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The Effect of Water-Based Therapy Compared to Land-Based Therapy on Balance and Gait Parameters of Patients with Stroke: A Systematic Review

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Abstract

Introduction: Stroke is defined as the lack of blood supply to the brain, leading to rapid loss of brain function presenting with impairments such as muscle weakness, spasticity, lack of coordination, and proprioception loss. Both hydrotherapy and land-based therapy aim to target these aspects in the process of rehabilitation. The study aims to determine the effectiveness of water-based therapy on balance and gait of patients with stroke compared to land-based therapy.

Methods: Data for this review was extracted from databases such as CINAHL, OTseeker, Ovid, PEDro, PubMed (MEDLINE), and other sources such as Google Scholar. PRISMA guidelines were followed to exclude irrelevant papers. Only randomized controlled trials (RCTs) were included and methodological quality was assessed using PEDro scale. A meta-analysis of extracted data was conducted.

Results: A total of 16 relevant RCTs were included for the review (n=412 participants). All RCTs investigated the effect of water-based therapy compared to land-based therapy on balance and gait of patients with stroke. Meta-analysis of studies that used Berg Balance Scale (BBS) as a primary outcome measure favored land-based therapy. Studies that used Good Balance System (GBS) and Biodex Balance System (BioBS) to measure the changes in Anteroposterior Sway (APS) and Mediolateral Sway (MLS) favored water-based therapy. The overall pooled effect favored land-based therapy in improving gait parameters.

Conclusion: Findings from meta-analysis support the effectiveness of land-based therapy in the improvement of balance and gait parameters of patients with stroke. However, the evidence for water-based therapy continues to be limited and further higher quality studies are required to determine the effectiveness of water-based therapy on patients with stroke, particularly on balance and gait.

Introduction

Overview of Stroke

Stroke is defined as an interruption of blood supply to the brain that may result from ischemic or hemorrhagic lesions in blood vessels leading to rapid loss of brain functions [1]. According to a report from the Global Burden of Disease (GBD) 2016 Lifetime Risk of Stroke Collaborators, the estimated global lifetime risk of stroke in 2016 for those aged 25 years or older was 24.9% [2]. The estimate includes an almost equal risk of stroke among women and men, and an 18.3% risk of ischemic stroke and 8.2% risk of hemorrhagic stroke [2]. Additionally, the prevalence of stroke is expected to increase. Notably, stroke remains the second leading cause of death worldwide, with 5.5 million deaths attributed to this cause in 2016 [2]. Fewer women (2.6 million) than men (2.9 million) died from stroke. Deaths due to ischemic stroke were slightly less frequent than those due to hemorrhagic stroke. Stroke was also the second most common cause of disability-adjusted life-years (DALYs) [2]. Most patients with stroke suffer from motor impairments, such as balance and gait abnormalities that affect their functional ability and quality of life [3]. Balance and gait abnormalities result from muscle weakness, spasticity, reduced sensation, abnormal muscle activation, impaired coordination, abnormal proprioception, and impaired postural control [3].

Balance is the ability to maintain posture and move without falling [4]. It includes both static and dynamic stability [4]. Static stability is the ability to maintain a given position with minimum fluctuation, while dynamic stability is defined as the ability to move from a given position to another without loss of balance or falling [4]. Gait refers to the process of maintaining a proper balance of the body [5]. The abnormal gait of patients with stroke is characterized by several factors such as asymmetry of stride length and time, poor postural control, reduced velocity, weak muscles, and abnormal muscle tone. Muscle weakness is common after stroke as the main cause of abnormal gait patterns in these patients [3]. Therefore, the goal of stroke rehabilitation is to increase muscle strength and improve patients' gait ability [3].

Water-based therapy

Hydrotherapy is one of the treatments for stroke rehabilitation and it is also known as water-based therapy. It uses water-based exercises to improve body movement of individuals. Water-based therapy is one of the basic methods of treatment used in the medical world and most commonly in neurological rehabilitation [6]. The exercises are done under different water properties that have to be set by the associated physical therapist [6]. Water properties can include density, buoyancy, hydrostatic pressure, and viscosity. In addition, water properties can also assist active movement and provide a role in postural support and relaxation of spastic muscles for neurological patients [3]. Hydrotherapy can be used alone or as an adjunct to other physiotherapy approaches [7].

