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The effects of aquatic therapy on mobility of individuals with neurological diseases: A systematic review

Andresa R Marinho-Buzelli[1], Alison M Bonnyman[2] and Mary C Verrier[2]

Abstract

Objective: To summarize evidence on the effects of aquatic therapy on mobility in individuals with neurological diseases.

Data sources: MEDLINE, EMBASE, PsycInfo, CENTRAL, CINAHL, SPORTDiscus, PEDro, PsycBITE and OT Seeker were searched from inception to 15 September 2014. Hand-searching of reference lists was performed in the selected studies.

Review methods: The search included randomized controlled trials and quasi-experimental studies that investigated the use of aquatic therapy and its effect on mobility of adults with neurological diseases. One reviewer screened titles and abstracts of retrieved studies from the search strategy. Two reviewers independently examined the full texts and conducted the study selection, data extraction and quality assessment. A narrative synthesis of data was applied to summarize information from included studies. The Downs and Black Scale was used to assess methodological quality.

Results: A total of 116 articles were obtained for full text eligibility. Twenty studies met the specified inclusion criteria: four Randomized Controlled Trials (RCTs), four non-randomized studies and 12 before-and-after tests. Two RCTs (30 patients with stroke in the aquatic therapy groups), three non-randomized studies and three before-and-after studies showed "fair" evidence that aquatic therapy increases dynamic balance in participants with some neurological disorders. One RCT (seven patients with stroke in the aquatic therapy group) and two before-and-after tests (20 patients with multiple sclerosis) demonstrated "fair" evidence on improvement of gait speed after aquatic therapy.

Conclusion: Our synthesis showed "fair" evidence supporting the use of aquatic therapy to improve dynamic balance and gait speed in adults with certain neurological conditions.

Keywords

Aquatic therapy, hydrotherapy, mobility, neurological diseases

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Introduction

Aquatic therapy is a common treatment modality used to address the complexity of patients with neurological disorders with the goal to achieve optimal functional independence.[1,2] The physical properties of hydrodynamics, such as buoyancy, viscosity and thermodynamics, appear to benefit mobility in populations with disabilities.[2,3] Although aquatic therapy continues to be widely utilized in neurorehabilitation, there is a lack of evidence on its effectiveness on mobility in adults with neurological disorders.

A systematic review in 2002 of the evidence of the effectiveness of aquatic therapy indicated that the majority of participants in aquatic therapy studies were older adults, individuals with low back pain and with rheumatoid arthritis.[4] In a Cochrane Review, Mehrholz et al.[5] systematically synthesized and compared the effects of aquatic and land-based therapies on activities of daily living (ADL) of patients following stroke and found that water-based exercises improved strength and ADL. Only four randomized controlled trials (RCTs) were included in Mehrolz's review and results were not focused on specific mobility outcomes defined in the scope of the present review. A review by Rammage[6] reported the effects of aquatic therapy on balance in stroke survivors, but was unable to make any strong conclusions owing to methodological quality of the five included studies. However, one of the studies, a single-blind RCT reported significant improvement for mobility as measured by walking speed.[7]

The primary objective of this study was to systematically review the effects of aquatic therapy on mobility of individuals with neurological diseases. The aim was to focus on mobility outcomes that ranged from bed mobility to walking, as conceptualized in the definition by Shumway-Cook and Woollacott.[8] Our goal in investigating a range of neurological diseases was to identify gaps in the literature and to guide future aquatic therapy intervention studies in the field of neurorehabilitation. The secondary objective of this review was to describe the aquatic therapy methodology and protocols used in the studies reviewed.

Methods

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were used to conduct and report the present systematic review.[9]

RCTs and quasi-experimental studies (non-randomized trials and before-and-after studies), which were peer-reviewed, were included in this systematic review. Descriptive (e.g. case reports) and qualitative studies were not included in this review. Review articles were identified as a source of additional primary studies.

Adults, male and female, 18 years of age and above, with neurological disorders (central, peripheral and/or neuromuscular) regardless of the duration of pathology were included.

