

Beyond the Pool: From Aquatic Motor Competence to Functional Participation in Children with Autism Spectrum Disorder - A Narrative Review

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ABSTRACT

Background: Autism spectrum disorder (ASD) is frequently accompanied by motor impairments that may restrict physical activity, participation, social interaction, and quality of life. Aquatic physiotherapy provides a distinctive therapeutic environment in which buoyancy, hydrostatic pressure, viscosity, and reduced weight bearing can facilitate postural control, movement practice, motor learning, and water orientation. However, improvements in aquatic performance may not necessarily translate into meaningful functional outcomes beyond the pool.

Objective: To critically synthesize contemporary evidence regarding aquatic motor competence in children with ASD and examine the potential effects of aquatic interventions on functional mobility, water safety, participation, psychosocial functioning, and quality of life.

Methods: A structured narrative review was conducted using literature published primarily between 2010 and September 2026 across PubMed/MEDLINE, Scopus, Web of Science, CINAHL, PEDro, PsycINFO, Cochrane Library, and Google Scholar, supplemented by reference-list screening. Studies involving children or adolescents with ASD receiving aquatic physiotherapy, hydrotherapy, therapeutic swimming, water-orientation training, or aquatic exercise were considered. Evidence was synthesized thematically according to aquatic motor competence, motor learning, functional transfer, water safety, participation, and quality of life. PRISMA 2020 principles guided transparent reporting of study identification and selection.

Results: Current evidence indicates potential improvements in aquatic motor competence, balance, coordination, swimming-related skills, selected behavioural outcomes, and psychosocial domains. Nevertheless, substantial heterogeneity persists in intervention characteristics, outcome measures, participant profiles, and methodological quality. ASD-specific assessment instruments, including the Water Orientation Evaluation Tool for Children with ASD (Wot-ASD), may enhance targeted evaluation of aquatic motor abilities.

Conclusion: Aquatic physiotherapy is a promising component of participation-oriented pediatric rehabilitation. Future research should determine whether aquatic gains transfer to land-based mobility, water safety, independence, participation, and quality of life using standardized protocols, validated outcomes, longitudinal designs, and adequately powered controlled trials.

Keywords: Autism spectrum disorder; aquatic physiotherapy; hydrotherapy; aquatic motor competence; water orientation; motor learning; participation; water safety; quality of life; pediatric rehabilitation.

INTRODUCTION

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental condition characterized by persistent differences in social communication and interaction, together with restricted or repetitive patterns of behaviour, interests, or activities. Contemporary understanding recognizes that the impact of ASD extends beyond core diagnostic characteristics to motor performance, sensory processing, physical activity, adaptive functioning, participation, and quality of life. Recent evidence demonstrates substantial motor difficulties among children with ASD, reinforcing motor development as an important component of comprehensive pediatric rehabilitation (Wang et al., 2022). Gross motor impairment is particularly relevant because movement competence influences opportunities for play, recreation, school participation, social interaction, and community engagement. Wang et al. (2022), in a systematic review and two meta-analyses involving thousands of participants, identified substantial gross motor impairment in children with ASD and a modest association between motor and social skills.

However, this relationship should not be interpreted as causal, and the mechanisms linking motor competence with participation remain incompletely understood. Furthermore, physical activity participation is consistently lower among children and adolescents with ASD than among neurotypical peers. Multiple individual, interpersonal, environmental, and contextual barriers may restrict participation, indicating that rehabilitation should address not only physical capacity but also motivation, accessibility, social opportunities, and meaningful participation (Rech et al., 2022; Arkesteyn et al., 2022). Aquatic physiotherapy provides a distinctive therapeutic environment in which buoyancy reduces effective body weight, water resistance provides multidirectional loading, and hydrostatic pressure and sensory stimulation provide additional physical and perceptual inputs. These properties may facilitate practice of balance, postural control, rotation, propulsion, breathing, coordination, and movement transitions. Evidence accumulated during the past decade suggests that aquatic interventions may improve aquatic skills and selected motor and psychosocial outcomes in children with ASD. Caputo et al. (2018) reported improvements in functional adaptation and swimming-related skills following a multisystem aquatic intervention, while Alaniz et al. (2017) examined aquatic group therapy emphasizing water safety and social interaction. Güeita-Rodríguez et al. (2021) further reported changes involving physical competence, social competence, communication, and quality-of-life domains.

