

# The Effect of Hydrotherapy on Balance and Mobility in Post Stroke: Meta Analysis

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## ABSTRACT

**Introduction:** Stroke is one of the leading causes of disability, affecting balance and mobility. Physical therapy rehabilitation efforts continue to be developed to optimize the recovery of motor function. Hydrotherapy, with the unique properties of the aquatic environment, is believed to offer therapeutic benefits in improving physical function and quality of life for post-stroke patients. This study aims to systematically and quantitatively evaluate the effectiveness of hydrotherapy in improving balance and mobility in post-stroke patients using a meta-analysis approach. **Methods:** The study was conducted by reviewing the literature from the PubMed and ScienceDirect databases from 2016 to 2025. Inclusion criteria included randomized controlled trials (RCTs) evaluating hydrotherapy interventions in post-stroke patients with outcomes related to balance and mobility. Data analysis was performed using a random-effects model with calculation of the standardized mean difference (SMD) and a heterogeneity test ( $I^2$ ). **Results:** A total of 6 studies met the inclusion criteria. The results of the meta-analysis showed that hydrotherapy was effective in improving balance (SMD = 0.84; 95% CI: 0.09 to 1.59;  $p=0.03$ ;  $I^2 = 90\%$ ) and mobility (SMD = -0.28; 95% CI: -1.37–0.80;  $p=0.61$ ;  $I^2 = 95\%$ ) compared to conventional land-based physical therapy interventions. **Conclusion:** In post stroke patients, hydrotherapy significantly improves balance, while its effect on mobility remains inconclusive. This intervention is worth considering as part of a physical therapy rehabilitation program. However, further research with more consistent methodological designs is still needed to strengthen the scientific evidence.

**Keywords:** hydrotherapy; aquatic therapy; water exercises; balance; mobility; post-stroke.

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## INTRODUCTION

Stroke is one of the leading causes of death and disability worldwide. Global epidemiological data indicate that there are approximately 12 million new cases of stroke each year, with more than 93 million people living with a history of stroke (Feigin et al., 2025). This places stroke as the second leading cause of death and the third leading cause of disability globally, with a massive disease burden in the form of lost Disability-Adjusted Life Years (DALYs). Epidemiological trends also show a significant increase in the incidence and prevalence of stroke over the past three decades, particularly in low- and middle-income countries (Kazi et al., 2024).

In Indonesia, the burden of stroke is high and represents one of the most serious public

health issues. It is estimated that there are more than 640,000 new cases each year, with nearly 5 million survivors living with a history of stroke (Kemenkes, 2023). The mortality rate from stroke in Indonesia is among the highest in Southeast Asia, far exceeding that of several neighboring countries. Major risk factors such as hypertension, diabetes mellitus, and a sedentary lifestyle contribute significantly to the high incidence of stroke in Indonesia (Global Burden Diseases, 2024).

Post-stroke patients typically experience various clinical manifestations reflecting neurological damage resulting from impaired cerebral circulation. These manifestations may include muscle weakness or hemiparesis, hemiplegia, coordination difficulties, and reduced



muscle tone, all of which impact daily functional abilities (Carroll et al., 2024). Additionally, balance and mobility impairments frequently arise due to damage to the motor and sensory systems, thereby increasing the risk of falls and reducing the patient's independence. Other commonly observed manifestations include speech disorders (aphasia or dysarthria), swallowing disorders (dysphagia), cognitive impairments, and behavioral and emotional changes. Clinically, this combination of symptoms creates a complex rehabilitation burden, requiring comprehensive and continuous physical therapy interventions to optimize the recovery of patients' motor, sensory, and psychosocial functions following a stroke (Sasegbon, 2025).

Balance disorders are one of the most common clinical manifestations in post-stroke patients. Damage to the central nervous system, particularly the areas regulating motor and sensory control, disrupts the integration of proprioceptive, vestibular, and visual information necessary for maintaining postural stability. Consequently, patients often struggle to maintain sitting or standing positions and are unable to perform movement transitions safely (Nayak et al., 2020). This condition increases the risk of falls, limits mobility, and reduces functional independence in daily activities. Post-stroke balance disorders also impact patients' quality of life, as mobility limitations often lead to fear, anxiety, and reduced social participation. Therefore, rehabilitation interventions focused on improving balance are an essential component of post-stroke physical therapy programs (Lim et al., 2021).