Any method of aquatic therapy was considered for inclusion. For the purpose of this systematic review, aquatic therapy was defined as a program, using mechanical and thermal characteristics of water during partial or complete immersion as a single, one-to-one or group treatment. This included any method of therapeutic movement, exercise or activity in a pool. Therapeutic activity in baths and spa pool was considered aquatic therapy. Aquatic therapy, if combined with land therapy in the intervention protocol, was not included in this review.

We considered a range of mobility outcomes that included bed mobility (e.g. rolling and supine-to-sit), reaching, transfers, dynamic balance, wheeling and walking/gait outcomes and running.[8] Outcome measures initially identified as having components of mobility were: Functional Reach Test (FRT),[10] Timed Up and Go Test (TUG),[11] dynamic balance subscores of the Berg Balance Scale (BBS),[12] mobility subscores of Functional Independence Measure (FIM),[13] walking velocity and distance measured by the 10-meter walking test (10MWT)[14] and 6-minute walk test (6MWT)[15], or other validated measures of functional mobility. Dynamic balance measured by center of pressure (COP) parameters was also included. Indirect measures of mobility (e.g. cardiovascular and respiratory outcomes), measures of muscle power and force, range of motion and muscle tone were not considered direct measures of mobility for this systematic review.

Search methods

A medical information specialist searched published literature from inception to 15 September 2014 using the following databases: MEDLINE, EMBASE, PsycInfo, Cochrane Central Register of Controlled Trials (CENTRAL), CINAHL, SPORTDiscus, Physiotherapy Evidence Database (PEDro), PsycBITE and OT Seeker. In an effort to identify further published studies, reference lists were scanned for selected articles and reviews on the topic. The search strategy contained three concepts: (1) nervous system diseases (e.g. stroke); (2) aquatic therapy (e.g. hydrotherapy); and (3) mobility (e.g. walking). We used a combination of subject headings and free text terms to maximize the retrieval of indexed literature (see Appendix 1, available online). The subject headings were adjusted for the different databases to avoid missing articles by the search strategy. We searched for studies in all languages and studies were limited to humans and adults. Appendix 1 illustrates the search strategy with results from Medline.

Study selection

The first review author (AMB) independently read the titles and, when available, abstracts of all retrieved studies from the search strategy. Articles were considered relevant if two out of the three concepts (aquatic therapy, neurological disease or mobility) were addressed by titles and/or abstracts. After all irrelevant literature was excluded, the full text articles were obtained for the remaining studies and two reviewers (AMB and AB) independently examined the full texts and conducted the study selection with detailed reasons for inclusion and exclusion described on the eligibility criteria chart. In the presence of disagreements, the third author (MV) was consulted to determine trial inclusion. Articles in foreign language were included for full text eligibility criteria. Articles in Portuguese, Spanish and Persian were eligible for full text analysis and were examined for final inclusion by one reviewer only. One other study in Japanese from 1963[16] could have been included in full text analysis; however, owing to the lack of resources for translation, it was excluded.

Data extraction and quality assessment

A data extraction form was developed and tested to ensure that all relevant information was captured. Two independent reviewers (AMB and AB) extracted the required information and discussed the results with a third reviewer (MV) if lack of consensus appeared. Given the diversity of the studies, a meta-analysis was not considered as a possibility. Therefore, narrative synthesis and descriptive statistics of the content of the studies were used.

Two review authors (AMB and AB) independently assessed the quality of all included studies. The Downs and Black Scale[17] was selected for critical appraisal of the included articles. The Downs and Black Scale for measuring study quality is deemed feasible for both randomized and non-randomized trials, demonstrating good reliability and internal consistency for the majority of its five subscales. The last question was modified from a 5-point score to a 0- or 1-point score, where 1 was scored if a power or sample size calculation was reported and 0 was scored where there was no sample size, power calculation or explanation whether the number of subjects was appropriate for the question being addressed. This modified version of the Downs and Black Scale has been used elsewhere[18,19] providing support for the use of this approach. Therefore, the total maximum score of the modified version was 28, with the higher score indicating a higher level of methodological quality. For the purpose of this review, the classification of the Downs and Black Scale was used in which scores were expressed in percentages with 100% being the maximum possible score. Scores below 50% were considered "weak"; those between 50% and 69% were considered "fair"; 70%–79% was considered "good"; and 80%–100% was deemed "very good" for methodological quality.[19]

