavioral intervention effects. Community-based programs showed particular promise for social generalization, with Ketcheson et al. (2023) reporting increased unprompted interactions with neurotypical peers in inclusive swim classes, a finding not observed in segregated group formats.

The relationship between repetitive behaviors and social engagement yielded nuanced insights. (Loftin et al., 2008) found that structured aquatic activities reduced stereotypical motor movements by 35%, which subsequently correlated with increased social initiations. This supports the hypothesis that repetitive behaviors may interfere with social opportunities and that their reduction through physically engaging in water-based activities could create space for social growth. However, the direction of causality in this relationship remains unclear, as increased social engagement might alternatively lead to decreased stereotypy.

Therapist involvement emerged as a critical moderator of social outcomes across studies. Direct therapist modeling of social behaviors during aquatic activities (Alaniz et al., 2017; Charlop et al., 2018) led to faster social skill acquisition than peer-mediated approaches alone. However, Ketcheson et al. (2023) demonstrated that gradual therapist fading led to better maintenance of social skills post-

intervention, suggesting an optimal balance between initial support and eventual independence. Program duration also influenced outcomes, with studies implementing at least 8-week interventions (Alaniz et al., 2017; Pan, 2010) showing more robust effects than shorter programs.

Differences in instructional approaches accounted for substantial variability in social outcomes. Explicit social skill instruction combined with aquatic activities (Yizengaw, 2022) yielded greater improvements in discrete social behaviors than aquatic exposure alone. Conversely, more naturalistic approaches emphasizing child-led play (Charlop et al., 2018) produced broader but less quantifiable social gains. This dichotomy suggests that optimal program design may depend on

whether targeted, measurable social skills or generalized social comfort is the primary intervention goal.

Behavioral Outcomes of Aquatic Programs for Children with Autism

Behavioral improvements represent a critical yet underexplored domain in aquatic interventions for children with autism spectrum disorder (ASD). The included studies demonstrate measurable changes in behavioral regulation, reductions in stereotypy, and improvements in emotional control following participation in structured aquatic programs. These outcomes are systematically categorized in Table 3 by behavioral focus areas and intervention characteristics.

Table 3. Taxonomy of Behavioral Outcomes in Aquatic Interventions for Children with ASD

Behavioral Outcome Focus	Intervention Type	Key Findings	Sources
Meltdown Reduction	Swimming programs	42% decrease in frequency and intensity of meltdown episodes	(Saleh et al., 2019)
Stereotypy Reduction	Game-based exercise	31% reduction in repetitive behaviors during post-intervention observation	(Yu et al., 2018)
	Dance movement therapy	Significant decrease in motor stereotypy with increased on-task behavior	(Ziadat et al., 2022)
Academic Engagement	Antecedent exercise	Improved attention and task persistence following aquatic sessions	(Neely et al., 2015)

The study by Saleh et al. (2019) demonstrated that structured swimming programs could substantially reduce meltdown reactions in children with ASD. Their findings indicated a 42% decrease in both the frequency and intensity of meltdown episodes following a 12-week intervention. The researchers hypothesized that the predictable routines of swimming instruction combined with water's calming sensory properties contributed to this behavioral regulation effect. The aquatic environment may provide a unique setting in which proprioceptive input helps modulate arousal levels, thereby preventing the escalation of distress behaviors.

Game-based aquatic exercise programs yielded significant reductions in stereotypical behaviors, as evidenced by Yu et al.'s (2018) randomized controlled trial. Their results showed a 31% decrease in repetitive movements during structured

observation periods following the intervention. This effect was particularly pronounced when games incorporated clear rules and visual supports, suggesting that the combination of physical engagement and cognitive structuring may disrupt automatic behavioral patterns. The study by Ziadat et al. (2022) further supported these findings, demonstrating that aquatic dance movement interventions could simultaneously reduce motor stereotypy and increase on-task behavior. Their data revealed a strong negative correlation between these variables, suggesting that redirecting repetitive movements toward purposeful dance actions may free up cognitive resources for task engagement.

Improvements in academic engagement emerged as an unexpected behavioral outcome in Neely et al.'s (2015) examination of antecedent aquatic exercise. Their study found that children exhibited longer attention spans and greater task persistence during

classroom activities when these activities were preceded by structured water-based exercise sessions. This carryover effect suggests that aquatic programs may prime neural pathways for improved behavioral regulation beyond the immediate intervention context. The researchers proposed that the combination of cardiovascular exertion and sensory modulation in water creates an optimal neurophysiological state for subsequent cognitive demands.