Mobility impairments are one of the primary consequences experienced by post-stroke patients due to damage to the motor and sensory systems. The resulting hemiparesis or hemiplegia leads to reduced muscle strength, limited range of motion, and impaired coordination, which directly impact the ability to walk and perform daily functional activities (Yang et al., 2024). Additionally, the presence of spasticity, changes in muscle tone, and impaired postural control further exacerbate the patient's ability to change positions or maintain efficient movement

patterns. These mobility limitations not only increase the patient's dependence on others or assistive devices but also reduce quality of life and social participation. Therefore, structured and continuous physical therapy rehabilitation interventions are essential to facilitate mobility recovery, reduce the risk of complications, and restore functional independence in post-stroke patients (Jiang et al., 2025).

Hydrotherapy is a form of physical therapy that utilizes the physical properties of water such as buoyancy, resistance, and hydrostatic pressure to support the rehabilitation process for post-stroke patients. Water's buoyancy helps reduce the load on joints and muscles, allowing patients to perform exercises with a lower risk of injury (Morer et al., 2020). Water's natural resistance provides balanced muscle stimulation, while hydrostatic pressure contributes to improved postural stability and proprioception. This combination of mechanisms makes hydrotherapy effective in addressing balance and mobility impairments, which are major issues for post-stroke patients. Additionally, the safe and supportive aquatic environment can boost patients' confidence in performing exercises, reduce the fear of falling, and facilitate progressive recovery of motor function. Thus, hydrotherapy holds great potential as an integral part of physical therapy rehabilitation programs to enhance functional independence and quality of life for post-stroke patients (Marinho-Buzelli et al., 2025).

Hydrotherapy, as a form of therapy, has been the subject of several clinical studies reporting its potential to improve balance and mobility in post-stroke patients; however, the results obtained remain inconsistent and have not yet yielded consistent conclusions. Although several meta-analyses have confirmed the general benefits of hydrotherapy, there are significant gaps in the current literature. Most previous reviews tended to combine subjects from various phases of stroke recovery without clear stratification by chronicity, thereby obscuring the clinical effectiveness in each specific phase. Furthermore, the validity of prior conclusions is often hampered by the inclusion of heterogeneous study designs (Veldema & Jansen, 2021).



Therefore, a comprehensive meta-analysis is needed to compile and analyze the available scientific evidence. This meta-analysis focuses exclusively on Randomized Controlled Trials (RCTs) to ensure the highest level of evidence. By rigorously evaluating RCTs that employ blinded outcome assessment, this study aims to minimize the risk of subjectivity bias which frequently arises in physical interventions while providing more precise recommendations for clinical practitioners. This approach is expected to provide a stronger picture of the effectiveness of hydrotherapy, while also serving as a basis for the development of physical therapy practice recommendations in the rehabilitation of post-stroke patients.

## METHODS

This study employed a meta-analysis design to evaluate the effectiveness of hydrotherapy on balance and mobility in post-stroke patients. The research process was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines without any data manipulation to maintain scientific integrity. This research framework was developed based on the Population, Intervention, Comparison, Outcome (PICO) approach to ensure clarity and consistency in the meta-analysis process.

The population under review consists of post-stroke patients, both male and female, who experience balance and mobility impairments. The interventions analyzed involve hydrotherapy or aquatic exercises, which utilize the physical properties of water such as buoyancy, resistance, and hydrostatic pressure as rehabilitation methods. Conventional land-based physical therapy interventions were used as a comparison, including balance exercises, mobility exercises, or standard rehabilitation programs without hydrotherapy. The primary outcomes evaluated were improvements in balance and mobility, measured using valid and reliable instruments.

The literature search strategy was conducted using the electronic databases PubMed and ScienceDirect, covering the years 2016 through 2025. The search terms included “stroke”

AND “hydrotherapy” OR “aquatic therapy” OR “water exercises” AND “balance” AND “mobility”. The inclusion criteria were experimental articles with randomized controlled trials (RCTs). Meanwhile, the exclusion criteria were articles that did not use an experimental design, did not involve a post-stroke population, or did not report quantitative results related to balance and mobility.