Results

Figure 1 depicts a flow diagram with the search results, study selection and reasons for exclusion. A total of 20 articles met the inclusion criteria and

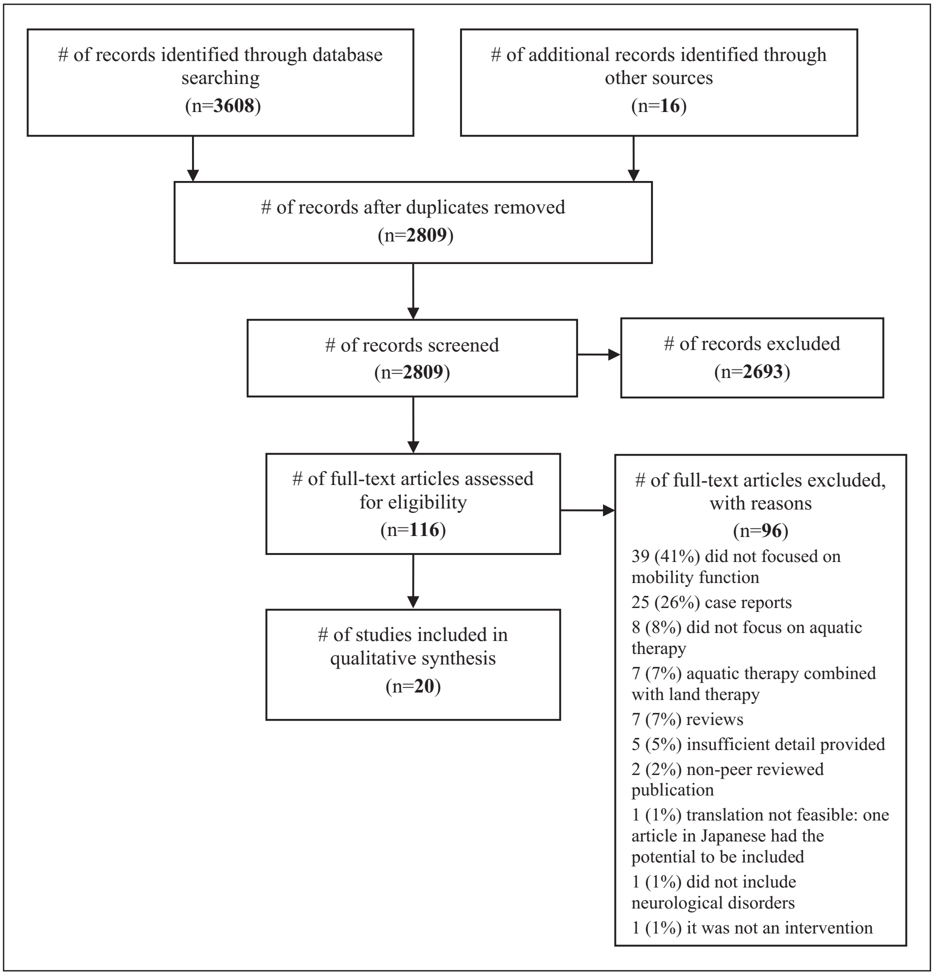

Figure 1. Flow diagram of study selection.

were described in the narrative synthesis (Table 1 and Table 2, available online). Table 1 describes the studies in a reverse chronological order, from the most recent in 2014 to the earliest from 1986, along with the country of origin and the characteristics of included studies. Studies varied in design and research settings (Table 1). Twelve of the 20 studies were a before-and-after test design.[20–31] Four studies were RCTs[7,32–34] and four were quasi-experimental non-randomized studies.[35–38] The majority of studies were conducted in outpatient settings associated with a rehabilitation center or association group.[20,26–28,31–33,37] Four studies were hospital-based[29,34,36,38] and three studies were set in the community.[7,24,25]

