Hong Kong Physiotherapy Journal (2016) 35, 12–20

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REVIEW PAPER

Systematic review of published studies on aquatic exercise for balance in patients with multiple sclerosis, Parkinson's disease, and hemiplegia

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KEYWORDS
aquatic exercise;
balance;
hemiplegia;
multiple sclerosis;
Parkinson's disease

Abstract *Background:* Multiple sclerosis, Parkinson's disease, and hemiplegia are common disorders that directly cause impairment of balance and gait. Aquatic exercises are used for neurological rehabilitation. It is suggested that the contributing factors of the water setting such as buoyancy, viscosity, and hydrostatic pressure offer an ideal environment for rehabilitative programmes.
Objective: To conduct a systematic review of studies that assess the effect of aquatic exercises on balance in neurological patients (i.e., patients with multiple sclerosis, Parkinson's disease, and hemiplegia).
Methods: A systematic literature search of six databases (MEDLINE, PEDro, AMED, CINAHL, Embase, SPORTDiscus) for randomized controlled trials and quasi-experimental trials on aquatic exercises in three different neurological disorders, namely, multiple sclerosis, Parkinson's disease, and hemiplegia, was performed. Reference lists from identified studies were manually searched for additional studies. Methodological quality was assessed using the Downs and Black checklist. The data were analyzed and synthesized by two independent reviewers. Disagreements in extracted data were resolved by discussion among the reviewers.
Results: The methodological quality of eight studies included in this review ranged from fair to good. The findings illustrated that there were statistically significant improvements in static

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http://dx.doi.org/10.1016/j.hkpj.2016.03.002

and dynamic balance in patients with multiple sclerosis and hemiplegia. The statistically significant improvements in gait ability were only found in the studies conducted on multiple sclerosis. No conclusions can be drawn in Parkinson's populations as only two trials conducted with a small sample size were available.
Conclusion: Aquatic exercises may be effective at improving balance impairment in patients with hemiplegia and multiple sclerosis. There is a need for further research investigating its effect on Parkinson's disease before encouraging the use of aquatic exercises.

Introduction

Neurological disorders are recognized as a large source of disease burden globally [1]. In London, over 1,00,000 people suffer from neurological disorders [2]; however, the precise number of neurological patients worldwide is unavailable due to limited information. Nevertheless, in the British population, the prevalence of neurological diseases such as Parkinson's disease has been estimated to be 19/1,00,000 in 2000 [2], stroke 7.2/1000 in 2008 [3], and multiple sclerosis 1,27,000 in 2010 [4].

Impairments in neuromuscular function limit functional and physiological ability, thereby leading to a progressive decrease in everyday activities and a reduction in quality of life [1]. The personal and economic costs of neurological disorders pose a significant problem to public health [5]. Patients with multiple sclerosis, Parkinson's disease, and stroke may experience a loss of balance due to a reduction in muscle strength, exercise tolerance, co-ordination, and reaction time [6,7]. It is suggested that poor balance may contribute to falls and accidents. In addition, patients who have experienced a fall are at risk of developing a fear of falling and a restriction in physical activities [8].

Exercise is recognized as a mechanism to maintain health, prevent disease, and rehabilitate a broad range of conditions. Evidence suggests that participation in exercise programmes can strengthen muscle [9], increase walking velocity [10], and provide better results in response time and balance control [11]. Aquatic therapy is an exercise modality performed in a controlled water environment and is commonly used in neurological rehabilitation [12].

Water creates a low-impact environment allowing patients to perform therapeutic exercise with less fear of falling [13]. Buoyancy and hydrostatic pressure created by the water environment provide a supportive force on joints and a reduction in gravitational force, which may facilitate postural control [12]. In addition, hydrostatic pressure and viscous force provide a different proprioceptive and sensory feedback from that experienced on land [14], thus influencing the postural control system and balance competence [15].

It is suggested that aquatic exercise provides an optimum environment for rehabilitation programmes for patients with neurological conditions [13]. To date, there has not been a systematic review evaluating the effects of aquatic exercise on balance in patients with neurological conditions. The aim of this study is to systematically review the evidence from randomized controlled trials (RCTs) and quasi-experimental studies to assess the effectiveness of aquatic exercises for balance improvement in patients with multiple sclerosis, Parkinson's disease, and stroke.

