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Effects of hydrotherapy on gait control in older adults with neurological conditions: A systematic review

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A R T I C L E I N F O

Keywords:
Aquatic therapy
Gait control
Hydrotherapy
Older adults
Thermal water

A B S T R A C T

Background: Hydrotherapy is the external use of water for therapeutic purposes, using the physical, physiological, and kinesiological effects of immersing the body in a pool to aid rehabilitation or prevent functional alterations.
Objective: This systematic review aims to assess hydrotherapy's effects on gait control in older adults with neurological conditions.
Methods: Computerised search in Scopus, PubMed, Web of Science, B-on, PEDro, and Cochrane databases, using the combination of keywords: Thermal water, Gait control, hydrotherapy, and Aquatic therapy for older adults. Methodological quality was analysed using the Physiotherapy Evidence Database (PEDro) scale. The selection criteria included randomised clinical trials in neurological cases in older adults with altered gait and balance.
Results: A comprehensive search was conducted in Scopus, PubMed, Web of Science, B-on, PEDro, and Cochrane databases. Randomised controlled trials involving older adults (≥65 years) with neurological disorders affecting gait and balance were included. Methodological quality was assessed using the PEDro scale.
Conclusion: Hydrotherapy appears safe and more effective than conventional physiotherapy for improving gait control, balance, and mobility in older adults with neurological impairments. Its buoyancy and resistance effects facilitate motor re-education and confidence in movement. Integrating aquatic therapy into neurorehabilitation programs may enhance outcomes and quality of life, although long-term follow-up studies are still needed.

1. Introduction

The ageing of the global population has led to a marked increase in neurological conditions that compromise mobility and independence among older adults. Common disorders such as stroke, Parkinson's disease, and multiple sclerosis frequently result in motor impairments, including bradykinesia, muscle rigidity, postural instability, and gait asymmetry. These deficits often manifest as reduced walking speed, impaired coordination, and decreased balance, substantially limiting functional autonomy and daily activity performance (World Health Organization, 2021).

Falls are one of the most serious consequences of gait and balance dysfunction in this population. Older adults with neurological conditions experience a two-to threefold higher risk of falling compared to their healthy peers, with approximately 60–80 % of individuals with Parkinson's disease or post-stroke reporting at least one fall per year. These events frequently result in fractures, soft tissue injuries, and hospitalizations, contributing to increased morbidity, mortality, and healthcare costs, as well as fear of falling and reduced quality of life.

Hydrotherapy, also known as aquatic therapy (AT), has become a promising approach for rehabilitating patients with neurological disorders. This therapy leverages the unique physical properties of water, including buoyancy, hydrostatic pressure, viscosity, and temperature, to create a supportive and low-impact environment that facilitates movement. The buoyancy of water counteracts gravity, reducing joint load and allowing safer practice of gait and balance exercises, while resistance and turbulence promote muscle activation and proprioceptive feedback. Additionally, the warmth of the water can enhance relaxation,

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decrease spasticity, and improve circulation, thereby supporting neuromuscular recovery (Geytenbeek, 2002).

Emerging evidence supports the benefits of hydrotherapy for improving functional mobility and gait control in older adults with neurological impairments. Studies have demonstrated significant improvements in balance, walking speed, postural stability, and quality of life following aquatic interventions compared with traditional land-based therapy. For example, systematic reviews and randomized controlled trials have reported enhanced gait parameters in patients with Parkinson's disease and improved lower-limb function and independence in post-stroke rehabilitation. Despite these encouraging findings, variations in study design, intervention protocols, and participant characteristics highlight the need for a comprehensive synthesis of the available evidence (Liu et al., 2023; Zhu et al., 2016).

Therefore, this systematic review aims to critically assess and summarize the effects of hydrotherapy on gait control in older adults with neurological conditions, providing an updated and evidence-based perspective on its therapeutic value for clinical practice and rehabilitation planning.

2. Methods

The review protocol is registered with PROSPERO (CRD42024541898). The systematic review adhered to Cochrane guidelines for evaluating evidence from randomized controlled trials on effectiveness, ensuring a structured and transparent method for assessing confidence in effect estimates.

2.1. Research framework

The study employs a quantitative methodology via a systematic literature review to identify, evaluate, and interpret research on the benefits of hydrotherapy in improving gait patterns among older adults with neurological conditions. This investigation explores experiences, perceptions, and quantitative data on the use of thermal water as a complementary intervention, aiming to enhance gait patterns, balance, mobility, and quality of life as measured by validated instruments such as the Berg Balance Scale (BBS), Timed Up and Go Test (TUG), and Parkinson's Disease Questionnaire (PDQ-39), among others.

2.2. Research question

The research question was developed to provide a clear focus for the study. Considering the specific aspects of the topic, the question was formulated using the Population, Intervention, Comparison, and Outcome (PICO) framework (Roever). In this review, the Population refers to older adults (≥65 years) with neurological conditions affecting gait and balance; the Intervention is hydrotherapy or aquatic therapy programs; the Comparison involves conventional or land-based physiotherapy interventions; and the Outcome includes improvements in gait control, balance, mobility, and overall functional performance. This structure ensured a systematic and transparent approach to defining the scope of the review and guiding the literature search. Consequently, the guiding investigative question was determined to align with the needs of the chosen topic:

> RQ1: What are the effects of hydrotherapy on gait control in the older adult population with neurological conditions?

2.3. Literature search

To achieve the research objectives, a comprehensive literature search was undertaken to identify articles providing scientific evidence on the effects of hydrotherapy on gait control in older adults with neurological conditions. The search was conducted across multiple databases, including PubMed (https://www.ncbi.nlm.nih.gov), b-on (https://www.b-on.pt), PEDro (https://www.pedro.org.au), Web of Science (https://www.webofscience.com), Scopus (https://www.scopus.com), and Cochrane (https://www.cochranelibrary.com). These databases were chosen for their extensive coverage of medical, nursing, physiotherapy, gerontology, and neurology literature.

