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Review Article

Effectiveness of Aquatic Dual-Task Training on Balance Recovery in Individuals with Stroke: A Review

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Abstract

Background: One of the most common complaints following a stroke is loss of balance, which affects around half of all stroke patients. Nevertheless, there is no general physiotherapy method that proved to be more effective in improving post-stroke balance. This study aimed to investigate literature regarding the use of aquatic dual-task exercises for improving balance ability post-stroke.

Methods: A literature search was performed with the help of Cochrane Library, PubMed, and Embase databases to select the studies related to aquatic dual-task training on balance improvement in stroke patients. The inclusion criteria were full-text published articles in English, studies that included patients above the age of 18 years with diagnosed stroke, which investigated any form of aquatic exercise therapy with a dual-task aimed at improving post-stroke balance control while comparing pre-intervention and post-intervention outcome measures.

Results: With the help of given keywords, 573 articles were found initially. After excluding articles for various reasons, three articles were finally included in the review.

Conclusion: According to the results of this study, it can be concluded that aquatic dual-task training has a positive impact on the balance improvement of stroke patients.

Keywords: Aquatic therapy, Balance, Dual-task, Hydrotherapy, Stroke

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Introduction

The main requirement for individuals to perform normal daily living activities and carry out their assigned tasks is the ability to maintain balance. However, one of the common complaints after stroke is loss of balance, and about half of the stroke patients present balance impairment (1). Loss of balance is linked to a higher risk of falling, a greater dependence on daily activities, and a reduced ability to walk (2,3). There is no general physiotherapy strategy that proved to be more effective in promoting balance recovery after a stroke (4).

Given the negative consequences and outcomes of impaired balance after stroke, identifying the best method for balance recovery is critical. Many daily activities necessitate the simultaneous performance of multiple tasks. The ability to cope with everyday life is considerably hampered without the ability to perform these types of simultaneous movements. Dual-task training attempts to maximize the capacity to do two or more activities simultaneously, reducing the risk of falling. Individuals who struggle with cognitive or physical functions, such as stroke patients and the elderly, lose physical abilities or experience physical injuries, such as falls, when they are placed in a situation that requires two more tasks (5).

Compared to single-task training, dual-task training has been suggested to have more effectiveness in increasing dual-task performance (6-8). Balance improved after the training sessions of dual-task training in elderly patients with chronic stroke (9). Lee *et al* found that dual motor task exercises can improve sitting balance and trunk control when joined with a traditional exercise program (10). Song and Park, in their study, showed that both dual-task and single-task training were effective in improving balance in stroke patients, and dual-task training was more effective (11).

Some physical therapists prefer to use a water-based environment for balance training in older adults as it can provide a number of unique features that are difficult to replicate on land. In comparison to the land-based dual exercise for recovering balance post-stroke, aquatic dual-task training was shown to offer a superior improvement (12-14). Although there is some evidence, research still needs to identify the effectiveness of aquatic dual-task training on balance performance in stroke patients based on the relevant evidence.

The current literature review aims to bridge the gap in the literature regarding the use of aquatic dual-task exercises for improving the balance ability post-stroke. Thus, this review will clarify if aquatic dual-task training is effective for improving post-stroke balance.

Materials and Methods

Study Criteria

Studies are required to meet the following criteria in order to be included:

1. To be published in English
2. Investigating any form of aquatic exercise therapy with a dual-task aimed at improving post-stroke balance control. We included both types of secondary tasks (motor and cognitive tasks). Any type of exercise therapy without dual-tasking in water, including therapy as routine, no treatment, or placebo treatment are all appropriate as control groups.
3. Full-text articles available.
4. Study comparing pre-intervention and post-intervention outcome measures.
5. Study with participants above the age of 18 years, who have been clinically diagnosed with a stroke, regardless of sex, type of stroke, or the length of the disease. Also, when data for individuals with stroke were available separately, we included experimental studies with mixed populations (people with stroke and people with other disorders) that meet the study's inclusion criteria.

Search Strategy

The search strategy checked several electronic databases, including Cochrane Library, PubMed, and Embase. For reaching more relevant studies, the author manually reviewed references from the collections. Keywords were: "Stroke", "Hydrotherapy", "Aquatic Therapy", and "Balance". The search terms included keywords and medical subject heading (MESH) terms associated with stroke (*e.g.*, "hemiplegia", "cerebrovascular accident"), balance (*e.g.*, "postural control", "postural stability", "stability"), and aquatic therapy (*e.g.*, "aqua*", "hydrotherapy", "water"'). In all databases, these terms were used as keywords in the title and abstract. The search strategy was

customized to work with different databases. The author did not apply any limit to the study setting or time frame. An example of a search strategy in the PubMed database was provided, which can be found in supplementary figure 1.