Methods

Literature search

An electronic literature search was conducted by two independent researchers in MEDLINE, PEDro, AMED, CINAHL, Embase, and SPORTDiscus using the following combination of various terms: (aquatic exercise OR aquatic therapy OR water-based exercises OR water exercises OR pool exercises OR pool therapy OR hydrotherapy) AND (balance OR postural control OR postural control) AND (stroke OR cerebrovascular OR cerebrovascular disorder OR hemiparesis OR hemiplegia OR parkinson disease OR parkinson OR demyelinating disease OR demyelinating OR demyelination OR multiple sclerosis OR neurodegeneration OR neurodegenerative). We limited our review to publications prior to December 31, 2014. The Cochrane Library and six databases (included in this review) were searched to ensure there were no other systematic reviews on this topic. Manual search of the reference lists of all relevant articles was conducted. Only articles written in English were included. Studies were included when (1) adult patients (18 years and above) were diagnosed with multiple sclerosis or Parkinson's disease or stroke; (2) trials included all types of aquatic exercises; (3) the outcome measure was balance and/or gait performance; and (4) the study was an RCT, a quasi-experimental study, or a pre—post study. Studies were excluded when (1) swimming was considered as an intervention; (2) the interventions failed to meet the recommendation of exercise for improving balance ability (the studies that delivered the intervention $<$4 weeks) [16]; and (3) studies appeared in previous relevant systematic reviews.

Data extraction and management

Independent reviewers (PM and CE) individually merged and screened all the titles and abstracts from the databases. Studies that failed to meet the selection criteria were excluded. Data extraction was analyzed and synthesized by two reviewers independently (PM and CE). The data

extraction form was developed based on the PICO questions [17] on population, intervention, comparison, and outcomes.

Methodological quality

The quality of included studies was assessed by two independent reviewers (PM and CE) using the criteria proposed by Downs and Black [18]. When no consensus between reviewers (PM and CE) was reached, a third reviewer (AF) made the final decision. Quality scores above 19 were considered as "good," between 11 and 19 as "moderate," and below 11 as "poor" [19].

Results

Selection of the studies

The flow chart in Figure 1 shows the steps in the selection of studies. From the electronic databases, a total of 101 published articles were identified. Of these, 67 were eliminated after screening of titles and abstracts. After duplicates were excluded, 14 remained. After reading the full-text articles, seven more studies were excluded because they failed to meet the inclusion criteria; thus, the seven remaining studies [20—26] were included in the review. An additional recent study by Lee et al [27] was added following hand searching of reference lists; this study was not featured in any of the searches in the databases. Consequently, eight studies were eligible to be included in the review.

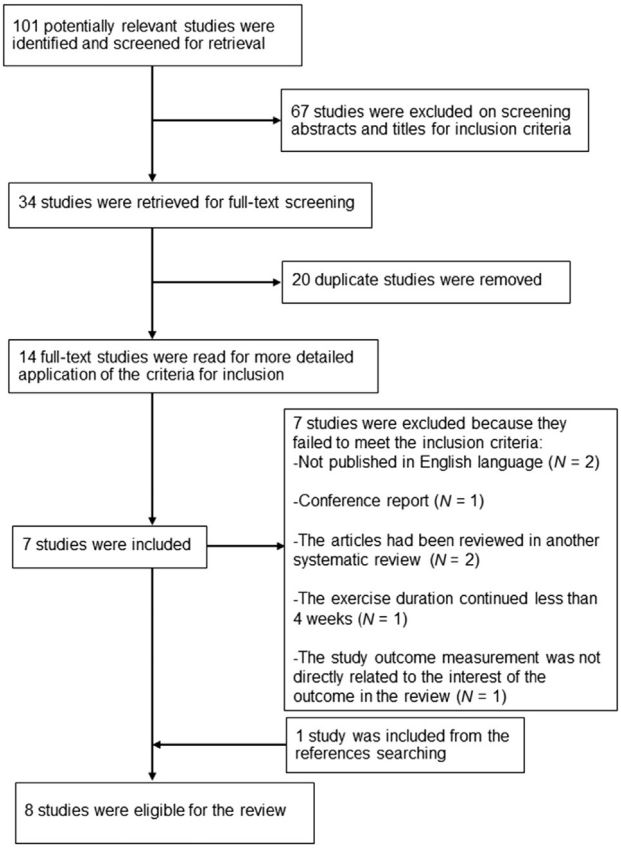

Figure 1. Flow chart for the selection of studies.