The search strategy utilized a combination of Medical Subject Headings (MeSH) terms, keywords, and Boolean operators. The query was structured as follows: ("Thermal water" OR "hydrotherapy" OR "aquatic therapy") AND ("gait control" OR "walking ability") AND ("elderly" OR "older adults") AND ("neurological conditions" OR "neurological disorders").

Additionally, synonyms and related terms were incorporated into the search strategy to maximize the retrieval of relevant studies. This approach aimed to ensure a comprehensive selection of peer-reviewed articles that meet the inclusion criteria, facilitating a thorough evaluation of the evidence on the effects of hydrotherapy on gait control in neurological conditions.

No restrictions were placed on the publication year or language for article selection. However, randomized controlled trials (RCTs) were applied as a filtering criterion to ensure the inclusion of high-quality evidence.

2.4. Inclusion criteria

Studies included were: (1) Randomised controlled trials (RCTs); (2) Human participants aged ≥65 years, of any ethnicity and gender, in a neurological context; (3) Research specifically involving AT, whether hydrotherapy or other therapy in thermal or non-thermal water as an intervention for gait and balance control, in populations with neurological conditions or disorders (such as stroke or Parkinson's disease).

2.5. Exclusion criteria

The following studies were excluded from the review: (1) Grey literature, unpublished studies, conference abstracts, review articles, books, book chapters, and non-empirical, observational, and quasi-experimental studies; (2) Studies conducted on animals or in vitro studies that do not involve human participants; (3) Studies that do not involve patients in AT; (4) Studies that focus exclusively on healthy individuals or those without neurological diseases; (5) Studies that evaluate interventions other than hydrotherapy/AT; (6) Research not directly related to aquatic and neurological contexts or that does not explicitly address gait control in neurological conditions; (7) Studies involving hydrotherapy unrelated to gait control or that focus solely on musculoskeletal conditions. A summary of the search results is provided in Table 1.

2.6. Types of outcomes measured

The primary outcomes of interest focused on the effects of

Table 1
The search strategy summary.

Items	Specification
Date of search	15/03/2024
Database and other sources searched	b-on, PEDro, PubMed, Web of Science, Scopus, and Cochrane
Search terms used	Hydrotherapy, aquatic therapy, thermal water, elderly, older adult, gait control, walking ability, neurological condition, neurological disorder.
Timeframe	No limitation
Inclusion criteria	RCT's in any language
Exclusion criteria	Non-experimental studies, studies only contained abstracts, papers published in conferences, books, or book chapters, and animal studies.
Selection process	The first and last authors selected all sources. The screening was undertaken in duplicate, independently.

hydrotherapy on gait control in older adults with neurological conditions.

2.7. Study selection

The screening process was conducted independently and in duplicate. One author (ZR) screened all citations (titles and abstracts, when available), while another author (TP) performed duplicate screening. For citations deemed relevant or lacking sufficient information for a decision, the full-text paper was retrieved for further evaluation. Any discrepancies regarding eligibility during the screening or full-text review were to be resolved through discussion by the wider review team.

2.8. Risk of bias

The risk of bias for each study was assessed by one author (SG) using the Cochrane Collaboration ROBINS-I (Risk Of Bias In Non-randomized Studies - of Interventions) tool (Higgins, 2011; Cochrane library of cochrane methods, 2008) with a second author (TP) independently verifying the assessments. This tool evaluates potential sources of bias across seven domains: confounding, participant selection, classification of interventions, deviations from intended interventions, missing data, outcome measurement, and selection of reported results. Each domain is rated as low, moderate, severe, or critical risk of bias. The ROBINS-I tool is particularly relevant to this review as it provides a structured framework for assessing the internal validity of studies that do not use random assignment, a common scenario in rehabilitation research, including hydrotherapy interventions. By applying this tool, we ensured a consistent and transparent appraisal of methodological quality across the included studies. Publication bias was also evaluated using funnel plots.

Disagreements were resolved through discussion. The Cochrane criteria for evaluating risk of bias encompass five areas: the randomization process, deviations from the intended intervention, missing outcome data, outcome measurement, and the selection of reported results (Higgins, 2011). Publication bias was evaluated using funnel plots. Both SG and TP independently assessed the risk of bias, and any discrepancies were addressed through negotiation. The risk of bias for each study was classified as high, some concern, or low, in line with the Cochrane Statement on Risk of Bias.

2.9. Data extraction

A data extraction table was created by one author (TP), which included the journal, year of publication, title, study characteristics, intervention details, outcomes, main findings, limitations, and additional notes. One author (ZR) abstracted the information, and a second author (TP) double-checked the data for accuracy.

3. Results

The results section summarizes the statistical outcomes of each study and its methodological quality based on the PEDro scale. PEDro scores ranged from 6 to 9, indicating generally moderate to high methodological quality. Common methodological strengths included clear randomization procedures and appropriate outcome reporting, while blinding of participants and therapists was rarely achieved due to the practical constraints of hydrotherapy interventions.

3.1. Study selection

Files in. ris format containing the exported search results were saved and imported into the Rayyan web tool (Ouzzani et al., 2016). The search, conducted across selected databases, retrieved 16 articles (MEDLINE via PubMed = 16; Scopus = 0; B-on = 0; Web of Science = 0; PEDro = 0). A thorough review of titles and abstracts was performed to identify potentially relevant studies, leading to the exclusion of articles that did not align with the research topic. This process resulted in a set of 15 articles. Full-text access to these articles was obtained through institutional subscriptions. The search process and article inclusion were documented and tracked using reference management software.

The entire search process is visually summarized in Fig. 1, following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021). This figure illustrates the number of articles identified, screened, and included at each stage. After a rigorous application of the inclusion and exclusion criteria, eight articles were deemed suitable. A summary of the main findings and overall limitations of these studies is provided in Table 2.