Selection of Studies

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement was used to conduct and report this review study (15). Titles and

Search	Actions	Details	Query	Results	Time
#20	•••	›	Search: **((((("Stroke"[MeSH Terms]) OR ("Stroke"[Title/Abstract])) OR ("Hemiplegia"[MeSH Terms])) OR ("Hemiplegia"[Title/Abstract])) OR ("Cerebrovascular Accident"[Title/Abstract])) AND (((((("Aquatic Therapy"[MeSH Terms]) OR ("Hydrotherapy"[Mesh:NoExp])) OR ("Hydro*"[Title/Abstract])) OR ("Aqua*"[Title/Abstract])) OR ("Water"[Title/Abstract]))) AND ((((((("Postural Balance"[MeSH Terms]) OR ("Postural Balance"[Title/Abstract])) OR ("Balance"[Title/Abstract])) OR ("Postural Stability"[Title/Abstract])) OR ("Postural Control"[Title/Abstract])) OR ("Stability"[Title/Abstract]))** Sort by: **Publication Date**	442	14:53:58
#19	•••	›	Search: **(((((("Postural Balance"[MeSH Terms]) OR ("Postural Balance"[Title/Abstract])) OR ("Balance"[Title/Abstract])) OR ("Postural Stability"[Title/Abstract])) OR ("Postural Control"[Title/Abstract])) OR ("Stability"[Title/Abstract])** Sort by: **Publication Date**	750,389	14:53:29
#18	•••	›	Search: **"Stability"[Title/Abstract]** Sort by: **Publication Date**	497,717	14:51:02
#17	•••	›	Search: **"Postural Control"[Title/Abstract]** Sort by: **Publication Date**	7,140	14:50:41
#16	•••	›	Search: **"Postural Stability"[Title/Abstract]** Sort by: **Publication Date**	3,573	14:50:16
#15	•••	›	Search: **"Balance"[Title/Abstract]** Sort by: **Publication Date**	251,865	14:49:51
#14	•••	›	Search: **"Postural Balance"[Title/Abstract]** Sort by: **Publication Date**	1,984	14:49:22
#13	•••	›	Search: **"Postural Balance"[MeSH Terms]** Sort by: **Publication Date**	26,453	14:48:08
#12	•••	›	Search: **((((("Aquatic Therapy"[MeSH Terms]) OR ("Hydrotherapy"[Mesh:NoExp])) OR ("Hydro*"[Title/Abstract])) OR ("Aqua*"[Title/Abstract])) OR ("Water"[Title/Abstract])** Sort by: **Publication Date**	2,320,113	14:47:29
#11	•••	›	Search: **"Water"[Title/Abstract]** Sort by: **Publication Date**	877,542	14:46:53
#10	•••	›	Search: **"Aqua*"[Title/Abstract]** Sort by: **Publication Date**	102,826	14:46:26
#9	•••	›	Search: **"Hydro*"[Title/Abstract]** Sort by: **Publication Date**	1,565,873	14:45:58
#8	•••	›	Search: **"Hydrotherapy"[Mesh:NoExp]** Sort by: **Publication Date**	2,616	14:44:42
#7	•••	›	Search: **"Aquatic Therapy"[MeSH Terms]** Sort by: **Publication Date**	6	14:36:55
#6	•••	›	Search: **((("Stroke"[MeSH Terms]) OR ("Stroke"[Title/Abstract])) OR ("Hemiplegia"[MeSH Terms])) OR ("Hemiplegia"[Title/Abstract])) OR ("Cerebrovascular Accident"[Title/Abstract])** Sort by: **Publication Date**	333,272	14:36:15
#5	•••	›	Search: **"Cerebrovascular Accident"[Title/Abstract]** Sort by: **Publication Date**	5,050	14:35:19
#4	•••	›	Search: **"Hemiplegia"[Title/Abstract]** Sort by: **Publication Date**	9,303	14:34:39
#3	•••	›	Search: **"Hemiplegia"[MeSH Terms]** Sort by: **Publication Date**	11,790	14:34:05
#2	•••	›	Search: **"Stroke"[Title/Abstract]** Sort by: **Publication Date**	279,400	14:33:25
#1	•••	›	Search: **"Stroke"[MeSH Terms]** Sort by: **Publication Date**	155,578	14:32:24

Figure 1. Search strategy in the PubMed database.

abstracts of all studies were identified by the search strategy and all irrelevant studies or studies which did not match the inclusion criteria were excluded. The author then filtered suitable full-text articles to identify relevant studies for inclusion, and finally, the remained articles were evaluated. Data extracted included clinical setting, patients' characteristics, intervention, inclusion and exclusion criteria, study population, study design, methodological quality, and outcome measures.