Study characteristics

Table 1 presents the main characteristics of the eight eligible studies [20—27]. These provided data for 221 participants: 91 with multiple sclerosis (3 studies) [20—22]; 20 with Parkinson's disease (2 studies) [23,24]; and 110 with stroke (3 studies) [25—27]. Four of the studies were RCTs [24—27] with the others being quasi-experimental studies [20—23]. The aquatic intervention comprised the following: Ai-Chi [20], community-based aquatic exercises [22], obstacle training [25], task-orientated training [27], and aquatic exercise [21,23,24,26].

Focusing on the aquatic setting, four studies reported the use of an accessible pool. Salem et al [22] and Jacobs et al [23] used the pool based in the university. Vivas et al [24] used a city spa. Park and Roh [26] set their aquatic experiment in the exercise therapy room in the hospital. The other four studies [20,21,25,27] failed to identify the place where the intervention took place. Six studies [20,21,24—27] had a comparison group and of these, four studies [24—27] compared the aquatic intervention with a land-based exercise. Bayraktar et al [20] compared aquatic-Ai-Chi with home-based exercise and Marandi et al [21] compared aquatic exercise with pilates and a control group. To deliver the intervention, Bayraktar et al [20], Salem et al [22], Vivas et al [24], and Lee et al [27] used physiotherapists as the exercise instructor, whereas in the study by Jacobs et al [23] physiotherapy students provided instructions about the exercise programme to the participants.

The duration of the intervention varied between studies from 35 minutes/session to 60 minutes/session. Four studies [20,22—24] used two times a week protocol and three studies [21,25,27] used three times a week protocol. Only one study [26] used six times a week protocol. The length of provision of the exercise intervention ranged from 4 weeks to 12 weeks.

Because of the heterogeneity of the study designs, participants, and outcome measures, it was impossible to conduct a meta-analysis. The measure of balance included Timed Up and Go Test, 6-minute walk test, one-leg standing test, six-spot step test, Berg Balance Scale, 10-meter walk test, sit-to-stand task, functional reach test, 5-minute walk test, and sway of centre of pressure with eyes closed and eyes open test.

Balance measurement was performed in all studies before and after intervention. One study monitored balance performance of patients at additional interim stages of the study [24]. Long-term follow-up was not performed in any of these studies. Of these, none provided concealed randomization.

Methodological quality

Results of the methodological quality assessment, modified from the Downs and Black's checklist, are presented in Table 2. The methodological quality of the included

Table 1 Characteristics of aquatic exercise programmes and measurements of outcome included in the review.

Reference	Design	Type of participants (*N*)	Dropouts (E/C)	Mean age (y) (E/C)	Interventions			Dosage		Duration (wk)	Method of balance-gait measurements
								Min/session	Time/wk		
Bayraktar et al [20]	QES	MS (23)	5 (4/1)	38/39	*N* = 11 Aquatic-Ai-Chi exercises	*N* = 7 Home exercise		60	2	8	TUG 6MWT 1LST
Marandi et al [21]	QES	MS (57)	12 (4/4/4)	Not reported	*N* = 15 Pilates exercise	*N* = 15 Aquatic exercise	*N* = 15 Control	60	3	12	SSST
Salem et al [22]	QES	MS (11)	1	55.9	*N* = 10 Aquatic exercise			60	2	5	BBS TUG 10-m walk
Jacobs et al [23]	QES	PD (8)	0	67.75	*N* = 8 Aquatic exercise			60	2	6	BBS STS step test
Vivas et al [24]	RCT	PD (12)	1 (1/0)	65.67/68.33	*N* = 5 Aquatic exercises	*N* = 6 Land-based exercises		45	2	4	BBS TUG FRT 5-m walk
Jung et al [25]	RCT	HEMI (30)	0	57.2/55.6	*N* = 15 Aquatic exercises	*N* = 15 Land-based exercises		40	3	12	Sway of centre of pressure with EC
Park and Roh [26]	RCT	HEMI (46)	0	54.6/56.6	*N* = 23 Aquatic exercises	*N* = 23 Land-based exercises		35	6	6	Sway of centre of pressure with EO and EC
Lee et al [27]	RCT	HEMI (34)	0	62.1/61.4	*N* = 17 Aquatic exercises	*N* = 17 Land-based exercises		50	3	12	Sway of centre of pressure with EO and EC