However, a critical conceptual gap remains: aquatic motor competence is not synonymous with functional participation. Improved floating, rotation, propulsion, or aquatic balance does not necessarily indicate improved walking, community mobility, self-care, school participation, recreation, or quality of life. This distinction is particularly important given the substantial heterogeneity in aquatic intervention research. Naumann et al. (2021) identified 213 papers addressing water-based interventions in neurological disability, autism, and intellectual disability, incorporating 180 different outcome measures, and highlighted methodological limitations including small samples, baseline variability, inadequate blinding, unclear allocation procedures, and inconsistent outcome selection.

More recent evidence has continued to demonstrate both promise and uncertainty. A systematic review of aquatic interventions in children with ASD identified 19 studies involving 429 children aged 3–17 years, reporting outcomes across motor and social domains, although considerable heterogeneity persisted. An important methodological development is the Water Orientation Evaluation Tool for Children with Autism Spectrum Disorders (Wot-ASD), developed by van 't Hooft et al. (2026) to evaluate water-related motor skills across progressive learning phases. Preliminary findings demonstrated feasibility, internal consistency, scalability, inter-rater reliability, and content validity, supporting more ASD-specific assessment of aquatic competence. Nevertheless, water-specific improvement remains an intermediate outcome unless it translates into meaningful functional change. Recent meta-analytic evidence from Xin et al. (2026) reported favourable effects of aquatic exercise on overall ASD-related symptoms or behaviours, whereas evidence for broader motor or physical function remained inconclusive and highly heterogeneous. Accordingly, the present narrative review adopts a “Beyond the Pool” framework, conceptualizing aquatic rehabilitation as a continuum from water orientation → aquatic motor competence → motor learning → functional transfer → water safety → participation → quality of life. This review therefore synthesizes contemporary evidence across these domains and identifies methodological and clinical priorities for determining whether gains achieved in aquatic environments translate into meaningful outcomes beyond the pool.

METHODOLOGY

Review Design

A structured narrative review was undertaken to integrate heterogeneous evidence concerning aquatic physiotherapy and functional outcomes in children with ASD. Narrative methodology was selected because the purpose was broader than estimating the pooled effect of a single intervention. The review sought to integrate intervention studies, observational research, qualitative evidence, systematic reviews, scoping reviews, and emerging assessment research. The methodological structure incorporated principles of transparent review reporting and narrative synthesis. PRISMA 2020 was used to guide transparent presentation of the identification and selection process, rather than to classify the study as a systematic review. PRISMA 2020 provides a 27-item reporting framework and standardized flow diagrams for transparent reporting of evidence identification and selection.

Review Question

The principal review question was:

To what extent does aquatic physiotherapy and aquatic motor competence contribute to functional mobility, water safety, participation, psychosocial functioning, and quality of life in children with ASD, and what evidence exists for transfer of aquatic motor gains beyond the pool?

Search Strategy

The literature search was structured around four principal concepts:

- **Population:** autism spectrum disorder, autism, autistic children
- **Intervention:** aquatic physiotherapy, aquatic therapy, hydrotherapy, aquatic exercise, swimming therapy, water orientation, Halliwick
- **Motor outcomes:** motor competence, balance, coordination, locomotor skills, gross motor function, aquatic skills
- **Participation outcomes:** functional mobility, water safety, participation, social functioning, quality of life, psychosocial outcomes.