Quality Appraisal of Included Studies

For assessing the methodological quality of the included studies, the author used the PEDro scale, which is valid and reliable (16,17). The PEDro scale comprised 11 items, and whether or not the items were met, determined the study's score. Each satisfied item (save the first) was worth one point toward the overall score, which varied from 0 to 10. The total score was divided into three levels: (1) high quality (score 6–10), (2) fair quality (score 4–5), and (3) poor quality (score≤3)(17).

Results

During the initial search, a total of 573 studies were identified. Three studies with a total of 100 met the inclusion criteria and were included in the final analysis after evaluating the full articles for additional details and excluding articles for various reasons, such as intervention or control groups that did not match the inclusion criteria or non-English publications. Figure 2 shows a flow chart of the search process.

Articles' selection

There were 573 articles found in the electronic literature search. There were 514 items left after the duplicates were removed. In addition, a manual search was carried out from other sources to identify and retrieve articles that were not found in the electronic search. Titles and abstracts were assessed, and 46 were chosen for further consideration. Three publications were chosen and included in this review after these studies were thoroughly read and analyzed for eligibility. Figure 2 depicts the selection procedure.

Table 1. Characteristics of the included studies in the review

Author(s)	Study type	Number of participants (EG/CG)	Mean age (years)	Gender (M/F)	Meantime post-stroke (months)	Outcome measure	Intervention
Kim *et al* (12)	RCT	10/10	EG: 69.1±3.2 CG: 68.0±3.1	EG:5/5 CG:5/5	EG:10.5±1.1 CG:11.3±1.1	BBS, FTSST, FRT	Both groups: NDT 30 min/day, 5 days/week, for 6 weeks. EG: aquatic dual-task training 30 min/day, 5 days/week, for 6 weeks
Shady *et al* (14)	RCT	15/15	EG: 52.33±5.54 CG: 53.27±3.88	EG:15/0 CG:15/0	More than six months	Biodex balance system (OASI, APSI, MLSI), FRT, timed up and go test	EG: aquatic dual-task training in water for 40 min/day, 3 days/week, for 4 weeks. CG: land-based dual-task training on the same schedule.
Saleh *et al* (13,18)	RCT	25/25	EG: 49.53±1.8 CG: 50±1.96	EG:13/12 CG:11/14	EG: 9.2±2.06 CG: 8.84±1.74	Biodex balance system (OASI, APSI, MLSI)	Both groups: same motor dual-task training 3 days/week, 45 min/day for 6 weeks. EG: in water CG:on land

Note: EG: Experimental group, CG: Control group, M: Male, F: Female, RCT: Randomized Control Trial, BBS: Berg Balance Scale; FTSST: Five-Time Sit to Stand Test; FRT: Functional Reach Test, NDT: Neuro-Developmental Treatment, OASI: Overall Stability Index, APSI: Anteroposterior Stability Index, MLSI: Mediolateral Stability Index