10-m walk = 10-meter walk test; 1LST = one-leg standing test; 5-m walk = 5-minute walk test; 6MWT = 6-minute walk test; BBS = Berg Balance Scale; E/C = experimental group versus control group; EC = eye closed; EO = eye open; FRT = functional reach test; HEMI = hemiparesis; MS = multiple sclerosis; *N* = number; PD = Parkinson's disease; QES = quasi-experimental study; RCT = randomized-controlled trial; SSST = six-spot step test; STS = sit-to-stand task; TUG = Timed Up and Go Test.

Table 2 An assessment of the methodological quality of studies assessed by the Downs and Black checklist.

	Checklist[a,b]																										
Study	1	2	3	4	5[c]	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27[d]	
	Study aim	Main outcome	Participant characteristics	Description of intervention	Principal confounders	Outcome data	Range of results	Adverse events	Lost to follow-up	Probability value (exact)	Source population	Representative of population	Staff, place, facility	Participants blind to intervention	Blind assessors	Data dredging	Same length of follow-up	Appropriate statistical tests	Compliance with the intervention	Accurate outcome measure	Control recruited same	Recruitment at same time	Randomized allocation	Concealed randomization	Adjustment for confounders	Participants lost to follow-up	Power	Total
Bayraktar et al [20]	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	U	U	N	N	Y	Y	Y	Y	U	Y	Y	U	N	N	Y	N	0	18/29
Marandi et al [21]	N	Y	N	Y	N	Y	Y	N	Y	N	U	U	U	N	U	Y	Y	Y	U	Y	Y	U	Y	N	N	U	2	13/29
Salem et al [22]	Y	Y	Y	Y	P	Y	Y	Y	Y	Y	U	U	Y	N	U	Y	Y	Y	Y	Y	Y	U	N	N	N	Y	0	18/29
Jacobs et al [23]	Y	Y	Y	Y	P	Y	N	Y	Y	Y	U	U	Y	N	N	Y	Y	Y	Y	Y	N	U	N	N	N	Y	0	16/29
Vivas et al [24]	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	U	U	Y	N	N	Y	Y	Y	Y	Y	Y	U	Y	U	Y	Y	0	20/29
Jung et al [25]	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	N	N	U	U	U	Y	Y	Y	Y	Y	Y	U	Y	U	Y	Y	0	19/29
Park and Roh [26]	Y	Y	Y	Y	Y	Y	Y	N	Y	N	U	U	Y	U	U	Y	Y	Y	Y	Y	Y	U	Y	U	Y	U	0	18/29
Lee et al [27]	Y	Y	Y	Y	Y	Y	Y	N	Y	N	U	U	U	N	U	Y	Y	Y	Y	Y	Y	U	Y	U	Y	Y	0	18/29

N = answer is no; P = partial answer; U = unable to determine; Y = answer is yes.

[a] All questions except Question Numbers 5 and 27 will assign a score of "0" if the answer is "no" or "unable to determine," and "1" if the answer is "yes." The total quality scores of studies are as follows: less than 11 = poor; 11–19 = fair; greater than 19 = good.

[b] Items 1–27 of the Downs and Black checklist.

[c] Question Number 5 will assign a score of "0" if the answer is "no," "1" if the answer is "partial," and "2" if the answer is "yes".

[d] Question Number 27 will assign a score of "0" if no power calculation is provided, "1" if a power calculation is provided but the importance or impact of the difference between groups used in the calculation is unclear, and "2" if the difference between groups is clearly defined as a clinically important difference.

studies in this review was variable: the overall quality was rated as fair (range from 13 to 20). Only two included studies demonstrated good methodological quality [24,25]. Five studies reported randomization [21,24–27]. All studies with the exception of one [21] failed to conduct a power calculation. Only two studies provided statements of single blinding: Bayraktar et al [20] blinded the assessor, but whether the assessor was blinded in Lee et al's study [27] is unclear. Four studies had no patient dropout [23,25–27]. The other four studies gave the following reasons for patient dropout: patients' illness [24]; water affecting a new tattoo [22]; absent for more than six sessions [21]; and difficulty to participate due to time, transportation, and family problems [20]. Three studies [20,22,23] reported no occurrence of adverse events; the remaining five [21,24–27] did not report on adverse events.