Water-based therapy mechanism

In this review, the intervention is water-based therapy. According to Iliescu et al. [8], use of water as a medium to perform exercises for motor recovery is beneficial. It has been stated that water-based therapy enhances balance and gait of patients with stroke in various ways. The buoyancy of water helps lower extremity motor function. This will reduce the gravity work on the body, which will result in reducing the load on the joints and thus the movement in all directions will need less effort. This method will improve the strength, range of movement, and the ability of weight bearing in the affected side of the body. Furthermore, this improves balance and gait characteristics [8]. It was also suggested that water-based therapy minimize the disabilities after stroke and is useful in enhancing the activities of daily living post-stroke [7]. In addition, studies showed that hydrostatic pressure improves sensory input and provides resistance on the muscles [8]. The temperature of water also plays a role in the relaxation of muscles and joints [8]. Hydrotherapy is also known for allowing patients with stroke to boost their cardiac capability, which enhances the strength of their heart and lungs [9]. Moreover, it helps in increasing muscles strength, mobility, and gait in these patients [10]. Patients with stroke may have difficulty in exercising on land due to muscle weakness and impaired balance, but water allows them to exercise easily [9].

Why this review is needed?

Water-based therapy appears to be a promising intervention in physiotherapy. Research over the past decade has examined the effects of hydrotherapy on different aspects in patients with stroke. The primary aim of this review is to integrate the results of investigations comparing water-based therapy to land-based therapy for patients with stroke on balance and gait. The secondary aims are to describe water-based and land-based exercises that had been evaluated in the RCTs and to summarize the ways in which balance and gait have been assessed.

In 2020, a systematic review was published by Nayak et al. [7] about the effect of aquatic therapy on balance and gait in patients with stroke. It included RCTs, non-RCTs, and quasi-RCTs. Also, a categorized comparison was done in the same study. Groups were divided into a) effect of aquatic therapy compared to land-based therapy on balance and gait in patients with stroke; and b) effect of aquatic therapy in conjunction with land-based therapy compared to land-based therapy alone on balance and gait in patients with stroke. In conclusion, the authors mentioned that aquatic therapy may be used to improve balance and gait after stroke; however, the evidence to support its use is still low.

On the other hand, this systematic review used additional databases than the ones used in Nayak et al. [7], including MEDLINE, OTseeker, Ovid and PEDro. Moreover, the selection included RCTs only to gather the best evidence available with minimal sources of bias. Additionally, it focuses mainly on the effect of water-based therapy compared to land-based therapy on gait and balance for patients with stroke. This can help in providing an in-depth insight and understanding of that aspect. Moreover, furthermore investigation of evidence was done to meet the recommendations of Nayak et al. [7] recent published systematic review in 2020 regarding the low evidence provided.

Methods

Selection Criteria

Studies included in this review were randomized controlled trials including pilot studies that were available in full text, written in English language, and used water-based therapy as an intervention and compared it to land-based therapy effect on balance and gait outcomes in patients with stroke. Studies in which participants performed aquatic or land-based exercises in conjunction with other interventions such as adjunctive medications were excluded. In addition, studies in which participants were diagnosed with dementia along with stroke were also excluded due to lack of their ability to concentrate on the given exercise program and recall it. The inclusion and exclusion criteria can be found in Appendix 1.

Search

The following search terms and approach were used to identify papers for this review.

Search Terms

The PICO framework was used to design certain search terms for this review. “Stroke”, “hydrotherapy”, “land-based therapy”, “balance”, and “gait” were the main keywords used to build-up the PICO table. Each of the keywords was placed at the top of a column, with its own synonyms listed beneath. Both Boolean operators and truncations were beneficial in combining search terms and in getting effective results. The search terms that were used to initiate the search method in this review are shown in Appendix 2.

Search Strategy

The commencement of this paper was from January 2020 and was carried on until September 2020. However, the search process was conducted between January 2020 and June 2020. Studies for this paper were gathered from several databases. These databases include CINAHL, MEDLINE, OTseeker,

Ovid, PEDro, and PubMed. Search was also conducted in EBSCOhost platform excluding MEDLINE and CINAHL to avoid redundancy of search. In addition, the search included other sources such as Google Scholar, Journal of Physical Therapy Science, and The Journal of Korean Physical Therapy (JKPT). Authors were contacted in the case of the unavailability of the full text version of the article but only 2 out of 13 authors responded.