Therapist involvement played a pivotal role in mediating behavioral outcomes across studies. In (Saleh et al., 2019) and (Yu et al., 2018), direct therapist guidance during aquatic activities was associated with more consistent behavioral improvements than self-directed water play. This pattern indicates that skilled facilitation may be necessary to translate the inherent properties of aquatic environments into measurable behavioral changes. However, Neely et al. (2015) demonstrated that even brief therapist-led warm-up sessions could establish behavioral momentum that persisted during subsequent independent activity periods.

Intervention duration and frequency emerged as important moderators of behavioral effects. Programs lasting at least 8 weeks (Saleh et al., 2019; Yu et al., 2018) produced more robust and sustained behavioral changes than shorter interventions. Similarly, sessions occurring twice weekly appeared more effective than single weekly sessions for establishing behavioral routines. These findings suggest that improvements in behavioral regulation may require consistent, repeated exposure to the structured aquatic environment to be internalized. The instructional approach also influenced outcomes, with clear visual schedules and predictable activity sequences (Yu et al., 2018; Ziadat et al., 2022) yielding greater behavioral stability than less structured formats.

DISCUSSION

Interpretation of Findings in Relation to Research Questions and Literature

The present systematic review examined how specific components of aquatic interventions, namely frequency, duration, instructional approach, and therapist involvement, influence motor, social, and behavioral outcomes among children with ASD. Overall, the findings demonstrate that aquatic interventions possess significant multidimensional potential, extending beyond physical rehabilitation to encompass broader developmental, psychosocial,

and behavioral domains. However, the review also reveals that intervention effectiveness is not determined solely by participation in aquatic activities themselves, but rather by the interaction between program structure, therapeutic design, and the developmental needs of autistic children. This distinction is critical because much of the existing literature has historically framed aquatic interventions as inherently beneficial without sufficiently interrogating the mechanisms through which outcomes are produced.

Regarding RQ1, which examined motor outcomes associated with aquatic interventions, the findings consistently indicate that interventions implemented at higher frequencies, particularly two to three sessions per week, and sustained over longer durations of approximately eight to twelve weeks, produce the most substantial improvements in gross motor functioning. Significant gains were commonly observed in balance, bilateral coordination, muscular endurance, postural control, and overall movement efficiency. These findings are strongly supported by Faraji et al. (2023) and Alesi (2019), both of whom reported notable improvements in postural stability and motor coordination following structured aquatic intervention programs. Similarly, studies involving swimming-based instruction demonstrated improvements in swimming competence, aquatic motor proficiency, and water safety skills (Alaniz et al., 2017; Pan, 2010), suggesting that repetitive and task-oriented practice within aquatic environments facilitates motor learning and movement adaptation.

Nevertheless, the significance of these findings extends beyond the improvement of isolated motor skills. Motor competence plays a foundational role in children's participation, autonomy, and social inclusion. Children with ASD frequently experience motor difficulties that restrict their engagement in recreational, educational, and peer-related activities, which may subsequently reinforce social withdrawal and dependency. Therefore, improvements in motor functioning achieved through aquatic interventions may indirectly contribute to broader developmental outcomes by increasing opportunities for participation and reducing barriers

to engagement. In this sense, aquatic interventions should not be interpreted merely as physical exercise programs, but rather as developmental platforms capable of supporting functional independence and psychosocial participation.

The effectiveness of aquatic interventions in improving motor outcomes can be further understood through the unique biomechanical and sensory characteristics of water. Buoyancy minimizes gravitational demands, enabling children with ASD to perform movements that might otherwise be physically challenging or anxiety-inducing in land-based settings. Simultaneously, water resistance provides continuous proprioceptive input that may enhance body awareness, neuromuscular coordination, and movement regulation (Herold et al., 2016). These findings are consistent with broader movement-based intervention literature, including Greco (2020) and Zhao and Chen (2018), which emphasize the relationship between structured physical activity and improvements in motor and executive functioning among autistic children. However, the variability observed across studies also suggests that motor improvements are highly dependent on the specificity, consistency, and intentional design of interventions. Studies involving sport-specific activities (Lieberman, 2011; Qi et al., 2025) and dance-oriented aquatic programs (Ziadat et al., 2022) indicate that not all movement-based aquatic interventions produce equivalent outcomes, highlighting the importance of structured therapeutic planning rather than assuming universal effectiveness across all aquatic activities.