The participants primarily included individuals with multiple sclerosis,[24,25,30,31,35,36] Parkinson's disease[22,23,26,32,37] and stroke[7,20,30,33,34](Table 1 (available online) and Table 3). Participants with multiple sclerosis and stroke were predominant among studies, 98 in each population. Individuals with Parkinson's disease corresponded to 61 individuals among the studies. Individuals with hereditary spastic paraparesis,[21] cervical dystonia,[27] brain injury,[28] poliomyelitis[29] and spinal cord injury[30,38] were also investigated. The majority of participants were in the chronic phase of their diseases, with average time since diagnosis ranging from 1.5 years to 35 years. Age ranged from 20 to 80 years and

Table 3. Summary of main findings of all selected studies grouped by neurological diseases and from most recent to the earliest ($N=20$).

Author (year), country	Study design	Neurological disease	Intervention types	Mobility outcomes	Significant results	Quality assessment classification
Zhang et al. (2014), New Zealand[21]	Before-and-after study	Hereditary spastic paraparesis	Aquatic only (1 group)	Gait kinematics	↑ walking speed	Weak
Bayraktar et al. (2013), Turkey[35]	Non-randomized controlled trial	Multiple sclerosis	Aquatic vs. control	TUG, 6MWT	↑ TUG, ↑ 6MWT after Ai-Chi	Fair
Marandi et al. (2013), Iran[36]	Non-randomized trial	Multiple sclerosis	Aquatic vs. pilates vs. control	SSST	SSST: Aquatic and pilates > control	Weak
Salem et al. (2011), USA[24]	Before-and-after study	Multiple sclerosis	Aquatic only (1 group)	10MWT, TUG	↑ 10MWT, ↑ TUG	Fair
Salem et al. (2010), USA[25]	Before-and-after study	Multiple sclerosis	Aquatic only (1 group)	10MWT, TUG	↑ 10MWT, ↑ TUG	Fair
Gehlsen et al. (1986), USA[31]	Before-and-after study	Multiple sclerosis	Aquatic only (1 group)	Gait kinematics	Not significant	Weak
Rodríguez et al. (2013), Spain[22]	Before-and-after study	Parkinson's disease	Aquatic only (1 group)	Gait kinematics	↑ stride length, ↑ ratio of single and double support	Fair
Ayán and Cancela (2012), Spain[37]	Non-randomized controlled pilot study	Parkinson's disease	Aquatic low intensity vs. Aquatic muscular resistance	FTSTS	FTSTS ↑ after muscular resistance training	Fair
Ayán and Cancela (2012), Spain[23]	Before-and-after study	Parkinson's disease	Aquatic only (1 group)	FFT	FFT: ↑ 2-min step, ↑ chair sit and reach	Fair
Vivas et al. (2011), Spain[32]	Randomized controlled, open-label pilot trial	Parkinson's disease	Aquatic vs. land	FRT, gait kinematics and TUG	Both groups ↑ FRT	Fair
de Andrade et al. (2010), Brazil[26]	Before-and-after study	Parkinson's disease	Aquatic only (1 group)	TUG	↑ TUG	Weak
Montagna et al. (2014), Brazil[20]	Before-and-after study	Stroke	Aquatic only (1 group)	TUG, unclear outcome for sitting-to-standing	↑ TUG	Weak

(Continued)

Table 3. (Continued)