Searching for keywords and their synonyms were done individually. Terms within each column were combined by the Boolean operator 'OR', followed by combining the total terms in each of these columns using the Boolean operator 'AND'. Depending on the source searched, specific filters were used as an approach to limit the search results according to the selection criteria of this review.
The search strategies for database and other sources are included appendix 3 and 4.
All eligible articles were stored in Mendeley and duplicates were removed. Screening of reference lists of all relevant articles was done.

Search Yield

A diagrammatical representation of the search yield and the flow of excluding articles is shown in Figure 1. PRISMA guidelines were followed to narrow the search yield and to get the most relevant articles. According to the search history of different sources (provided in Appendix 3 and Appendix 4), a total of 1,003 articles were collected. First, duplicate studies were removed, and then irrelevant articles were excluded based on titles and abstracts screening. Finally, full-text papers that did not meet the eligibility criteria were excluded. A total number of 16 studies were included in the final systematic review.

Quality Assessment

PEDro scale was used to assess the quality of relevant RCTs. The items of this scale include identification of eligibility criteria, random allocation, allocation concealment, similarity between groups at baseline, blinding, attrition, intention-to-treat use, and between-group statistical comparisons. It is considered as an important scale in which it helps in assessing the trustworthiness of the included papers and in identifying any sources of bias in the used RCTs. Quality assessment of included articles was peer reviewed for consistency. Quality assessment scores of included studies are presented in appendix 5.

Data Extraction

Relevant data from included studies were extracted into tables. These include the study details, participant information, intervention and comparison details, and outcome measures. Data extraction tables are included in appendices 5 to 9.

Data Synthesis

Randomized controlled trials are mainly designed to compare the difference between the intervention and control groups. A quantitative data synthesis through meta-analysis was done to determine the effect size across all the included studies. Review Manager (RevMan) was used to analyze data and conduct forest plots for studies that used similar and different outcome measures to assess either balance or gait. Appropriate statistical tools were considered in the case of different outcome measures. This will be helpful in increasing the power of the findings.

Prior to Meta-analysis

Balance

A total of 16 studies had investigated balance as an outcome. Berg Balance Score (BBS), Good Balance system (GBS), and Biodex Balance System (BioBS) were the three main outcome measures used for the meta-analysis of balance.

Berg Balance Score (BBS)

Berg Balance Scale is used to objectively assess the patient's ability to safely maintain balance during a series of specified tasks. It is a 14-items scale with each item ranging from 0 to 4, with 0 indicating the lowest level of function and 4 indicating the highest level of function.
Nine out of sixteen papers used BBS as an outcome measure for balance. Other outcome measures were also used in some studies, but the focus was to extract data of BBS based on inclusion criteria. Appendix 10 presents the data of all studies that used BBS.

Good Balance System (GBS) and Biodex Balance System (BioBS)

GBS is used for the measurement of postural sway in patients with stroke. BioBs is mainly used for static and dynamic balance testing and training. Both provides data about the patients' anteroposterior sway (APS) and mediolateral sway (MLS). Therefore, a meta-analysis for both outcome measures will be considered. Appendix 11 (anteroposterior sway) and Appendix 12 (mediolateral sway) show these studies and their relevant data. Data of static balance with the eyes being closed was collected in both GBS and BioBS for APS and MLS.

Gait

Different outcome measures were used to test the changes in gait for patients with stroke who went under either water-based therapy or land-based therapy, such as 2-minute walk test (2MWT), 6-Minutes Walking Test (6MWT), Figure-of-Eight Walk Test (F8WT), Medical Research Council (MRC), 10 Meter Walk Test (10MWT), 8m Walkway, and Biodex Gait Trainer (BioGT). Studies were divided into tables depending on their units. These units include meters (distance), seconds (time), and meters per second (speed). These are presented in appendices 13 to 15.

Studies excluded from meta-analysis

A total of 3 relevant studies were excluded from the meta-analysis. Park et al. [11] had combined results of balance and gait together in the Performance-Oriented Mobility Assessment (POMA). Therefore, data cannot be extracted from this study. Also, Park and Park [12] in addition to Park et al. [13] were excluded because they had their own variables that are not relevant to this review. Appendix 16 presents all excluded studies and their relevant data.