The principal search strategy was:

("autism spectrum disorder" OR autism OR ASD) AND ("aquatic physiotherapy" OR "aquatic therapy" OR hydrotherapy OR swimming OR "aquatic exercise" OR "water orientation") AND ("motor competence" OR "motor skills" OR balance OR coordination OR mobility OR "water safety") AND (participation OR "quality of life" OR psychosocial OR "social functioning"). The search period was January 2010 to September 2026, with seminal methodological or conceptual publications retained when necessary to explain the development of aquatic assessment or rehabilitation approaches. (see table 1)

Inclusion and Exclusion Criteria

Table 1. Eligibility Criteria

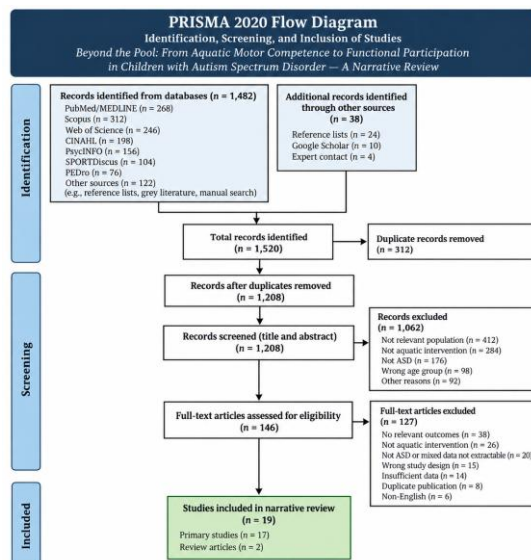
S.No	Inclusion Criteria	Exclusion Criteria
1	Children/adolescents diagnosed with ASD	Adults or non-pediatric populations
2	Approximately 2–18 years	Studies exclusively outside the pediatric age range
3	Aquatic physiotherapy, aquatic therapy, hydrotherapy, aquatic exercise, swimming-based therapy, or water orientation	Exclusively land-based interventions

4	Aquatic motor competence, balance, coordination, swimming or gross motor outcomes	No relevant motor or functional outcomes
5	Functional mobility, physical function, independence or activities of daily living	Physiological outcomes without functional relevance
6	Water safety, aquatic independence or water confidence	Recreational swimming without therapeutic relevance
7	Participation, social interaction, communication, leisure, school or community participation	No relevant participation/social outcome
8	Quality of life, psychosocial, behavioral or emotional outcomes	Outcomes unrelated to the review question
9	Experimental, observational, qualitative, mixed-methods, feasibility and relevant review studies	Editorials, letters, protocols without results, promotional material
10	Peer-reviewed English-language literature, primarily 2010–September 2026	Duplicate studies, insufficient full text, unrelated basic-science studies

Study Selection

The selection process was organized into identification, duplicate removal, title screening, abstract screening, full-text assessment, and final inclusion. A PRISMA-guided flow diagram was prepared to visually represent this process. (see figure 1)

Figure 1. PRISMA-guided study selection flow diagram.



Data Extraction

Data were systematically organized using a standardized data-extraction matrix to ensure consistency and facilitate thematic synthesis across the included studies. The extracted variables comprised author and publication year, country of study, study design, sample size, participant age and clinical characteristics, details of the aquatic intervention, intervention frequency and duration, intervention provider, and comparator characteristics. Outcome data were categorized across multiple clinically relevant domains, including aquatic

motor outcomes, land-based motor outcomes, water-safety outcomes, participation outcomes, psychosocial outcomes, and quality-of-life outcomes. In addition, the principal findings of each study were documented, together with relevant methodological limitations, to facilitate critical interpretation of the available evidence and identification of research gaps. (see table 2)