Author (year), country	Study design	Neurological disease	Intervention types	Mobility outcomes	Significant results	Quality assessment classification
Lee et al. (2010), USA[33]	Randomized controlled trial	Stroke	Aquatic vs. land	Time and distance of the COP	↑ time and ↑ distance of COP: Aquatic > land	Fair
Noh et al. (2008), USA[34]	Randomized controlled pilot study	Stroke	Aquatic vs. conventional	Weight bearing ability using mtd-balance, Modified Motor Assessment Scale gait scores	↑ forward and ↑ backward weight bearing: Aquatic > conventional	Fair
Chu et al. (2004), Canada[7]	Single-blind randomized controlled trial	Stroke	Aquatic vs. control	Gait speed over 8-meter distance	↑ gait speed: Aquatic > control	Fair
da Silva et al. (2005), Brazil[38]	Non-randomized controlled trial	Spinal cord injury	Aquatic vs. control	FIM	↑ transfers: Swimming > control	Fair
Useros-Olmo and Collado-Vasquez (2010), Spain[27]	Before-and-after study	Cervical dystonia	Aquatic only (1 group)	TUG	↑ TUG	Weak
Driver et al. (2004), USA[28]	Before-and-after tests with randomized groups	Brain injury	Aquatic vs. control	Sit-to-reach test	↑ Sit-to-reach after aquatic	Weak
Willén et al. (2001), Sweden[29]	Before-and-after study with 2 groups	Late poliomyelitis	Aquatic vs. control	30-meter walking speed	Not significant	Fair
Zamparo and Pagliaro (1998), Italy[30]	Before-and-after study	Spastic paresis (stroke, multiple sclerosis, and spinal cord injury)	Aquatic only (1 group)	Gait speed	↑ gait speed only in patients with spinal cord injury	Weak

↑: improvement; >: improved in comparison with; 6MWT: 6-minute walk test; 10MWT: 10-meter walking test; COP: center of pressure; FIM: Functional Independence Measure; FFT: Fullerton Fitness Test; FRT: Functional Reach Test; FTSTS: Five Times Sit-to-Stand Test; SSST: Six Stop Step Test; TUG: Timed Up and Go Test.

younger individuals were those with spinal cord injury and multiple sclerosis (Table 1).

Influence of aquatic therapy on mobility

The most commonly used outcome to assess mobility was dynamic balance, measured through a variety of tests including the Timed Up and Go Test (Table 2 (available online) and Table 3). One non-randomized controlled study[35] and five before-and-after studies[20,24–27] showed a significant improvement in Timed Up and Go Test scores in individuals with stroke, multiple sclerosis, Parkinson's disease and cervical dystonia. Laboratory measures were also used to assess dynamic balance in individuals with chronic stroke.[33,34] One RCT analyzed the COP time and distance of individuals with stroke to measure dynamic standing balance while reaching for a target.[33] The aquatic exercise group significantly demonstrated change in their COP parameters after 36 sessions of a 10-series aquatic exercise. One pilot RCT used a balance system to investigate the load forces of the left and right legs during transfers.[34] In this study, forward and backward weight shift significantly improved after 24 sessions of Halliwick and Ai Chi methods.

The dynamic balance through functional reaching was assessed in three other studies in individuals with brain injury[28] and Parkinson's disease.[23,32] The sit and reach performance of patients with brain injury improved after 24 sessions of aerobic and resistance exercise in the pool.[28] The chair sit-and-reach performance of the Fullerton Fitness Test significantly increased after 24 sessions of aquatic therapy.[23] Performance on the Functional Reach Test improved similarly in both land and aquatic exercise groups of individuals with Parkinson's disease after eight sessions.[32]

One study used the Functional Independence Measure to assess aspects of functional mobility after aquatic therapy intervention for individuals with spinal cord injury.[38] Functional Independence Measures subscores of transfers significantly improved after 30 sessions of a swimming program compared with a control group.

The second most common mobility outcome was walking, which was measured by clinical tools[7,24,25,29,30,35] and gait kinematics[21,22,30] (Table 3). One RCT with participants with stroke demonstrated that 24 sessions of aquatic therapy improved gait speed compared with 24 sessions of upper limb program on land.[7] However, another RCT comparing 24 sessions of aquatic therapy to general conditioning exercise on land, showed that both approaches were effective in improving gait performance in patients with stroke.[34] Rodríguez et al.[22] assessed stride length and the ratio of single and double support in patients with Parkinson's disease and demonstrated improvement after 20 sessions of aquatic therapy. The walking speed of individuals with multiple sclerosis showed significant improvement after aquatic interventions that included aerobics, balance exercises and walking.[24,25]