Primary outcomes: Balance performance

Multiple sclerosis

Three studies [20–22] assessed balance control using different types of measurements; Bayraktar et al [20] used Timed Up and Go Test, 6-minute walk test, and one-leg standing test; Marandi et al [21] used six-spot step test; and Salem et al [22] used Berg Balance Scale, Timed Up and Go Test, and 10-meter walk test. There was variation in design, intensity, frequency, and duration of exercise across the studies (Table 1). However, it was concluded that exercises in water improved postural control in patients with multiple sclerosis ($p < 0.05$) [20,22] (mean difference $= -5.88$) [21]. There was no statistically significant difference in the effects on dynamic balance between pilates and aquatic exercises [21].

Parkinson's disease

Two studies assessed balance control in the Parkinson's population [23,24]. The study population in both trials had similar mean ages; however, the stage of symptoms was different. Participants in one study [23] had Stage I to II, whereas in the other [24], participants had Stage II to III Parkinson's disease according to the Hoehn and Yahr Scale [28]. Despite the variation in symptom stage and intervention, both studies demonstrated a statistically significant increase in the Berg Balance Scale ($p \leq 0.05$). Both water-based and land-based exercises improved functional reach test but there was no significant difference between them ($p = 0.087$) [24]. Vivas et al's study [24] found that balance improvement in the aquatic exercise group remained when reassessed 17 days after completion of the programme, whereas that in the land-based group did not.

Stroke

Three studies [25–27] evaluated the effect of postural control in hemiplegia. The study population in these three RCTs was homogeneous. Participants had their stroke at least 6 months before enrolment and had the ability to walk at least 15 m. The age of participants ranged from 54 years to 62 years and all were recruited in Korea. All studies demonstrated that aquatic exercise resulted in an improvement in static ($p < 0.05$) [25,26] and dynamic balance ($p < 0.05$) [27] compared with land-based exercises.

Secondary outcomes: Gait ability

Multiple sclerosis

Two studies measured the effectiveness of aquatic exercises on functional mobility [20,22]. One study [20] comparing aquatic-Ai-Chi exercises with home-based exercise showed a statistically significant improvement in functional mobility during the 6-minute walk test and the Timed Up and Go Test ($p < 0.05$); no significant difference was observed in the home-based exercise group ($p > 0.05$). Aquatic exercises also provided statistically significant increase in gait speed [22].

Parkinson's disease

Only one study [24] compared aquatic exercises with land-based exercises on gait ability in the Parkinson's population. Both groups received trunk mobility exercises and postural stability training but in different environments. Both interventions demonstrated no statistically significant improvement in gait velocity, step amplitude, turn time, cadence, and the Timed Up and Go Test ($p > 0.05$).

Stroke

None of the trials included in this review provided information about the change in gait performance in the stroke population after undergoing aquatic therapy.

Discussion

This systematic review has provided information about the therapeutic effects of aquatic exercises on balance ability in selected neurological disorders, in comparison with land-based exercises [24–27], home-based exercises [20], pilates [21], and medicine therapy (control group) [21], or with no comparison [22,23]. The findings of the review highlighted that aquatic exercises might increase static and dynamic balance in patients with multiple sclerosis, Parkinson's disease, and hemiplegia.

The quality of studies

Only four RCTs were included in this review [24–27] but these demonstrated methodological flaws. None of them described the randomization method in detail and there was lack of concealment of allocation potentially leading to selection bias. Only one RCT [27] provided details of blinding within the trial although this was limited to a statement of *single blinded*. Moreover, intention-to-treat within the studies was unclear. When considering external validity of the studies in this review, the patients included in the studies were not representative of the neurological population. Seven studies [20,22–27] had small samples and only one study reported consideration of powering the sample [21]. A small sample size can increase the risk of a Type II error and a false-negative result [29].