The selection process was conducted in stages, beginning with a screening of titles and abstracts, followed by a full-text review. The data collected included study characteristics, namely year of publication, sample size, duration of intervention, type of hydrotherapy intervention, and instruments used to measure balance and mobility. Statistical analysis was performed using a random-effects model to calculate the standardized mean difference (SMD) with a 95% confidence interval. Heterogeneity was assessed using the  $I^2$  statistic. Sensitivity analysis and publication bias tests were also conducted to evaluate the consistency of the results.

The risk of bias assessment was conducted independently by two researchers using the JBI Critical Appraisal Checklist for Randomized Controlled Trials. This tool was selected for its ability to thoroughly evaluate clinical technical aspects, particularly regarding allocation concealment and blinded outcome assessment. A total of 13 critical questions were evaluated for each article; a score of ‘Yes’ was assigned for met criteria, ‘No’ for unmet criteria, and ‘Unclear’ if information was insufficient. Disagreements between researchers were resolved through in-depth discussion to reach consensus.

This study is a meta-analysis that uses secondary data from publicly available articles; therefore, it does not require direct ethical approval from a health ethics committee. Nevertheless, the researchers uphold ethical principles by including only primary studies that have obtained ethical approval from their respective institutions and have obtained written informed consent from all stroke participants involved.



Table 1. Article Characteristics (n=302)

Author (Year)	Country (Sample Size)	Population	Intervention	Comparison	Outcome	
					Balance	Mobility
Cha et al., (2017)	Korea (n=22)	Chronic Stroke Patients	Bad Ragaz Ring Method (once a day for 60 minutes, 3 days per week for 6 weeks)	Conventional Rehabilitation Therapy (once a day for 60 minutes, 3 days per week for 6 weeks)	Balance Index	Timed Up and Go Test
Lee et al., (2018)	Korea (n=32)	Primary Ischemic or Hemorrhagic Stroke	Aquatic Therapy (once a day for 30 minutes, 5 days per week for 4 weeks)	Land-Based Aerobic Exercise (once a day for 30 minutes, 5 days per week for 4 weeks)	Berg Balance Scale	
Pérez-De la Cruz, (2020)	Spain (n=27)	Chronic Stroke	Ai Chi Aquatic Therapy (once a day for 45 minutes, twice days per week for 12 weeks)	Dry Land Therapy (once a day for 45 minutes, twice days per week for 12 weeks)	Single Leg Stance; and Tinetti Test	
Park et al., (2020)	Korea (n=29)	Stroke	Aquatic Trunk Exercises (30 minutes each time, twice per day, 5 days per week, for 4 weeks)	Conventional Physical Therapy (30 minutes each time, twice per day, 5 days per week, for 4 weeks)	Berg Balance Scale; and Functional Reach Test	
Pérez-De La Cruz, (2021)	Spain (n=32)	Acquired Brain Injury: Stroke	Ai Chi Aquatic Therapy (once a day for 45 minutes, twice days per week for 12 weeks)	Dry Land Therapy (once a day for 45 minutes, twice days per week for 12 weeks)	Berg Balance Scale	Timed Up and Go Test; Five Timed Sit to Stand; and Tendem Stance
Bei et al., (2023)	China (n=160)	The First Stroke and Lower Limb Dysfunction	Hydrotherapy Underwater Exercises (Each training session lasted for 30 to 40 minutes, once a day, six days a week, for a total of 48 times)	Conventional Drug Therapy and Traditional Rehabilitation Training (Each training session lasted for 30 to 40 minutes, once a day, six days a week, for a total of 48 times)	Berg Balance Scale	Functional Walking Scale



## RESULTS

Of the total 150 articles identified through the literature search, 6 articles met the inclusion criteria and were further analyzed in this meta-analysis. A systematic full-text review was then conducted in accordance with the PRISMA guidelines, as shown in Figure 1.