3.2. Study characteristics

This systematic review includes 409 participants, with an average age of 62.41–78.4 years, indicating that the individuals are either ageing or already in the geriatric phase. In this population with neurological conditions, 227 older adult individuals suffered from stroke, and 182 were diagnosed with Parkinson's Disease.

In the experimental groups (EG), two of the studies underwent nonspecific aquatic exercises (Volpe et al., 2014; Silva and Israel, 2019). One study simultaneously underwent nonspecific aquatic exercises and conventional therapy exercises, both nonspecific (Tripp and Cracóvia, 2014); another study underwent immersion baths with electrical stimulation (Bei et al., 2023); one study underwent Aquatic Multidisciplinary Rehabilitation (MIRT-TA) (Clerici et al., 2019); three studies conducted Ai-Chi (Furnari et al., 2014; Pérez-de la Cruz, 2018; Kurt et al., 2018); and two conducted Halliwick (Tripp and Cracóvia, 2014; Furnari et al., 2014);. In the control groups (CG), all studies underwent conventional physiotherapy with nonspecific exercises but with balance, gait, and strength training. The Multidisciplinary Rehabilitation Program (MIRT) was also implemented in one of the studies (Clerici et al., 2019).

3.3. Methodological quality assessment

The methodological quality of the included studies was evaluated using the Physiotherapy Evidence Database (PEDro) scale, which assesses key aspects of trial design such as random allocation, concealed allocation, baseline comparability, blinding of participants, therapists, and assessors, adequacy of follow-up, intention-to-treat analysis, and statistical reporting. Scores on the PEDro scale range from 0 to 10, with higher scores indicating better methodological quality.

Overall, the included studies demonstrated moderate to high methodological quality, with PEDro scores ranging from 6 to 9 points. Most studies satisfied criteria for random allocation, between-group comparisons, and adequate statistical reporting. However, blinding of participants and therapists was often not feasible due to the nature of hydrotherapy interventions.

3.4. Risk of bias

The assessment of bias risk among the included studies demonstrates a generally favourable methodological adherence, reflecting considerable rigour in most studies (Fig. 2). Most studies exhibit a low risk of bias in participant selection (D2), intervention classification (D3), outcome measurement (D6), and selection of reported outcomes (D7). This suggests that these aspects were generally well-controlled across the studies. Study 3 (Bei et al., 2023) stands out with a moderate to serious risk of bias regarding confounding (D1), deviation from intended intervention (D4), missing data (D5), and selection of reported outcomes (D7). This indicates potential issues in the study design, execution, and reporting, raising concerns about the reliability of its results. Study 5 (Furnari et al., 2014) also raises concerns about a moderate risk of bias in confounding (D1), missing data (D5), and possibly deviation from

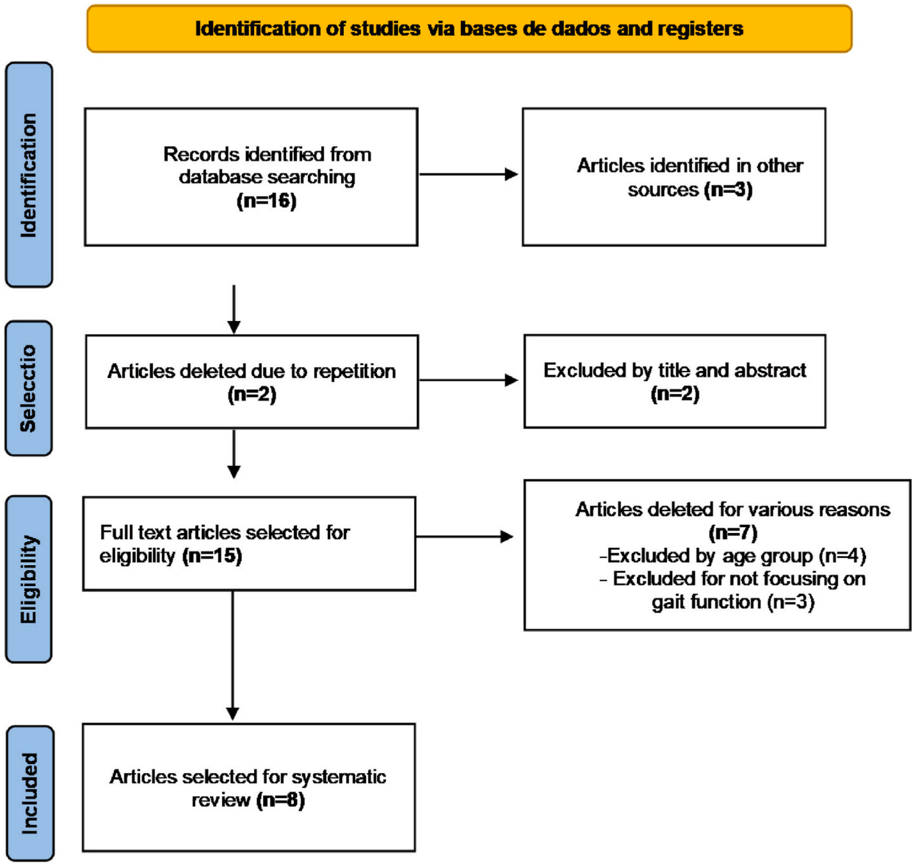

Fig. 1. Flowchart illustrating the article selection and inclusion process based on the PRISMA methodology outlined by Page et al., 2021.

intended intervention (D4). This suggests that the results of this study may be less robust due to these factors. Study 2 (Silva and Israel, 2019) and Study 7 (Pérez-de la Cruz, 2018) both have a moderate risk of bias regarding confounding (D1), deviation from intended intervention (D4), and possibly missing data (D5). Although not as severe as Study 3 (Bei et al., 2023), this moderate risk in multiple domains still requires caution when interpreting the results of these studies. While most studies exhibit a low risk of bias in several key domains, the presence of moderate to serious risks in some studies, especially Study 3, underscores the importance of critically evaluating the methodology and results of each study to assess its validity and reliability.