Multiple sclerosis

This review was able to find only three quasi-experimental studies [20—22] examining the therapeutic effects of aquatic exercises on balance in patients with multiple sclerosis. The methodological quality was fair. The findings of this review suggest that aquatic exercise programmes that include walking, functional exercises, balance training, and stretches benefit patients with multiple sclerosis.

The results of two studies included in this review suggest that aquatic exercises might be effective in increasing dynamic balance [21,22]. A 5-week intervention of aquatic exercises enhanced postural stability and gait performance [22]. However, a small sample of eligible patients may have increased the risk of selection bias. There was no significant distinction between the effectiveness of aquatic exercises and pilates [21]. This may be because of the similarities between these interventions; for example, both included stretching, strengthening, and balance training. Neuromuscular coordination training was part of the pilates regime, whereas aquatic exercises employed buoyancy and viscosity to organize coordinated motor strategies [30]. Both aquatic exercises and pilates were considered more effective than receiving only medicine therapy (control group).

The remaining study assessed the effect of aquatic-Ai-Chi exercise in comparison with a home-based programme [20]. Greater efficacy in static balance, gait performance, fatigue, and muscle strength was observed in the aquatic exercise group, but no significant improvement was found in the home-based group. Improvement after practicing aquatic exercises may be attributable to the buoyancy of water supporting body weight and enhancing the ability to move [15]. Water turbulence and resistance might also provide a suitable environment for balance and gait training [12].

It is possible that the superior results shown in aquatic-Ai-Chi group exercise compared with home-based individual exercise may be also due to the degree of exercise supervision influencing exercise compliance. It is suggested that patients have better compliance, motivation, and adherence to exercise when they participate in a group or have an instructor to guide them [31].

Parkinson's disease

Only two studies investigating the effects of water-based exercises among Parkinson's disease participants were identified in this review [23,24].

In the pre—post study [23], the Berg Balance Scale and the step test scores improved after a 6-week intervention, whereas scores in the sit-to-stand analysis, utilizing the Balance Master tool, exhibited no significant improvement. This may be because exercises in this study included stretching, strengthening, balance, and aerobic activities and none provided feedforward control and positioning required to support sit-to-stand transfer performance. It is also possible that this is due to excessive trunk stabilization and reluctant response in Parkinson's individuals that might have caused difficulties in sit-to-stand transferring and account for the unchanged centre of gravity sway velocity measurement [32]. Performance of sit-to-stand also requires lower-extremity strength in addition to balance yet this exercise protocol had an emphasis on balance training [32] because it focused on balance than on lower-extremity strength.

Only one RCT of good quality [24] examined the therapeutic effects of aquatic exercises on gait performance. The findings revealed no statistically significant difference in recovery of gait impairment between land-based and water-based exercise groups. It is possible that the experimental period of 4 weeks and the frequency of two times a week might be inadequate to effectively restore gait impairment in Parkinson's disease.

Previous research has suggested that patients who perform aquatic exercises three times a week for 20 weeks demonstrate an improvement in gait and quality of life [33]. It can be inferred that there may be a positive correlation between the duration and frequency of the intervention and effectiveness. At present, there is no clear evidence regarding this and further research is required. The studies included in this review recruited participants with different stages of Parkinson's disease (Stage I to II [23] vs. Stage II to III [24]). However, the effects of severity of the disease on the effectiveness of aquatic exercises are inconclusive due to the diverse study designs.

The limited amount of persuasive evidence and the substantial heterogeneity between the included trials prevent conclusions being drawn for the effectiveness of aquatic exercises in Parkinson's population.

Stroke

The findings of this review suggest that aquatic exercise appears to be effective at improving balance in Stroke survivors [25—27]. Three RCTs reported a significant increase in balance ability as measured by the Good Balance System (Metitur Ltd, Jyväskylä, Finland). This is in contrast to the findings of a previous review [34] that suggested aquatic therapy for hemiplegic patients did not offer statistically significant improvement in postural control. Although the included trials in the previous review were RCTs and of fair to good quality, only two studies with a total of 38 participants [35,36] were included. This small sample size might increase the possibility of inaccuracy and lack of generalizability of the results. In addition, the contrasting findings of this review might be explained by differences in exercise regimen. For example, Chu et al [35] focused on exercises for improving cardiovascular fitness that might not be expected to improve measurements of balance.