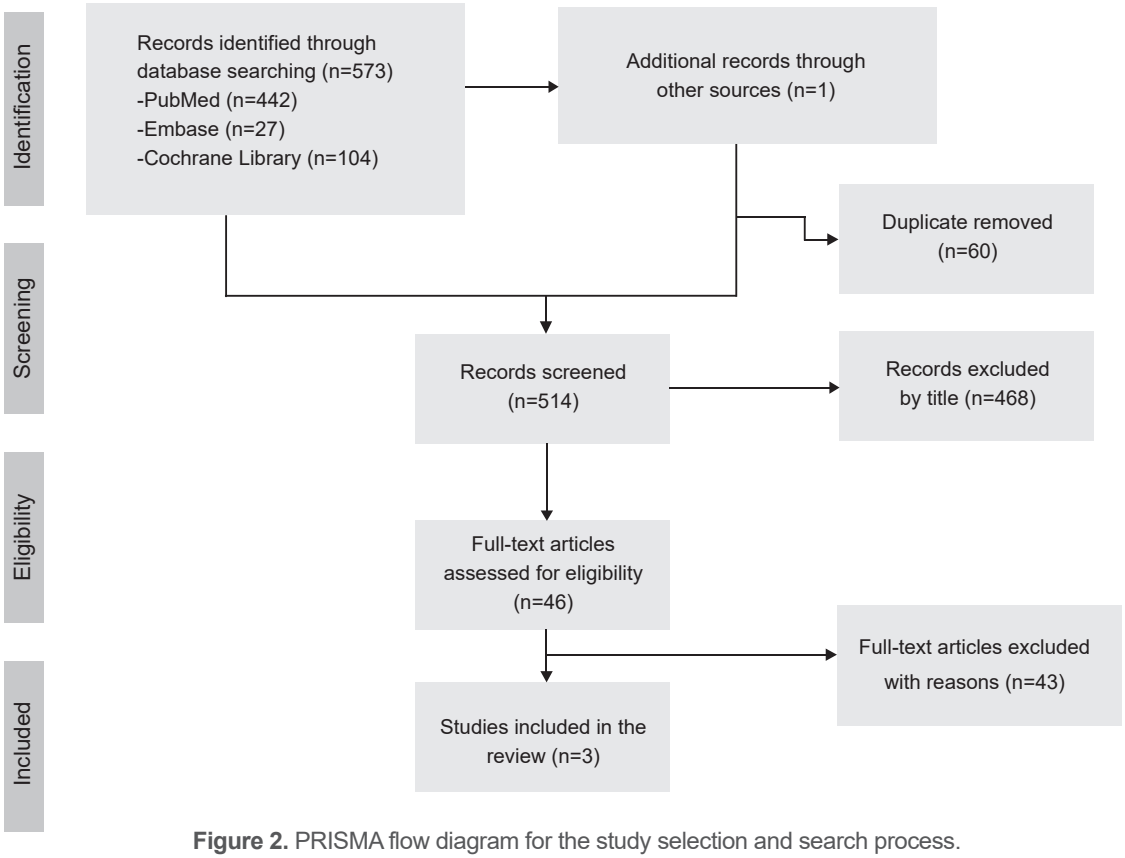

Figure 2. PRISMA flow diagram for the study selection and search process.

Characteristics of the Included Studies

Details of included studies' characteristics are summarized in table 1.

Study Design of the Selected Studies

All three studies included in this review were randomized control trial studies. However, none of these studies was a double-blinded trial.

Participants

Three studies with a total of 100 patients were included in the review, of which 50 were in the experimental group (33 men and 17 women) and 50 were in the control group (31 men and 19 women). The trials had a maximum sample size of 50 people and a minimum sample size of 20 people.

Intervention

For intervention, one study adopted neurodevelopmental treatment combined with aquatic dual-task training for the experimental group, while the control group only underwent neurodevelopmental treatment (12). The other two studies adopted dual-task exercises the same as exercises for the control group, which practiced on the land (13,14). Secondary tasks were motor dual-tasks in all the studies.

Duration of Treatment and Follow-up

The minimum intervention duration was four weeks (14) and was a maximum of six weeks (12,13). Training frequency varied between three to five times per week. The minimum total number of sessions was 12 and a maximum of 30 sessions. One study had a follow-up assessment session, one at two weeks (14), and there was no follow-up on the other two.

Outcome measures

Studies adopted different outcome measures to value the balance function including BBS, FTSST, FRT, timed up and go test, OASI, APSI, and MLSI. Among the included articles, balance was assessed with OASI, APSI, and MLSI in two studies (13,14). And, two studies used FRT to assess balance (12,14). Timed up and go test (14), FTSST (12), and BBS (12) were other outcomes used in the included studies. Details can be found in table 1.

Table 2. Included Studies' PEDro Scores

Study	Eligibility Criteria	Random Allocation	Concealed Allocation	Baseline Compara-bility	Subject Blinded	Clinician Blinded	Assessor Blinded	Data for at Least 1 Outcome From >85% of Subjects	No Missing Data or If Missing, Intention-to-Treat Analysis	Between-Groups Analysis	Point Estimates and Variability	Total Score (/10)
Kim *et al* (12)	No	1	0	1	0	0	0	0	0	1	1	4
Shady *et al* (14)	Yes	1	1	1	0	0	0	0	0	1	1	5
Saleh *et al* (13,18)	No	1	1	1	0	0	0	v	0	1	1	6

Methodological Quality of the Selected Studies

The methodological quality of the included studies ranged from 4 to 6 based on the PEDro scale, with a median of 5 points. Based on the PEDro scale, methodological quality was high in one study (13), and the other two studies had fair quality. A detailed evaluation of the PEDro scores can be found in table 2.