4. Discussion

Across the studies included in this systematic review, the evidence consistently indicates that AT interventions lead to measurable improvements in balance, functional mobility, and gait control among older adults with neurological impairments. The results of the studies reviewed consistently demonstrate that AT produces significant improvements in balance, functional mobility, and gait control among older adults with neurological conditions. Notably, several studies reported measurable gains in standardized outcome measures. For instance, Tripp et al. (2014) observed a mean increase of 8 points in the Berg Balance Scale (BBS) following a two-week Halliwick program in post-stroke patients, while Da Silva and Israel (2019) reported a reduction of 2.3 s in the Timed Up and Go (TUG) test and improved performance in the Five Times Sit to Stand (FTSTS) test among participants with Parkinson's disease after 10 weeks of aquatic training. Similarly, Furnari et al. (2014) found that hydrotherapy led to statistically significant improvements ($p < 0.05$) in balance and functional gait measures compared to land-based physiotherapy. These findings collectively indicate that AT demonstrates superior outcomes relative to conventional land-based rehabilitation.

Building on these general findings, several studies have specifically explored the effects of AT in individuals with Parkinson's disease. The positive effects of AT can be partially attributed to the inherent properties of water, including hydrostatic pressure, buoyancy, and turbulence, which amplify the benefits of exercise. Additionally, AT offers a distinct advantage for special populations, such as individuals with Parkinson's disease or those recovering from a stroke, by enabling movements that may be difficult or impossible to execute on land (Pinto et al., 2019). A recent study by Medrado et al. (2022) revealed that water buoyancy significantly enhances muscle functionality. The study also demonstrated that aquatic exercise effectively alleviates pain, reduces disease activity, and improves physical function in individuals with inflammatory arthritis, underscoring the added benefits of AT for musculoskeletal conditions (Medrado et al., 2022).

Recent systematic reviews and meta-analyses further support these findings. Liu et al. (2023) demonstrated that hydrotherapy significantly improves postural stability and gait functionality in Parkinson's disease, while Carroll et al. (2021) confirmed that aquatic exercise enhances lower-limb motor function and quality of life in patients with Parkinson's disease (Liu et al., 2023; Carroll et al., 2021). Similarly, a 2024 network meta-analysis by Zhao et al. (2024) found that water-based motor interventions lead to greater improvements in coordination and dynamic balance compared with conventional land-based therapy (Zhao et al., 2024). In stroke rehabilitation, Li et al. (2024) and Bei et al. (2023) reported comparable benefits of aquatic exercise on gait speed, balance, and lower-limb strength (Bei et al., 2023; Li et al., 2024). Collectively, these recent analyses reinforce the growing consensus that AT is an effective, evidence-based intervention for improving mobility and quality of life in older adults with neurological conditions.

Zhao et al. (2024) reported that water immersion enhances motor coordination in individuals with Parkinson's disease, enabling smoother

Table 2
Systematic review articles n = 8.

Author/Year	Sample (n)	Age (Mean ± SD)	Population	Evaluation	Duration	Frequency	Protocol	Results
(1) Tripp, 2014	EG: 12 GC: 15	EG: 64.8 ± 15.0 CG: 65.0 ± 15.	Stroke	BBS FAC FR RMI	2 wk	EG: 3x/wk, Halliwick sessions (35 min) and 2x/wk conventional physiotherapy sessions (45 min); CG: Conventional physiotherapy 5x/wk (45 min).	EG: Acclimatisation to the aquatic environment (5 min); Rotational control exercises (15 min); Locomotion at various depths and different environmental disturbances (15 min); CG: Not reported.	EG: Statistically significant differences in BBS; Improvement in functional capacity of gait; CG: No statistically significant differences.
(2) Da Silva, 2019	EG: 14 CG: 11	EG: 63,12 ± 13,61 CG: 64,23 ± 13,45	PD	TUG FTSST BBS DGI	10 wk	EG: 20 sessions of AT, 2x/week (60 min); CG: Not Reported.	EG: Vital signs assessment (10 min); immersion and dual-task aquatic exercises (50 min); CG: Only instructed to maintain ADLs.	EG: Significant changes in TUG; Improvement in functional mobility, balance, gait, and dynamic movement ability; CG: No statistically significant differences.
(3) Bei et al., 2023	EG: 80 CG: 80	EG: 62,63 ± 6,79 CG: 62,68 ± 6,56	Stroke	NIHSS MRS FMA FAC BBS MBI	8 wk	EG: 48 sessions, 1x/day (30/40 min), 6x/wk; GC: 48 sessions, 1x/day (40 min), 6x/wk.	EG: The training was divided into two stages: exercises for hemiplegia and aquatic walking training. The exercises included: Butterfly bath rehabilitation exercise; Immersion bath with electrical stimulation, and weight-lifting exercises during water walking. GC: Assisted walking training with physiotherapist support.	EG: Significant differences in NIHSS and MRS scores; Significant improvements in lower limb control and improvement in balance, coordination, and gait. GC: No statistically significant differences.
(4) Volpe, 2017	EG: 24 CG: 12	EG: 78,4 ± 4,6 CG 74,7 ± 4,9	PD	UPDRS-III TC6m TUG BBS PDQ-39	3 wk	EG: 1x/day (40 min); CG: 1x/day (40 min).	EG: Hydrotherapy sessions (walking for 40 min at a fast pace forward and backwards, with immersion level at nipple line); CG: Overground walking for 40 min at a fast pace forward and backwards.	EG: Walking speed significantly increased; Significant improvement at the joint level, notably in hip and ankle rotation and knee and ankle flexion; CG: No statistically significant differences.
(5) Furnari et al., 2014	EG: 20 CG: 20	EG: 68 ± 3 CG: 72 ± 5	Stroke	Barometry BI MIF MAS TT	8 wk	EG: Hydrotherapy, 3x/wk, and conventional physiotherapy, 3x/wk (60 min); CG: Conventional physiotherapy, 6 x/wk (60 min).	EG: 10 min of warm-up; 15 min of the Halliwick method; 15 min of the Ai-Chi method; 10 min of strength training for lower limbs; 10 min of cool-down; CG: 10 min of warm-up; 20 min of strengthening for lower limbs; 20 min of postural control exercises; 10 min of gait training.	EG: Greater acceptance of load on the affected side; Significant differences in all applied scales; CG: No significant statistical differences.
(6) Clerici et al., 2019	EG: 27 CG: 25	EG: 67 ± 8 CG: 67 ± 11	DP	FOGQ UPDRS total UPDRS-II UPDRS-III BBS TUG TC6	4 wk	EG: Implementation of the MIRT-AT program: 4 daily rehabilitation sessions for 5 days (60 min); 3x/wk, with one AT session on the 1st, 3rd, and 5th days; 60 min of physiotherapy exercises on the 6th day. CG: Implementation of the MIRT program: 4 daily rehabilitation sessions for 5 d (60 min); 60 min of physiotherapy exercises on the 6th day.	EG: 1st session - focused on muscle recruitment, coordination, and reactive balance control. On the 2nd, 4th, and 6th days, AT sessions focused on muscle recruitment, coordination, anticipatory and reactive strategies, gait training, and rotation; 2nd session - improving gait, balance, endurance, and motor control; 3rd session - occupational therapy; 4th session - speech therapy; 6th day - training with equipment only (60 min); CG: 1st session - focused on muscle recruitment, coordination, and reactive balance control; 2nd session - improving gait, balance, endurance, and motor control; 3rd session - occupational therapy; 4th session - speech therapy.	EG: Significant improvements in UPDRS, TC6, TUG, and BBS, although the outcome of AT was not superior to land-based physiotherapy; CG: Significant improvements in UPDRS, TC6, TUG, and BBS.
(7) Pérez-de la Cruz, 2018	EG: 14 CG: 15	EG: 65,87 ± 7,09 CG: 66,44 ± 5,72	PD	VAS TUG FTSST GDS PDQ-39	11 wk	EG: Aquatic Ai-Chi sessions, 2x/wk (45 min); CG: Conventional physiotherapy, 2x/wk (45 min).	EG: Recreational warm-up; 30 min of Ai-Chi practice with gradually increasing difficulty and ends with a relaxation activity; GC: 10 min of warm-up, including walking exercises, trunk mobility, upper and lower limbs; 30–40 min of strength training and aerobic	EG: Significant improvement in VAS and TUG scales; Presentation of safer gait and greater postural control; GC: No statistically significant differences.