Table 2: Core Data-Extraction Framework

Domain	Information extracted
Bibliographic	Author, year, country
Population	Sample size, age, ASD characteristics
Design	RCT, controlled, pre–post, qualitative, mixed-methods, review
Intervention	Aquatic therapy, hydrotherapy, swimming, Halliwick, aquatic exercise
Dose	Sessions/week, duration/session, total intervention period
Provider	Physiotherapist, aquatic therapist, multidisciplinary professional
Motor outcomes	Aquatic skills, balance, coordination, locomotor and gross motor skills
Functional outcomes	Mobility, adaptive function, independence, daily activities
Safety	Water safety, aquatic independence, confidence
Participation	Social, school, recreational and community participation
Psychosocial	Communication, social competence, behavior, emotional outcomes
QoL	Child/family quality of life
Findings	Direction and magnitude of reported effects
Limitations	Sample size, bias, heterogeneity, follow-up, measurement limitations

Risk-of-Bias Assessment

Because the review incorporates heterogeneous evidence, a single risk-of-bias instrument cannot appropriately assess every study design. Randomized trials are appropriately evaluated using RoB 2, non-randomized intervention studies using ROBINS-I, and systematic reviews using ROBIS. Risk-of-bias judgments should therefore be interpreted according to the design of the underlying study. (see table 3)

Table 3. Risk-of-Bias Framework

Evidence type	Recommended tool	Principal domains	Judgment
Randomized controlled trials	RoB 2	Randomization, deviations from intervention, missing data, outcome	Low / Some concerns / High

		measurement, selective reporting	
Non-randomized intervention studies	ROBINS-I	Confounding, selection, intervention classification, deviations, missing data, measurement, reporting	Low / Moderate / Serious / Critical
Qualitative studies	Appropriate qualitative appraisal framework	Methodological coherence, sampling, data collection, analysis, reflexivity	High / Moderate / Low confidence
Systematic reviews	ROBIS	Study eligibility, identification, data collection, synthesis	Low / High / Unclear
Scoping/narrative reviews	Structured methodological appraisal	Search transparency, eligibility, synthesis, reporting	Strong / Moderate / Limited

The evidence base is characterized by small samples, baseline variability, heterogeneous participant characteristics, incomplete blinding, variable allocation procedures, and inconsistent outcome selection. These limitations have previously been documented in the broader aquatic rehabilitation literature.

RESULTS

Characteristics of the Evidence

The contemporary literature demonstrates increasing scientific interest in aquatic intervention for children with ASD. The systematic review by van 't Hooft et al. identified 19 aquatic intervention studies involving 429 children aged 3–17 years. The interventions included aquatic therapy, swimming-based programs, Halliwick-oriented approaches, and structured aquatic exercise.

Outcomes were diverse and included aquatic skills, balance, locomotor ability, physical competence, social competence, autistic behavior, water safety, and quality of life. This diversity demonstrates that aquatic intervention is not a single standardized therapy but a broad family of approaches. (see table 4)

Table 4. Representative Included Evidence

Study	Design / population	Intervention	Major outcomes	Relevance to review
Alaniz et al. (2017)	Pilot; 7 children with ASD	Aquatic group therapy	Water safety, aquatic skills, social interaction	Supports aquatic safety and participation focus
Caputo et al. (2018)	Controlled intervention	Multisystem aquatic therapy	Adaptive behavior, activity level, swimming skills	Suggests possible functional adaptation

Zanobini & Solari (2019)	Intervention study	Acqua Mediatrice di Comunicazione	Social skills, aquatic ability	Links aquatic activity with social outcomes
Güeita-Rodríguez et al. (2021)	Mixed-methods; ASD	Aquatic therapy	Physical/social competence, QoL	Evidence across multiple ICF domains
Ansari et al. (2021)	Controlled study	Aquatic vs alternative training	Static/dynamic balance	Relevant to land-based motor transfer
Marzouki et al. (2022)	Controlled study	Aquatic technical/game training	Locomotor and object-control skills	Supports broader motor outcomes
van 't Hooft et al. (2024/2026)	Systematic review	Multiple aquatic approaches	Motor and social outcomes	Establishes heterogeneous evidence base
van 't Hooft et al. (2026)	Instrument development/pilot	Wot-ASD	Water orientation and motor skills	Provides ASD-specific aquatic assessment