Aquatic therapy comparison to land therapy

Two studies detailed the aquatic and land-based interventions, explicit in targeting the same principles of movement therapy enabling a good comparison of water-based and land-based programming.[32,33] An open-label pilot RCT by Vivas et al.[32] compared the effects of eight sessions of land-based therapy with eight sessions of aquatic therapy (warm-up, trunk mobility, postural stability and transfers on land and in water) in persons with Parkinson's disease and concluded both groups similarly improved their Functional Reach Test scores. One RCT by Lee et al.[33] carried out 10 sessions of similar land-based therapy and aquatic therapy, such that water resistance was mimicked on land by resistance from a physiotherapist. The study reported that those individuals with stroke who exercised in water significantly improved time and distance of the COP excursion compared with the land exercise group.

Aquatic therapy protocols and pool characteristics

The duration of the aquatic therapy interventions ranged from two weeks to eight months (Table 1, available online). The average frequency was 2.4 ±0.9 sessions per week, ranging from one to five sessions per week. The session durations ranged from 40 to 60 minutes. Exercise protocols consisted of warm-up, targeted exercises and cool-down periods. Warm-up sessions mostly included walking,[22–25,32,34,36,37] and stretching.[7,24,25,33,36–38] The most common target exercises were aerobics,[7,24,25,28,29,33,36] strengthening,[22,24,25,28,29,33,37] balance[22,24,25,29,33,37] and coordination.[22,23,30,33,37] Four studies reported using the Halliwick,[20,27,32,34] two studies reported using the Ai Chi[34,35] and one study used Watsu[27] methodologies. Two studies incorporated swimming exercise as the part of the main session.[31,38] The cool-down session was described in 13 of 20 aquatic interventions, with stretching[22–25,27,28,33,35,37] and flotation[22,23,37,38] the most common approaches. Group therapy was described in the majority of studies with five studies describing a one-to-one or patient-to-therapist intervention.[20,21,25,27,28,32] The temperature of the pools varied from 24 °C to 34 °C. Seven studies reported the dimensions of their pools,[22,23,32–35,37] which ranged from 7.75 to 14 m in length and 3.55 to 7.75 m in width. Depths of the pools ranged from 0.75 to 1.5 m.

Quality assessment

Table 4 (available online) shows the score for each subcomponent of the modified Downs and Black Scale. The average Downs and Black Scale total score of included studies was 13.8 ±4.1 (range from 7 to 19), considering the maximal score of 28. The RCTs had the higher scores ranging from 17 to 19 in quality assessment, whereas before-and-after studies had scores ranging from 7 to 16. According to the classification proposed for this study, 12 articles were assessed as “fair” (50%–68%) and eight articles were classified as “weak” (25%–46%).

Discussion

The present systematic review is the first to summarize the evidence of the effectiveness of aquatic therapy on a defined and broad concept of mobility, investigating adults with all central and peripheral neurological diseases. Our synthesis indicates that there is a lack of RCTs demonstrating strong evidence that aquatic therapy would be superior to land therapy in improving mobility outcomes in patients with neurological disorders. Two out of four RCTs were pilot studies with small sample sizes.[7,32] Although most of the studies were based on small samples, there was “fair” evidence among randomized and non-randomized studies that aquatic therapy improves dynamic balance[33–35,37,38] and gait performance[7,35] in individuals with neurological disorders. In addition, some before-and-after studies provided information to guide future aquatic therapy interventions when reporting aquatic protocols that were effective to improve gait speed and dynamic balance in people with multiple sclerosis[24,25] and Parkinson’s disease.[22,23]