Results

Forest Plots

RevMan was used to conduct a meta-analysis for a total of 16 studies. All papers investigated the effects of hydrotherapy compared to land-based therapy on balance and gait for patients with stroke. Figures 2, 3, 4 and 5 present the forest plots for balance and gait.

Nine studies had BBS as an outcome measure for balance. A meta-analysis for BBS was done using weighted mean difference (WMD) and a random effect (Fig. 2). Data related to water-based therapy and land-based therapy groups can be seen in Figure 2. The experimental group has a total of 101 participants, whereas the control group shows a total of 92 participants. The weight (%) illustrates the influence that an individual study has had on the pooled result. Therefore, Park 2018 [14] had the most weight of effect on the pooled result (19.1%), while Chan 2017 [15] had the least (4.6%). The diamond shows the pooled results, concluding that pooled data favours land-based therapy on water-based therapy to improve balance for patients with stroke. Studies used are considered as highly heterogeneous (I^2=57%) and the result of overall effect is statistically significant (p=0.002).

Three studies had GBS as an outcome measure for balance, while two used BioBs. A meta-analysis for APS (anteroposterior sway) was done combining the 5 studies using standardized mean difference (SMD) and a random effect (Fig. 3). Data related to water-based therapy and land-based therapy groups can be seen in Figure 3. The experimental group has a total of 82 participants, whereas the control group shows a total of 81 participants. Saleh 2019 had the most weight of effect on the pooled result (26.4%), while Jung 2014 [1] had the least (22.6%). Saharan 2016 [17] had no weight due to the low sample size, indicating no effect on the overall pooled result. The diamond concludes that pooled data favours water-based therapy on land-based therapy to improve APS component of balance for patients with stroke. Studies used are considered as highly heterogenous (I^2=52%) and the result of overall effect is statistically significant (p=0.01).

Another forest plot was done for the same 5 studies in Figure 3, but with a meta-analysis for MLS (mediolateral sway) using Standardized Mean Difference (SMD) and a fixed effect (Fig. 4). Total number of participants in each group remained the same. On the other hand, the weight (%) of individual studies has changed in numbers. Saleh 2019 [16] again had the most weight of effect on the pooled result, but with a weight of (30%), while Jung 2014 [1] had the lowest (19.3%). Saharan 2016 [17] had no weight due to the low sample size, indicating no effect on the overall pooled result. In conclusion, pooled

outcome favours water-based therapy on land-based therapy to improve MLS component of balance for patients with stroke. Studies used are considered as highly homogeneous (I^2=0%) and the result of overall effect is statistically significant (p=0.001).

A total of 10 studies went through meta-analysis and were divided depending on the units of the results that they provide. Four studies provide distance (m), two papers provide time (s), and another four studies provide speed (m/s). A standardized mean difference (SMD) and a random effect were used to create the meta-analysis for gait (Fig. 5). The water-based therapy group has a total of 116 participants, while the control group shows a total of 113 participants. Saleh 2019 [16] had most weight of effect on the pooled result (15.4%), while Saharan 2016 [17] had the least effect (2.2%). The diamond shows that that pooled data favours land-based therapy on water-based therapy to improve gait for patients with stroke. Studies used are considered as homogeneous (I^2=42%) and the result of overall effect is statistically significant (p=0.01).

Discussion

The main purpose of this review is to compare the effects of water-based therapy to the effects of conventional land-based therapy on balance and gait for individuals with stroke. This is an important comparison as it investigates the most beneficial and effective therapy for these patients. According to Zhu et al. [18], around 80% of patients with stroke experience motor impairments and deficits in balance and gait, which limit their mobility and decreases their physical activity. It has been proven that increasing the capacity of exercising enhances the ability of functioning during daily living for patients with stroke [19]. Water-based therapy is known as an outstanding medium to reach the maximal exercise level for people with or without disabilities by taking the advantages of its physical properties and its relationship with the human body [20]. Furthermore, it has been vastly used for the treatment of many conditions such as arthritis and neuromuscular conditions [20]. Thus, we hypothesized that water-based therapy is more effective than land-based therapy in improving balance and gait for patients with stroke.