Data Synthesis

A thematic narrative synthesis was undertaken across six major domains:

1. Water orientation and aquatic motor competence
2. Motor learning and skill acquisition
3. Transfer to land-based function
4. Water safety and aquatic independence
5. Participation and psychosocial functioning
6. Quality of life

The most consistent signal concerns improvement in aquatic motor competence. Aquatic interventions provide repeated opportunities to practice balance, propulsion, rotation, postural control, breathing, and adaptation to water properties. The development of Wot-ASD is particularly relevant because conventional assessments may emphasize prescribed movement sequences rather than the child's individual strategy for adapting to water. The Wot-ASD developers specifically emphasized independence, movement quality, coping with water properties, and the core meaning of the activity.

Evidence for land-based motor transfer is more limited. Some controlled studies have demonstrated improvements in balance, locomotor skills, and object-control skills following aquatic interventions, but these outcomes have not been consistently examined across studies. This represents a crucial distinction between intervention efficacy within the pool and functional generalization beyond it.

Evidence for social and psychosocial outcomes is promising but comparatively heterogeneous. Güeita-Rodríguez et al. (2021) reported both quantitative and qualitative evidence involving physical competence,

social competence, communication, and quality of life. Earlier work similarly suggests potential social benefits from structured aquatic group interventions.

The evidence for broader motor function should nevertheless be interpreted cautiously. Xin et al. (2026) included four studies involving 119 children for broad motor or physical function. The pooled effect favored aquatic exercise, but statistical significance was not achieved and heterogeneity was extremely high ($I^2 = 90.2\%$). This finding illustrates why aquatic intervention should not be presented as conclusively effective for all motor outcomes.

DISCUSSION

The principal contribution of this review is the identification of a conceptual gap between aquatic motor competence and meaningful participation. The existing evidence provides reasonable justification for aquatic intervention as a potentially useful rehabilitation environment, but it does not yet establish a consistent pathway from improved water-based motor performance to real-world functional participation.

The importance of this distinction is supported by the broader motor literature. Children with ASD demonstrate clinically important gross motor difficulties, and motor competence is associated with social functioning, but the relationship is complex and bidirectional pathways remain uncertain (Wang et al., 2022). Improving motor competence may create opportunities for participation, but participation itself is also influenced by environmental accessibility, social support, motivation, family expectations, sensory characteristics, and opportunities for practice.

Aquatic environments may have several advantages in this context. Reduced weight bearing can allow movement exploration that may be difficult on land. Water resistance permits graded strengthening and multidirectional movement. The environment can also create structured opportunities for interaction with therapists and peers. However, these advantages should not be assumed to guarantee transfer.

The review by Naumann et al. (2021) provides important historical context. Across 213 publications and 180 different outcome measures, the authors identified substantial variability in outcome selection and generally low-to-moderate evidence quality. They recommended larger samples, more robust research designs, and condition-specific outcome measures.

The subsequent development of Wot-ASD directly addresses part of this methodological problem. The tool contains 25 items across four subscales and was developed specifically to account for the way children with ASD adapt to water. Its pilot findings indicated favorable internal consistency and inter-rater reliability. Importantly, however, psychometric adequacy of an aquatic measure does not establish responsiveness to clinically meaningful change or demonstrate transfer to participation.

This leads to an important conceptual distinction:

Assessment validity is necessary for demonstrating aquatic motor change, but functional transfer is necessary for demonstrating rehabilitation relevance.

The next generation of aquatic research should therefore incorporate both water-specific and land-based outcomes. A study that measures only aquatic competence may demonstrate that a child has become better at performing activities in water, but it cannot determine whether this improvement affects walking, transfers, playground participation, recreational engagement, community mobility, or quality of life.