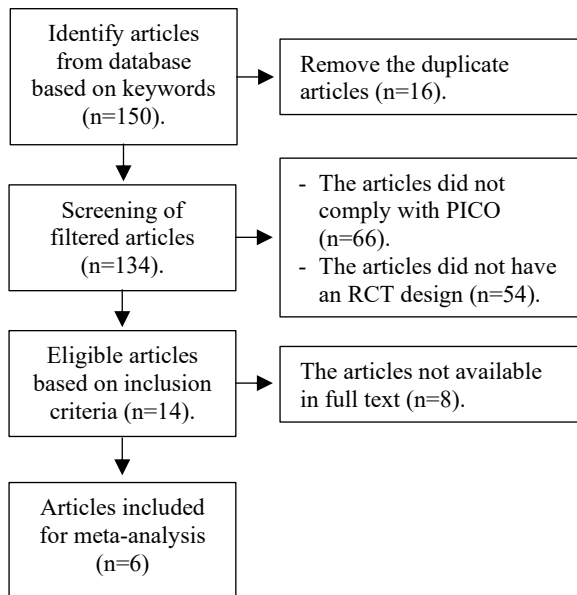


Figure 1. PRISMA flowchart

The sample size for this meta-analysis was 302 participants from three countries: South Korea, Spain, and China. The population consists of patients with both ischemic and hemorrhagic strokes. The intervention used in this meta-analysis was a hydrotherapy program consisting of underwater exercises, employing various methods such as the Bad Ragaz Ring Method, Ai Chi, and trunk exercises. The comparison or control group in this meta-analysis received land-based conventional drug therapy and traditional rehabilitation training.

The primary outcome analyzed was post-stroke patients' balance ability. Balance was measured using several clinically validated instruments, namely the Balance Index, Berg

Balance Scale (BBS), Single Leg Stance Test, Tinetti Test, and Functional Reach Test (FRT). The use of these various instruments allowed for a comprehensive assessment of postural control, fall risk, and the patients' functional capacity.

The secondary outcomes analyzed were patients' mobility following a stroke. Mobility was measured using several instruments with established reliability and validity, namely the Timed Up and Go Test (TUG), the Five-Repetition Timed Sit-to-Stand Test, the Tandem Stance Test, and the Functional Walking Scale (FWS). These instruments provide a comprehensive picture of the patient's functional capacity, including walking speed, lower limb muscle strength, dynamic postural control, and the ability to walk during daily activities.

The meta-analysis shown in Figure 2 indicates that hydrotherapy significantly improves balance ability in post-stroke patients. A standardized mean difference (SMD) of 0.84 with a 95% confidence interval (0.09 to 1.59) and a p-value of 0.03 confirms that hydrotherapy is more effective than land-based therapy in improving balance. These results indicate that patients undergoing hydrotherapy experienced an improvement in balance ability approximately 0.84 times greater than patients receiving conventional physical therapy interventions.

However, the level of heterogeneity among studies was quite high ( $I^2 = 90\%$ ;  $p < 0.01$ ), so the analysis was conducted using the Random Effects Model. This high heterogeneity indicates variations in intervention protocols, patient characteristics, and measurement instruments used across the analyzed studies. Nevertheless, the direction of the results remains consistent in demonstrating the benefits of hydrotherapy for balance, thereby strengthening the scientific evidence that water-based interventions can serve as an effective rehabilitation strategy for post-stroke patients.