With respect to RQ2, which focused on social outcomes, the findings indicate that aquatic interventions are particularly effective when implemented within structured group-based contexts that intentionally promote interaction and communication. Studies by Pan (2010) and Alaniz et al. (2017) demonstrated that group aquatic activities contributed to improvements in eye contact, turn-taking, cooperative participation, and verbal communication skills. Importantly, these findings suggest that aquatic settings may provide socially facilitative environments that reduce anxiety and encourage participation among autistic children

who often experience social challenges in conventional settings. The playful and less restrictive nature of aquatic activities appears to create opportunities for spontaneous engagement and reciprocal interaction that may not emerge as naturally within more rigid therapeutic contexts.

Furthermore, studies by Charlop et al. (2018) and Yizengaw (2022) reinforce the importance of structured instructional strategies in facilitating social development. The integration of visual supports, social scripts, predictable routines, and structured play activities appears essential in helping autistic children navigate social expectations and participate meaningfully in group interactions. This finding is particularly significant because it challenges the assumption that exposure to social environments alone is sufficient to produce social gains. Instead, meaningful social outcomes appear to depend heavily on intentional facilitation and structured interactional support. Similarly, Bella (2019) and Ketcheson et al. (2023) suggest that inclusive and community-based aquatic programs may further enhance social participation by fostering opportunities for peer interaction within naturalistic environments.

An important contribution emerging from this review is the apparent interdependence between motor and social outcomes. Improvements in motor competence may increase children's confidence and willingness to participate in group activities, thereby creating additional opportunities for social engagement (Zhao & Chen, 2018). Conversely, collaborative play, peer modeling, and structured social interaction during aquatic activities may reinforce motor learning and skill acquisition. This reciprocal relationship highlights the inadequacy of examining motor and social outcomes as entirely separate domains. Instead, the findings suggest that aquatic interventions may operate through interconnected developmental mechanisms in which physical participation, social engagement, and emotional regulation mutually reinforce one another.

In addressing RQ3, which examined behavioral outcomes, the review demonstrates that aquatic interventions may contribute to reductions in maladaptive behaviors, including stereotypical

behaviors, emotional dysregulation, and attention difficulties, particularly when programs are therapist-led and systematically structured. Saleh et al. (2019) reported significant reductions in the frequency and intensity of meltdowns following a twelve-week swimming intervention, while Yu et al. (2018) and Ziadat et al. (2022) observed decreases in repetitive behaviors through movement-oriented and game-based aquatic activities. These findings align with Neely et al. (2015), who reported improvements in attention and task engagement following antecedent aquatic exercise. Collectively, these findings suggest that aquatic activities may regulate physiological arousal and create sensory conditions that support emotional and behavioral stability.

However, the findings also reveal that behavioral improvements are not automatically generated by the aquatic environment itself. Rather, therapist involvement emerges as a central mechanism influencing intervention effectiveness. Lawson et al. (2025) and Charlop et al. (2018) emphasize the importance of therapist guidance in structuring activities, modeling adaptive responses, reinforcing appropriate behaviors, and facilitating emotional regulation. At the same time, Ketcheson et al. (2023) argue that excessive therapist dependency may limit the generalization of learned behaviors, highlighting the importance of gradually fading support to encourage independence and self-regulation. These findings indicate that therapist involvement must be carefully balanced between providing sufficient structure and promoting autonomous functioning.

Critically, this review highlights a broader conceptual issue within aquatic intervention research. Many existing studies prioritize outcome reporting while paying insufficient attention to intervention mechanisms, contextual influences, and long-term sustainability. The field remains dominated by relatively short-term studies with small sample sizes and inconsistent methodological approaches, limiting the development of standardized evidence-based guidelines. Moreover, few studies critically engage with neurodiversity-oriented perspectives that emphasize participation, inclusion, and quality of life rather than solely focusing on symptom reduction. Consequently,

future research should move beyond evaluating whether aquatic interventions “work” and instead examine how, why, and under what conditions they produce meaningful developmental outcomes for autistic children.

Overall, the findings of this review suggest that aquatic interventions represent a promising multidimensional approach for supporting children with ASD. Nevertheless, their effectiveness depends heavily on intervention quality, instructional structure, therapist engagement, and the alignment between program design and the unique developmental profiles of autistic children. These findings reinforce the need for more theoretically informed, individualized, and evidence-based aquatic intervention models that prioritize not only functional improvement, but also participation, autonomy, and holistic well-being.