In a recent RCT ($n = 30$), with average time since stroke of 51.9 days [37], patients undertaking aquatic exercise demonstrated a statistically significant improvement in postural stability in comparison with conventional physiotherapy. Another RCT ($n = 44$) of stroke survivors [38] further corroborates the suggestion that joint position sense was enhanced in an aquatic exercise group when compared with a conventional treatment group. Joint position sense is considered to be directly associated with balance performance [6], thus suggesting that aquatic therapy improves postural stability in this population.

A Cochrane review [34] reported no significant improvement in gait ability with the use of water-based exercises. This is in contrast with a recent RCT [37] which suggested improvement in Functional Ambulation Categories [39] in patients participating in an aquatic exercise group. This RCT [37] utilized a population of postacute stroke patients with dependent gait, whereas trials included in the Cochrane review [34] were conducted on chronic stroke participants with independent gait. This suggests that the duration of symptoms before enrolment might affect the outcome, that is, shorter duration of symptoms at the time of the intervention might lead to enhanced outcomes independent of the ability to walk independently unaided.

It would appear that aquatic exercise confers therapeutic benefits on balance in stroke survivors. However, current evidence lacks information about the effects of aquatic exercise on balance performance in stroke patients with different lengths of symptoms. Future studies should include stroke patients with acute stage because the only existing study in this field was conducted by Tripp and Krakow [37].

In conclusion, the findings of this review suggest that therapeutic benefits are gained from the use of exercises in water for patients with multiple sclerosis and hemiplegia. However, the superiority of aquatic exercise programme over other interventions (i.e., conventional physiotherapy, land-based exercises) is unclear due to the limitations of existing research.

Limitations of the review

This review contains literature published in English language only, which increases the risk of publication bias and the possibility of overestimation of treatment outcomes. Further limitations include the small number of trials meeting the eligibility criteria and the paucity of methodological quality. In addition, most studies had small sample sizes and significant heterogeneity in the baseline characteristics of included populations and treatment protocols. For example, the different outcome measures used in studies prevented the statistical calculation and comparison of effectiveness among these studies. This limits the generalizability of this review.

Implications for research

There are very limited numbers of high-quality RCTs investigating the effects of aquatic exercise among patients with neurological conditions. More RCTs with enhanced methodological quality are required. Furthermore, the majority of studies had limited numbers of participants, which may have caused inadequate power to detect clinical effects. Future research should aim to recruit larger sample sizes to provide precise estimation of intervention effects.

Moreover, intervention and assessment must be made by care providers (physiotherapist or exercise instructor) and assessors who are blinded to group allocation. It is also necessary to standardize the outcome measure to create a large single group on which statistical tests and meta-analysis can be reapplied.

Stroke, Parkinson's disease, and multiple sclerosis cause a long-term impairment on balance and gait. However, no trials included long-term follow-up of outcomes. Future research should examine the influence of water-based exercise training with long-term follow-up.

Conclusion

This study identified eight studies that investigated the effect of water exercise on balance in patients with multiple sclerosis, Parkinson's disease, and hemiplegia. There was substantial variation in population characteristics, treatment protocols, and outcome measurements among the studies. Hence, a comparison between studies is difficult due to this heterogeneity. Participants in the studies had evidence of balance and gait impairment that may be due to differences in balance mechanisms and the nature of their clinical disorder. It is possible that the effectiveness of aquatic exercise is dependent on the nature of the underlying disease or impairment.

The overall methodological quality of eligible trials in the review was fair to good and only four RCTs were found. Inadequate description of population characteristics (i.e., duration of symptom and baseline impairment) and some missing information (i.e., adverse effects) potentially decreases the reliability and validity of the included studies.

Based on the finding of this review, the employment of aquatic exercise programmes potentially offers short-term benefits on balance in individuals with multiple sclerosis and hemiplegia. In hemiplegic patients, it has been demonstrated that aquatic exercise is superior to land-based exercise in improving balance. In addition, a reduction in gait deficits is demonstrated in individuals with multiple sclerosis after participating in aquatic exercise for at least 5 weeks. No conclusions can be drawn to support the use of water-based exercise for Parkinson's disease due to the small number of participants.

Conflicts of interest

All authors declare that they have no conflicts of interest.

Funding/support

No funding was received for this systematic review.

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