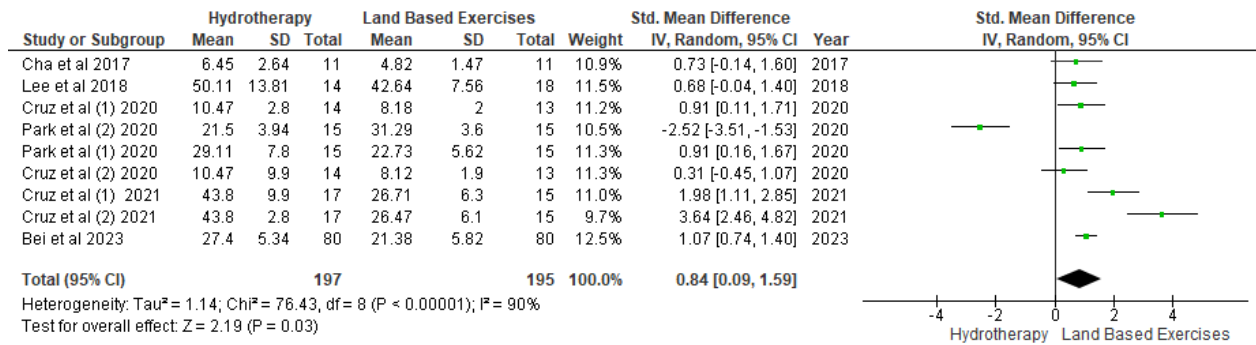


Figure 2. Forest plot of balance

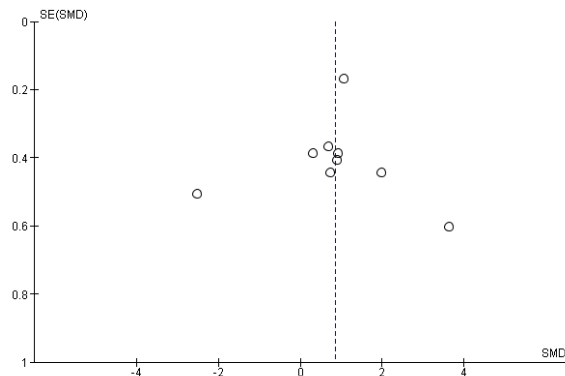


Figure 3. Funnel plot of balance

The meta-analysis shown in Figure 4 indicates that hydrotherapy has a positive effect on mobility in post-stroke patients, although the results were not statistically significant. A standardized mean difference (SMD) of -0.28 with a 95% confidence interval (-1.37 to 0.80) and a p-value of 0.61 indicates that the difference between hydrotherapy and land-based therapy in improving mobility does not reach strong clinical significance.

Additionally, the level of heterogeneity among studies was very high (I<sup>2</sup> = 95%; p < 0.01),