In this review, data was gathered from 16 studies and the effectiveness of water-based therapy compared to land-based therapy on balance and gait for patients with stroke was summed up. Douris [24] is the only study that examined older adults instead of stroke patients; however, it included all the other research question components. Both water-based therapy and land-based therapy improved the participants' scores in BBS [14,15,18-24]. A higher improvement was seen in water-based therapy group compared to

land-based therapy group [14,18,20,21,23]. Three studies stated that there is no significant difference between the two groups in the scores of BBS [15,22,23]. Out of 9 studies, only one study showed that land-based therapy was more effective than water-based therapy in BBS scores [19].

Five studies did not use BBS as an outcome measure, instead they used GBS and BioBS for measuring the effectiveness of water-based therapy and land-based therapy on APS and MLS. Both groups showed significant improvement on APS and MLS post-treatment [1,16,17]. However, only one study has showed that balance has improved in water-based therapy group [25]. Another study showed that both groups improved MLS, but APS was only improved in water-based therapy group [26]. Water-based therapy was more effective than land-based therapy in improving balance [1,16].

Saharan et al. [17] stated that they were unable to determine which group improved more than the other. Distance traveled by patients through walking has improved significantly in both groups, but the improvement was greater in the water-based therapy group [15,18,21,27]. The time that patients require to cross a specific distance through walking has improved in water-based therapy group and there was no significant difference in the land-based therapy group [14,23]. Walking speed improved in both groups and there was no significant difference between both [17,28]. However, two other studies showed that water-based therapy group had a greater improvement in gait speed whereas there was no significant difference in land-based therapy group post-treatment [16,19].

Water-based therapy was more effective in most of the results individually, however data in meta-analysis was pooled to the land-based therapy for both balance and gait. The main findings from the meta-analysis for balance suggest that land-based therapy is more convenient than water-based therapy for studies that used BBS as an outcome measure ($p=0.002$). However, studies that used BioBS and GBS as an outcome measures suggest the opposite (APS: $p= 0.01$; MLS: $p=0.001$).

After measuring the effectiveness of both therapies for gait on different aspects including distance, time, and speed, the main findings from the forest plot shows that land-based therapy is more effective than water-based therapy for improving gait ($p=0.01$). Increased variability in water-based therapy group compared to the land-based therapy group justifies the alignment of the pooled result toward the control group.

One of the limitations of this review is the exclusion of non-randomized controlled trials which has decreased the chance of presenting some important findings that were mentioned in other types of studies. In addition, the small sample size in some of the included papers was not helpful to draw out conclusions. However, these studies were included due to their link to the topic investigated. Additionally, there was a huge variability in the age of the participants in the included studies which made it difficult to review the effect of water-based therapy compared to land-based therapy for patients with stroke in a specific age group. Moreover, the review team was unable to access full text of some studies that were relevant to this review.

Conclusion

This review aimed to provide an updated systematic review that focuses mainly on investigating the effect of water-based therapy on balance and gait for patients with stroke compared to land-based therapy. Most of the studies showed that there is a significant difference between the effect of water-based therapy on balance and gait compared to land-based therapy. However, the meta-analysis favored land-based therapy on water-based therapy in four comparisons out of six. Further high-quality RCTs with a greater sample size are required to investigate the actual effects of water-based therapy on balance and gait for patients with stroke.

Ethical Considerations

Since this paper is a systematic review that is based on integrating previously published data, no ethical approval was needed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

Conceptualization, databases searching, selection of studies, review of literature, data synthesis and analysis, and writing the original draft of manuscript were done by NZ, AA, RA, ZE, and HE. On the other hand, supervision, review, and editing of manuscript were completed by MG and SR.

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Figure Legends

Fig. 1. Flow of studies exclusion in systematic review using PRISMA.

Fig. 2. Water-Based Therapy versus Land-Based Therapy Effect on Balance – BBS.

Fig. 3. Water-Based Therapy versus Land-Based Therapy Effect on Balance – GBS and BioBS (APS).

Fig. 4. Water-Based Therapy versus Land-Based Therapy Effect on Balance – GBS and BioBS (MLS).

Fig. 5. Water-Based Therapy versus Land-Based Therapy Effect on Gait – DISTANCE, TIME, and SPEED.