(continued on next page)

Table 2 (*continued*)

Author/ Year	Sample (n)	Age (Mean ± SD)	Population	Evaluation	Duration	Frequency	Protocol	Results
							exercises, ending with muscle relaxation and stretching exercises.	
(8) Kurt et al., 2018	EG: 20 CG: 20	EG: 62,41 ± 6,76 CG: 63,61 ± 7,18	PD	BBS TUG PDQ-39 UPDRS-III	5 wk	EG: 25 sessions of Ai-Chi, 5x/wk (60 min each session); CG: 25 sessions of land-based physiotherapy, in group sessions, 5x/wk (60 min each session).	EG: 15 min of warm-up; 30 min of Ai-Chi program with 16 different postures, with water at shoulder level and knees slightly bent; 15 min of relaxation with walking and stretching; CG: 10 min of warm-up sitting or standing, with light aerobic activities; 10 min of stretching, sitting, lying on dorsal and ventral decubitus, and standing; 30 min of balance and gait training in different planes and axes, with changes in amplitude and speed and weight shifting in different directions. Walking training on different surfaces; 10 min of calm down with muscle relaxation and stretching.	EG: Significant improvements in BBS and TUG scales; Significant improvements in dynamic balance; CG: Significant improvements in baseline static balance values.

ADL - Activities of Daily Living; **AT –** Aquatic Therapy; **BBS** - Berg Balance Scale; **BI** - Barthel Index; **CG** - Control Group; **D** - Day; **DGI** - Dynamic Gait Index; **EG** - Experimental Group; **FAC** - Functional Ambulation Categories; **FMA** - Fugl-Meyer Assessment; **FOGQ** - Freezing of Gait Questionnaire; **FR** - Functional Reach; **FTSST** - Five Times Sit to Stand; **GDS** - Geriatric Depression Scale; **MAS** - Modified Ashworth Scale; **MBI** - Modified Barthel Index; **MI's** - Lower limbs; **MIF** - Modified Independence Measure; **min** - Minute; **MIRT-AT** - Multidisciplinary Aquatic Rehabilitation Therapy; **MIRT** - Multidisciplinary Rehabilitation; **MRS** - Modified Rankin Scale; **MS's** - Upper limbs; **NIHSS** - National Institutes of Health Stroke Scale; **PD** - Parkinson's Disease; **PDQ-39** - Parkinson's Disease Quality of Life Questionnaire; **RMI** - Rivermead Mobility Index; **TC6m** - 6-Minute Walk Test; **TT** - Tinetti Test; **TUG** - Timed Up & Go; **UPDRS** - Unified Parkinson's Disease Rating Scale; **VAS** - Visual Analog Scale; **wk** – Week; **x/wk** – Times per week.

and more controlled movements. This improvement is attributed to the aquatic environment, which reduces the risk of falls and supports the rehabilitation process (Carroll et al., 2021). These findings are consistent with a study by Li et al. (2024), which observed that AT enhances balance and gait in stroke survivors (Li et al., 2024).