Adverse Events

There was no report of any adverse events during the trial period in any of the three included studies, which had a total of 100 participants.

Effects of Interventions

Kim *et al* (12) found that aquatic dual-task exercises have a beneficial effect on balance recovery after a stroke. Twenty stroke patients were recruited for the study and were divided into experimental and control groups. Neurodevelopmental therapy was given to both groups. Additionally, the experimental group received aquatic dual-task training. They discovered that following the experiment, the experimental group had a substantial change in balance as measured by the BBS, FTSST, and FRT ($p<0.05$). The experimental group demonstrated a relatively more significant change in those balance assessment tests ($p<0.05$) when compared to the control group.

Dual-task training in water positively affected the postural stability of stroke patients when compared to land-based dual-task exercises in the study by Shady *et al* (14). Results of their study on thirty stroke hemiparetic male patients showed a significant improvement in both control and experimental groups. However, the aquatic group demonstrated a greater percent of improvement for all the measured variables, including time up and go, functional reach test, overall stability index, medial/lateral stability index, and anterior/posterior stability index.

Saleh *et al* (13) concluded that aquatic dual-task training is more effective in comparison with land dual-task exercises for balance improvement in the chronic stroke population. Stroke patients received the same exercises in either water or on land for motor dual-task training. There are two groups of 25 individuals. In both groups, all the outcome measures showed a significant improvement after treatment compared to pr-treatment ($p<0.05$). Overall stability index ($p=0.02$), anteroposterior stability index ($p=0.03$), and mediolateral stability index ($p=0.002$) were all significantly improved in patients who received motor dual-task training in water compared to patients treated on land.

Discussion

This review aimed to evaluate the effect of dual-task training in water for improving balance in patients with a stroke. In total, three studies of dual-task training in water were given, in which two studies were compared with the same exercise approaches on land. One study compared the addition of NDT to the control group to improve balance in the selected population.

Dual-task training was shown to be an effective approach for balance improvement in patients with stroke (11,18). In addition, aquatic therapy can enhance dynamic balance (19). Han *et al* (20) suggested that

water-based exercises are more effective than land-based exercises for improving joint sense and balance in stroke patients (21). The physical properties of water, such as functional resistance of water and buoyancy, may be related to balance improvement.

Included studies did not have a sufficient number of participants, and a wide range of outcome measures was reported. There was no adequate follow-up following the study's completion in any of the studies. Only one study had a follow-up assessment session two weeks after the end of treatment (14). Therefore, it is challenging to draw any conclusions concerning how long any improvements can be maintained. Also, the trial design (length of study, follow up, the intensity of the intervention) and characteristics of therapeutic interventions (types of exercises) were different.

In all the included studies, participants received motor dual-task exercises as their secondary tasks. No study used cognitive as secondary tasks for intervention. *Thus*, the findings of this review are only related to motor dual-tasks. Furthermore, from the data from the included studies, it may not be possible to generalize the efficacy of water-based dual-task training on the balance recovery of the full range of post-stroke patients. The reason is that all of the studies recruited patients who were at their chronic stage of a stroke.

Limitations of the Review

The limitation of this study is that it only found relevant small RCTs, and the majority of them had methodological limitations, such as lack of concealed allocation or blinded assessors and clinicians. Since different experimental intensities were used, the included studies were clinically different (Table 1). Furthermore, only studies that used cognitive tasks as a secondary intervention task were found.

Implications for Future Practice and Research

There is inadequate evidence to establish that water-based dual-task training is useful in improving balance impairment in people post-stroke. However, there is not enough information to conclude that water-based dual-task exercises are inefficient. Better and larger trials should be designed to improve current clinical practices. The lack of evidence is due largely to the short number of trials and the small number of included participants. As a result, better and larger RCTs are needed to assess the effectiveness of aquatic dual-task training for stroke patients' balance recovery.

Conclusion

Aquatic dual-task training has a positive impact on balance improvement in chronic stroke patients and produces greater benefits in balance than land-based dual-task training and standard rehabilitation in people after a stroke. To confirm this assertion, additional high-quality large studies are needed.

Conflict of Interest

The author declares no conflicts of interest.

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