Theoretical Implications

The findings of this review extend existing theoretical frameworks in ASD intervention by reinforcing the integration of motor learning theory, sensory integration theory, and behavioral regulation models. The consistent improvements observed across motor, social, and behavioral domains support the proposition that structured physical activity can enhance neural connectivity and cross-domain development (Greco, 2020; Zhao & Chen, 2018). The multisensory properties of aquatic environments, particularly the provision of proprioceptive and tactile input, align with sensory integration theory, suggesting that water-based interventions may facilitate self-regulation and adaptive behavior in children with ASD (Herold et al., 2016).

However, the heterogeneity of outcomes across studies highlights the limitations of existing theoretical models in accounting for individual variability. Factors such as sensory sensitivity, cognitive functioning, and autism severity likely moderate the effectiveness of interventions but remain underexplored in the literature. Future theoretical development should therefore adopt a more individualized and interactionist perspective, integrating environmental, behavioral, and

neurodevelopmental variables to better explain differential responses to aquatic interventions.

Practical and Policy Implications

From a practical perspective, the findings provide clear, evidence-based recommendations for clinicians and educators. Effective aquatic programs should prioritize frequency (minimum 2 sessions per week) and duration (8–12 weeks) to ensure sufficient exposure and skill acquisition. Instructional approaches should incorporate visual supports, structured routines, and progressive skill scaffolding, as demonstrated in studies by Pan (2011) and Charlop et al. (2018). Additionally, therapist involvement should be strategically implemented, with initial direct support followed by gradual withdrawal to facilitate independence and skill transfer (Ketcheson et al., 2023).

At the policy level, these findings support integrating aquatic therapy into inclusive education systems and community-based intervention programs. Given the demonstrated benefits across multiple developmental domains, policymakers should consider investing in accessible aquatic facilities, specialized instructor training, and standardized program guidelines. The establishment of evidence-based protocols, as advocated by Caputo et al. (2018), is essential to ensure consistency, quality, and scalability of aquatic interventions across different settings.

Limitations of the Study

Several limitations must be acknowledged when interpreting the findings of this review. First, the heterogeneity of study designs, intervention protocols, and outcome measures limits the ability to draw definitive conclusions regarding causality and optimal program components. Many studies employed small sample sizes and lacked control groups, reducing the robustness and generalizability of findings (Baena-Beato et al., 2013). Second, publication bias may have led to an overrepresentation of studies reporting positive outcomes, while studies with null or negative findings remain underreported.

Furthermore, the review was restricted to English-language publications, potentially excluding relevant research conducted in non-English-speaking

contexts. This limitation may affect the global applicability of the findings. Additionally, the lack of longitudinal studies limits understanding of the sustainability of intervention effects over time, as most studies focus on immediate post-intervention outcomes. Finally, the variability in how intervention components are reported, particularly therapist involvement and instructional strategies, complicates efforts to systematically compare and synthesize findings across studies.

CONCLUSION

This systematic review provides critical evidence that the effectiveness of aquatic interventions for children with autism spectrum disorder (ASD) is fundamentally shaped by programme structure rather than by exposure to aquatic environments alone. Across the reviewed studies, interventions delivered with higher frequency, sustained duration, structured instructional approaches, and active therapist involvement consistently produced more meaningful improvements in motor, social, and behavioural domains. These findings reinforce the position that aquatic interventions should not be conceptualised merely as recreational or supplementary activities, but as structured therapeutic modalities capable of supporting multidimensional developmental outcomes in children with ASD.

A major contribution of this review lies in its shift from outcome-focused reporting toward a more analytical understanding of intervention mechanisms. Existing literature has often treated aquatic programmes as universally beneficial without critically examining which components drive effectiveness. By synthesising evidence across intervention characteristics, this review demonstrates that programme precision, including session consistency, instructional scaffolding, predictable routines, and therapist-guided engagement, is central to achieving measurable developmental gains. Importantly, the findings also highlight the interconnected nature of motor, social, and behavioural outcomes, suggesting that improvements in one domain may facilitate broader participation, self-regulation, and social interaction.

From a practical perspective, this review offers important implications for clinicians, educators, therapists, and policymakers involved in ASD intervention planning. The findings support the implementation of structured aquatic programmes conducted at least two to three times weekly over extended periods, with intentional therapeutic facilitation tailored to the developmental and sensory needs of autistic children. At the same time, the review exposes significant inconsistencies within the current evidence base, including

methodological variability and the absence of standardised intervention frameworks.

Ultimately, this study advances the field by establishing a clearer evidence base for designing effective aquatic interventions while identifying critical directions for future research. Strengthening methodological rigor and developing evidence-based implementation guidelines will be essential to ensuring that aquatic interventions produce sustainable, inclusive, and meaningful long-term outcomes for children with ASD.

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