The pool depth and the water temperature are two factors that can significantly influence the physiological effects of AT and, consequently, its therapeutic outcomes. For instance, water temperature directly affects muscle relaxation, circulation, and cardiovascular responses. Warmer water (30–32 °C) promotes vasodilation, which enhances blood flow to muscles, reduces muscle stiffness, and facilitates relaxation, making it particularly beneficial for individuals with spasticity or joint stiffness, such as those with Parkinson's disease or post-stroke conditions. However, excessively high water temperatures can lead to arterial hypotension, which may cause dizziness or fatigue, especially in older adults or those with cardiovascular conditions (Terrens et al., 2018). Therefore, maintaining an optimal water temperature of 30–32 °C ensures a balance between therapeutic benefits and safety, maximizing relaxation and pain relief while minimizing risks (Dai et al., 2023; Kopack, 2024). Pool depth also plays a crucial role in determining the level of buoyancy and resistance experienced by patients. Shallow water (e.g., waist-deep) provides partial weight-bearing support, which is ideal for gait training and balance exercises, as it reduces the load on joints while still allowing for controlled movement. Deeper water (e.g., chest-deep) increases buoyancy, further reducing weight-bearing and enabling patients with severe mobility impairments to perform movements that might be impossible on land. This is particularly advantageous for individuals recovering from strokes or traumatic brain injuries, as it allows for safe practice of functional movements without the risk of falls. Additionally, the increased resistance in deeper water enhances muscle engagement and strength development during exercises, contributing to improved functional mobility and gait control (Auza-Santivañez et al., 2023). By carefully adjusting water temperature and pool depth, therapists can tailor AT sessions to meet the specific needs of patients, optimizing outcomes such as improved balance, reduced pain, enhanced range of motion, and greater independence in activities of daily living.

While AT shows clear benefits for individuals with Parkinson's disease, similar positive effects have also been observed in stroke rehabilitation, particularly in balance and gait recovery. Two studies evaluated possible improvements in a two-week Halliwick program in functional mobility in stroke patients. The Halliwick method enabled individuals to enhance their independence in water by fostering mental adaptation and improving rotation control, effectively replicating Activities of Daily Living (ADLs). Functional mobility and improvement in balance are fundamental points to optimise gait pattern and control, facilitating the performance of ADLs and increasing independence. Auza-Santivañez et al. (2023) reinforced that adaptation to the aquatic environment not only improves functional independence but also contributes to increased self-confidence, which is crucial for patients recovering from neurological events (Auza-Santivañez et al., 2023).

Another study reported clinically significant improvements in the Timed Up and Go (TUG) test, along with enhanced functional mobility, balance, gait, and dynamic movement abilities in individuals with Parkinson's disease. A systematic review examining the effects of AT on mobility in individuals with neurological conditions, including Parkinson's disease, revealed that AT improves dynamic balance and gait speed. The review also highlighted notable improvements in postural stability and a reduction in falls among patients with neurological disorders (Alves and Júnior, 2022). Furthermore, in patients with severe traumatic brain injury undergoing post-acute intensive neurorehabilitation, AT has been shown to complement multidisciplinary rehabilitation efforts, enhancing motor functions and quality of life (Curcio et al., 2020).

Beyond neurological disorders, AT has also demonstrated benefits in managing chronic musculoskeletal conditions such as fibromyalgia. AT has benefits in patients with fibromyalgia, providing a reduction in muscle tone, increased joint range of motion, recovery of a regular pattern of upper and lower limbs, relaxation, spinal traction and stretching, muscle improvement, trunk alignment and stability, muscle strengthening, improvement in resistance and functional capacity (Zamunér et al., 2019). A recent systematic review and meta-analysis highlighted the effectiveness of AT as a complementary treatment to standard care for individuals with fibromyalgia. AT exercises were

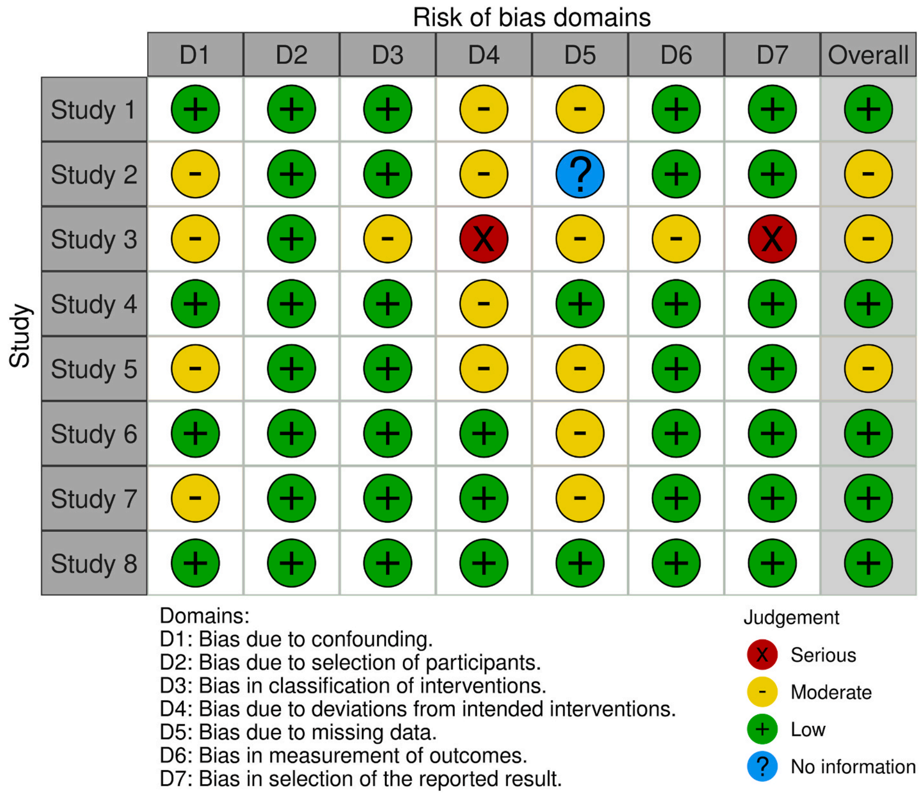

Fig. 2. Risk of bias.

found to significantly improve symptoms such as sleep quality, pain, and overall quality of life in adults with fibromyalgia (Bravo et al., 2024).