Dynamic balance was the most commonly assessed mobility function measured by clinical and laboratory parameters in a variety of tests during sitting and standing. The Timed Up and Go Test and the Berg Balance Scale were the most common dynamic balance measures among the selected studies. However, total scores of balance tests such as Berg Balance Scale, which included static balance components, were excluded from the scope of mobility in this review. In addition to the Timed Up and Go Test,[20,24,25,27,35] other measures of dynamic balance such as Fullerton Fitness Test,[23] Six Stop Step Test[36] and Five Times Sit-to-Stand Test,[37] improved after aquatic interventions. The aquatic environment has the potential to facilitate controlled movement during weight transfer as the viscosity of the water enables a longer response time and assists balance control during the task.[3,32] In addition, the aquatic medium provides a safe environment for the client by reducing the impact of a fall.[2,3]

Walking performance was the second most frequent mobility outcome among the studies. One RCT reported that aquatic therapy was more effective than the control group in improving gait speed of individuals with stroke.[7] Four before-and-after studies and one non-randomized controlled trial showed significant improvement in walking performance in individuals with multiple sclerosis,[24,25,35] spinal cord injury[30] and individuals with hereditary spastic paraparesis.[21] This might be accounted for as the aquatic therapy has been suggested to enable improved walking performance by utilizing the hydrodynamic properties of buoyancy and viscosity for progressive weight-bearing and assisted upright standing for individuals unable to stand without support on land.[3]

Outcome measures not included in the scope of mobility in this review, which could potentially influence mobility performance, were cardiorespiratory conditioning, muscle strength, range of motion and muscle tone.[7,30,39] As an example, Chu et al.[7] found that muscle strength of the affected leg and cardiovascular conditioning improved along with gait speed after 24 sessions of aquatic therapy in individuals with stroke.

Overall, the research methodology was lacking in follow-up. In these 20 studies the long-term effects of aquatic therapy on mobility of the neurological population remain unknown. Only one study reported a follow-up period of 17 days where no significant change in mobility was found in a small sample of participants with Parkinson's disease.[32]

The interventions were not always matched to a land-based intervention and it was difficult to determine if the land-based represented best practice or standard care. Therefore, it is recommended that future research comparing water with land-based interventions should appropriately compare similar methods in both environments. For example, Vivas et al.[32] achieved the same movements in water and on dry land targeting trunk mobility, postural stability and postural transitions. The postural instability that occurred while squatting in water was enacted on land by sitting on a therapy ball. The results showed that both groups of participants with Parkinson's disease significantly improved Functional Reach Test scores yet walking speed did not change after land and aquatic therapies. This result may illustrate the effectiveness of the task-specific approach in improving task-specific functional outcomes regardless of the environment.[40]

Owing to the lack of RCTs on aquatic neurorehabilitation and research, this systematic review included, in addition to RCTs, quasi-experimental studies (non-randomized and before-and-after studies) and assessed their methodological quality using the Downs and Black Scale.[17] Twelve out of the 20 studies were before-and-after designs. The Downs and Black Scale provided a quality assessment with the overall methodological quality of these twelve studies rated "weak" or "fair". This was expected as before-and-after design does not adhere to the strict protocol of the RCT and scored low in items such as external validity, confounding and bias. The gold standard of the RCT is not always feasible in rehabilitation studies since recruiting large numbers of subjects for the required power, bias control and randomization is difficult, timely and costly in both manpower and dollars.[41]

There is "fair" evidence to suggest that aquatic therapy is beneficial in the attainment of mobility in individuals with Parkinson's disease, multiple sclerosis, stroke and spinal cord injury. However, there is insufficient evidence to show aquatic therapy is superior to land therapy to improve mobility in individuals with a neurological condition. The diversity in study design and outcome measures of the included studies made it difficult to identify significant conclusions for a specific group of neurological disorders.

Important questions need to be addressed, such as if a combination of land and aquatic therapy is more or less effective than aquatics only, and what are the long-term effects of training in water. Further investigation of the mechanical and thermal stimuli of the aquatic environment on mobility could help to inform best practice in neurorehabilitation.

Clinical messages

- There is "fair" evidence that aquatic therapy is effective in improving mobility in individuals with neurological disorders, especially those with multiple sclerosis, Parkinson's disease and stroke.
- There is a lack of strong evidence to suggest that aquatic therapy is superior to land therapy in favoring mobility recovery after a neurological disease.

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Conflict of interest

None declared.

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