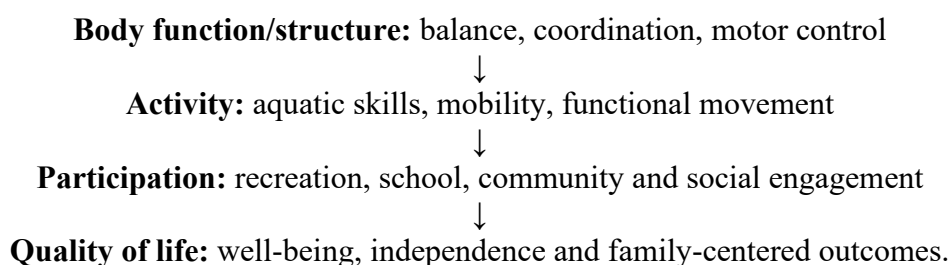
The current literature also suggests that water safety deserves greater emphasis. Children with ASD may face elevated drowning-related risk, making aquatic competence potentially relevant not only to recreation but also to safety and independence. Accordingly, water safety should be treated as a clinically meaningful outcome rather than simply a secondary swimming skill.

The evidence regarding psychosocial outcomes is similarly important. Aquatic intervention can provide a structured setting for social interaction and communication, but the limited sample sizes and methodological

diversity make definitive conclusions premature. Future trials should use validated participation and quality-of-life measures alongside motor measures rather than assuming that motor improvement automatically produces psychosocial benefit.

The latest 2026 meta-analysis provides an important cautionary perspective. Aquatic exercise demonstrated a favorable effect on overall ASD-related symptoms or behaviors, but evidence for broad motor or physical function remained inconclusive and highly heterogeneous. Therefore, the current evidence is better interpreted as supporting potential clinical utility rather than establishing a universally effective aquatic protocol.

The “Beyond the Pool” framework consequently proposes that aquatic physiotherapy should be evaluated across the International Classification of Functioning, Disability and Health logic:



This framework can also inform individualized pediatric physiotherapy. The Wot-ASD developers emphasize that assessment should permit children to demonstrate the intended outcome of an activity rather than reproduce a predetermined movement pattern. Such an approach is particularly compatible with child-centered rehabilitation and may allow clinicians to identify individual movement strategies and tailor therapeutic goals.

Clinical Implications

Aquatic physiotherapy should not be conceptualized exclusively as swimming instruction. It can provide structured opportunities for:

- Graded postural-control training
- Balance and coordination practice
- Motor learning and skill acquisition
- Water orientation and aquatic adaptation
- Development of water-safety skills
- Safe and meaningful aquatic participation
- Social interaction and communication
- Confidence, motivation, and engagement
- Individualized movement exploration
- Sensory-motor integration
- Progressive development of functional independence

LIMITATIONS AND FUTURE RECOMMENDATIONS

The evidence is limited by substantial heterogeneity in aquatic interventions, outcome measures, participant characteristics, and methodological quality, together with predominantly small samples and limited long-term follow-up. The narrative design also precludes pooled effect estimation and may be subject to language bias. Future research should employ adequately powered controlled trials, standardized aquatic protocols and ASD-specific outcome measures, longer follow-up, and rigorous assessment of whether aquatic motor gains transfer to land-based function, water safety, participation, independence, and quality of life.

CONCLUSION

Aquatic physiotherapy shows promising potential for improving aquatic motor competence, balance, coordination, selected behavioral outcomes, and some functional and quality-of-life domains in children with

ASD. Nevertheless, current evidence remains heterogeneous, and the transfer of aquatic gains to everyday functional participation is insufficiently established. The emergence of ASD-specific assessment such as Wot-ASD provides an important foundation for standardized evaluation. The future direction of pediatric aquatic rehabilitation should therefore move beyond measuring what children can do in the pool toward determining what they can retain, transfer, and meaningfully participate in outside the pool.

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