The European physiotherapy guidelines for exercise in Parkinson's disease recommend a treatment duration of 8 weeks, with sessions held three times a week for 45 min. In the studies reviewed here, aquatic exercise interventions typically lasted 45–60 min, with a duration ranging from 3 to 11 weeks. Aquatic exercise has the potential to significantly improve the quality of life for patients with Parkinson's disease due to its unique benefits. For instance, water pressure helps alleviate muscle fatigue and reduces pain during exercise. Additionally, AT enhances balance, increases the range of motion, and improves the ability to perform daily activities. Regular physical activity in an aquatic environment also promotes psychological well-being. It boosts self-efficacy, reduces anxiety and depression, and improves mood and self-esteem. Furthermore, it relieves stress and contributes to a better overall quality of life (Dai et al., 2023).

4.1. Limitations and future directions

While this systematic review highlights the significant benefits of AT for individuals with neurological conditions, several limitations should be acknowledged. First, the heterogeneity of the included studies in terms of sample size, intervention protocols, and outcome measures limits the generalizability of the findings. Many studies had small sample sizes, which may reduce the statistical power and reliability of the results. Additionally, variations in the duration, frequency, and intensity of aquatic therapy interventions make it challenging to establish standardized guidelines for clinical practice.

Another limitation is the lack of long-term follow-up in most studies. While the short-term benefits of AT are well-documented, the sustainability of these improvements over time remains unclear. Furthermore, the majority of the studies focused on specific populations, such as individuals with Parkinson's disease or stroke survivors, with limited exploration of other neurological conditions or comorbidities.

Future research should aim to address these limitations by conducting large-scale, multicenter randomized controlled trials with standardized intervention protocols. Long-term follow-up studies are also needed to evaluate the durability of the therapeutic effects of AT. Additionally, further research should explore the mechanisms underlying the benefits of AT, such as the role of hydrostatic pressure, buoyancy, and water resistance in improving motor function and balance. Investigating the cost-effectiveness of AT compared to land-based therapies could also provide valuable insights for healthcare providers and policymakers.

Finally, future studies should consider the impact of individual factors, such as age, gender, and severity of neurological impairment, on the outcomes of AT. This would help tailor interventions to meet the specific needs of diverse patient populations and maximize therapeutic benefits.

5. Conclusion

This systematic review synthesizes current evidence on the effects of AT on balance, functional mobility, gait, and quality of life in older adults with neurological conditions, particularly Parkinson's disease and post-stroke. The proposed AT protocols appear to be both safe and effective for individuals with neurological impairments, such as gait difficulties related to Parkinson's disease and stroke. The findings suggest that AT positively influences balance, functional mobility, and gait control in older adults, showing improvements over conventional physiotherapy in both experimental and control groups. Furthermore, the unique properties of water, including hydrostatic pressure, buoyancy, and temperature, enhance exercise outcomes by promoting muscle relaxation and relieving joint load. Despite substantial evidence supporting the benefits of AT, further research is needed to explore its long-term therapeutic effects, as studies with follow-up data are scarce. Longitudinal studies tracking older adults over extended periods could provide valuable insights into the long-term impact of AT on functionality, independence, and quality of life. While many studies focus on stroke and Parkinson’s disease, other neurological conditions, such as multiple sclerosis, Alzheimer’s disease, and Huntington’s disease, may also benefit from AT. Future research could examine the efficacy of AT across various neurological conditions, addressing existing gaps in knowledge. Such studies would contribute to a deeper understanding of AT’s effectiveness and inform clinical practices and health policies regarding the rehabilitation of older adults with neurological disorders.

CRediT authorship contribution statement

Zélia Rodrigues: Writing – review & editing, Project administration, Methodology, Investigation, Formal analysis. **Patrícia Pires:** Writing – review & editing. **Sónia Pires:** Writing – review & editing. **Sara Gonçalves:** Writing – review & editing, Writing – original draft, Visualization, Validation, Resources, Investigation. **Telma Pires:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Ethical statement

The authors state that the article does not require an ethics committee approval as it is a subject of comparison between theories and literature review.

Data sharing statement

Data supporting the findings and conclusions are available upon request from the corresponding author.

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References

Alves, W.C., Júnior, E.M.G., 2022. Efeitos da fisioterapia aquática no tratamento da Doença de Parkinson: um estudo de revisão. Rev Bras Reabil E Atividade Física 11, 60–67.

Auza-Santivañez, J.C., Condori-Villca, N., Santander, I.O., Gómez, L.M.T., Manzaneda, L. P.M., Condo-Gutierrez, A.R., et al., 2023. Improvements in functionality and quality of life after aquatic therapy in stroke survivors. AG Salud 1. https://doi.org/10.62486/agsalud202315, 15-15.

Bei, N., Long, D., Bei, Z., et al., 2023. Effect of water exercise therapy on lower limb function rehabilitation in hemiplegic patients with the first stroke. Alternative Ther. Health Med. 29, 429–433.

Bravo, C., Rubí-Carnacea, F., Colomo, I., et al., 2024. Aquatic therapy improves self-reported sleep quality in fibromyalgia patients: a systematic review and meta-analysis. Sleep Breath. 28, 565–583. https://doi.org/10.1007/s11325-023-02933-x.

Carroll, L., Morris, M., O’Connor, W., Volpe, D., Salsberg, J., Clifford, A., 2021. Evidence-based aquatic therapy guidelines for parkinson’s disease: an international consensus study. J. Park Dis. 21 de novembro de 12, 621–637.

Clerici, I., Maestri, R., Bonetti, F., et al., 2019. Land plus aquatic therapy versus land-based rehabilitation alone for the treatment of freezing of gait in parkinson disease: a randomized controlled trial. Phys. Ther. 99, 591–600. https://doi.org/10.1093/ptj/pzz003.

Cochrane library of cochrane methods. Risk of bias tools - ROBINS-I tool. https://www.riskofbias.info/welcome/home, 2008–. (Accessed 19 July 2024).

Curcio, A., Temperoni, G., Tramontano, M., De Angelis, S., Iosa, M., Mommo, F., et al., 2020. The effects of aquatic therapy during post-acute neurorehabilitation in patients with severe traumatic brain injury: a preliminary randomized controlled trial. Brain Inj. 34 (12), 1630–1635. https://doi.org/10.1080/02699052.2020.1825809.

Dai, S., Yuan, H., Wang, J., Yang, Y., Wen, S., 2023. Effects of aquatic exercise on the improvement of lower-extremity motor function and quality of life in patients with Parkinson’s disease: a meta-analysis. Front. Physiol. 14, 1066718. https://doi.org/10.3389/fphys.2023.1066718.

Furnari, A., Calabrò, R.S., Gervasi, G., et al., 2014. Is hydrokinesitherapy effective on gait and balance in patients with stroke? A clinical and baropodometric investigation. Brain Inj. 28, 1109–1114. https://doi.org/10.3109/02699052.2014.910700.

Geytenbeek, J., 2002. Evidence for effective hydrotherapy. Physiotherapy 88, 514–529. https://doi.org/10.1016/S0031-9406(05)60134-4.

Higgins, J.P., 2011. Cochrane Handbook for Systematic Reviews of Interventions. The Cochrane Collaboration.

Kopack, J.K., 2024. Aquatic therapy. In: Principles of Therapeutic Exercise for the Physical Therapist Assistant. Routledge, pp. 223–240.

Kurt, E.E., Büyükturan, B., Büyükturan, Ö., et al., 2018. Effects of Ai Chi on balance, quality of life, functional mobility, and motor impairment in patients with Parkinson’s disease<sup. Disabil. Rehabil. 40, 791–797. https://doi.org/10.1080/09638288.2016.1276972.

Li, X., He, Y., Wang, D., Rezaei, M.J., 2024. Stroke rehabilitation: from diagnosis to therapy. Front. Neurol. 15, 1402729. https://doi.org/10.3389/fneur.2024.1402729.

Liu, Z., Huang, M., Liao, Y., et al., 2023. Long-term efficacy of hydrotherapy on balance function in patients with Parkinson’s disease: a systematic review and meta-analysis. Front. Aging Neurosci. 15, 1320240. https://doi.org/10.3389/fnagi.2023.1320240.

Medrado, L.N., Mendonça, M.L.M., Budib, M.B., Oliveira-Junior, S.A., Martinez, P.F., 2022. Effectiveness of aquatic exercise in the treatment of inflammatory arthritis: systematic review. Rheumatol. Int. 42 (10), 1681–1691. https://doi.org/10.1007/s00296-022-05145-w.

Ouzzani, M., Hammady, H., Fedorowicz, Z., et al., 2016. Rayyan—A web and mobile app for systematic reviews. Syst. Rev. 5, 210. https://doi.org/10.1186/s13643-016-0384-4.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., et al., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Br. Med. J. n71. https://doi.org/10.1136/bmj.n71.

Pérez-de la Cruz, S., 2018. A bicentric controlled study on the effects of aquatic Ai Chi in Parkinson disease. Compl. Ther. Med. 36, 147–153. https://doi.org/10.1016/j.ctim.2017.12.001.

Pinto, C., Salazar, A.P., Marchese, R.R., et al., 2019. The effects of hydrotherapy on balance, functional mobility, motor status, and quality of life in patients with parkinson disease: a systematic review and meta-analysis. Pharm. Manag. PM R 11, 278–291. https://doi.org/10.1016/j.pmrj.2018.09.031.

Roever L. PICO: model for clinical questions. Evid. Base Med.. Epub ahead of print 9 August 2018. DOI: 10.4172/2471-9919.1000115...

Silva, AZ da, Israel, V.L., 2019. Effects of dual-task aquatic exercises on functional mobility, balance and gait of individuals with Parkinson’s disease: a randomized clinical trial with a 3-month follow-up. Compl. Ther. Med. 42, 119–124. https://doi.org/10.1016/j.ctim.2018.10.023.

Terrens, A.F., Soh, S.-E., Morgan, P.E., 2018. The efficacy and feasibility of aquatic physiotherapy for people with Parkinson’s disease: a systematic review. Disabil. Rehabil. 40, 2847–2856. https://doi.org/10.1080/09638288.2017.1362710.

Tripp, F., Cracóvia, K., 2014. Effects of an aquatic therapy approach (Halliwick-Therapy) on functional mobility in subacute stroke patients: a randomized controlled trial | PDF | physical therapy | stroke. Clin. Rehabil. 28, 432–439. https://doi.org/10.1177/0269215513504942.

Volpe, D., Giantin, M.G., Maestri, R., et al., 2014. Comparing the effects of hydrotherapy and land-based therapy on balance in patients with Parkinson’s disease: a randomized controlled pilot study. Clin. Rehabil. 28, 1210–1217. https://doi.org/10.1177/0269215514536060.

World Health Organization, 2021. Ageing and health. https://www.who.int/news-room/fact-sheets/detail/ageing-and-health. (Accessed 12 July 2024).

Zamunér, A.R., Andrade, C.P., Arca, E.A., et al., 2019. Impact of water therapy on pain management in patients with fibromyalgia: current perspectives. J. Pain Res. 12, 1971–2007.

Zhao, H., Zhang, L., Yang, J., Guo, W., Sun, C., Shi, R., Wang, Z., 2024. Parkinson’s disease motor intervention patterns: a network meta-analysis based on patient motor function. Front. Neurol. 15, 1432256. https://doi.org/10.3389/fneur.2024.1432256.

Zhu, Z., Cui, L., Yin, M., et al., 2016. Hydrotherapy vs. conventional land-based exercise for improving walking and balance after stroke: a randomized controlled trial. Clin. Rehabil. 30, 587–593. https://doi.org/10.1177/0269215515593392.