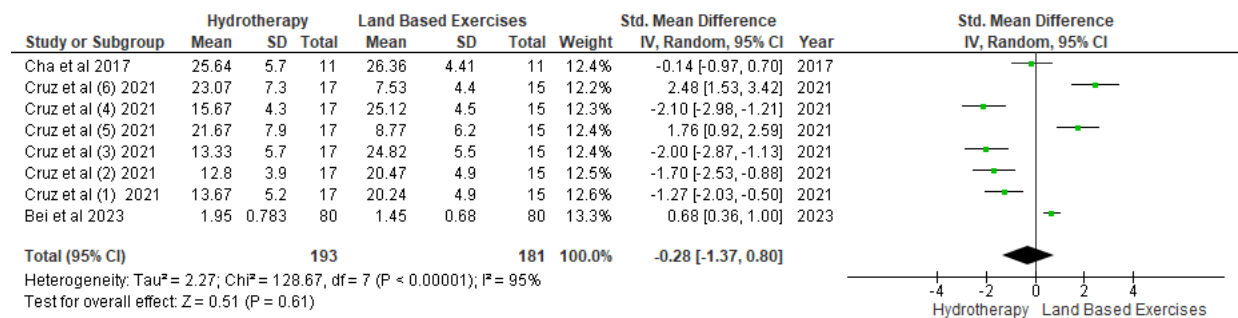


Figure 4. Forest plot of mobility



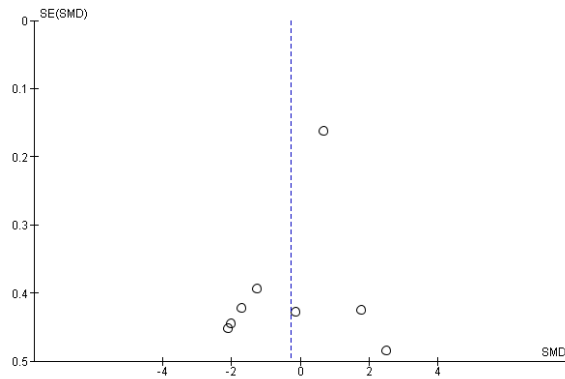


Figure 5. Funnel plot of mobility

## DISCUSSION

The results of the meta-analysis indicate that hydrotherapy has a significant effect on improving balance ability in post-stroke patients. This effectiveness can be explained by the unique physiological mechanisms of the aquatic environment, where buoyancy reduces the load on the extremities, making it easier for patients to perform exercises without the risk of excessive injury. Additionally, water's natural resistance provides uniform muscle stimulation, while hydrostatic pressure plays a role in improving postural stability and proprioception. These conditions allow patients to train in a safe, supportive environment that fosters self-confidence, thereby reducing the fear of falling a common barrier to balance training on land (Gento-Andres et al., 2025).

These findings are consistent with several clinical studies reporting improved Berg Balance Scale scores in groups of patients undergoing hydrotherapy compared to those receiving conventional physical therapy. Thus, hydrotherapy can be viewed as an effective rehabilitation intervention and is worth considering as an integral part of post-stroke physical therapy programs, although further research with more homogeneous methodological designs is still needed to strengthen the existing scientific evidence (Li & Zheng, 2021).

The findings of the meta-analysis indicate that hydrotherapy has the potential to improve mobility in post-stroke patients, although the improvements achieved were not statistically

significant. The positive effects observed can be explained by the physiological mechanisms of water, in which buoyancy helps reduce the load on joints and muscles, making it easier for patients to perform walking exercises or change positions. Water resistance also provides uniform muscle stimulation, which theoretically supports improvements in movement patterns. However, variations in intervention protocols, differing exercise durations, and heterogeneity in patient characteristics across studies may affect the consistency of results (Sanz-esteban et al., 2026).

Additionally, psychological factors such as fear of falling and limited patient motivation may also play a role in limiting the achievement of optimal mobility. Therefore, although hydrotherapy shows potential benefits for mobility, the existing evidence is not yet strong enough to conclusively demonstrate its significant effectiveness. Further research with more homogeneous methodological designs, adequate intervention durations, and larger sample sizes is needed to strengthen the scientific evidence regarding the role of hydrotherapy in post-stroke mobility recovery (Lv et al., 2026).

The scientific novelty of this study lies in its use of a meta-analysis approach to evaluate the effectiveness of hydrotherapy on balance and mobility in post-stroke patients. Although a number of previous clinical studies have examined the benefits of hydrotherapy, the results obtained have varied and have not yet yielded consistent conclusions. By compiling and analyzing data from various randomized controlled trials, this study is able to provide a more comprehensive and quantitative picture of the effectiveness of hydrotherapy.

Another novelty of this study is its focus on two key aspects of rehabilitation balance and mobility which have rarely been analyzed together in previous studies. Furthermore, this study highlights the differences in the level of significance between these two outcomes, thereby offering a new perspective on the potential and limitations of hydrotherapy in physical therapy practice. This study not only strengthens existing scientific evidence but also opens the door to the development of more targeted and evidence-



based rehabilitation strategies for post-stroke patients.

This study has several limitations that require critical consideration. First, there is considerable heterogeneity among the analyzed studies in terms of methodological design, intervention duration, and patient characteristics which may affect the consistency of the meta-analysis results. Second, the sample sizes in some studies are relatively small, which may reduce the statistical power needed to draw more generalizable conclusions. Third, variations in the balance and mobility measurement instruments used across studies may introduce bias in the comparison of results. Additionally, the possibility of publication bias cannot be entirely avoided, given that studies with positive results are more likely to be published than those with negative or non-significant results.

The researchers implemented several methodological steps to address these limitations. The analysis was conducted using a random-effects model to account for heterogeneity across studies. Sensitivity tests were performed to assess the consistency of the results, while potential publication bias was analyzed using funnel plots. Additionally, the article selection process was conducted independently by two researchers using a cross-verification procedure to minimize selection bias.

## CONCLUSION

This meta-analysis indicates that hydrotherapy is effective and significantly improves balance in post-stroke patients, while the improvement in mobility observed was positive but not statistically significant. These findings suggest that hydrotherapy can be considered a physical therapy rehabilitation intervention focused on restoring balance, with additional potential benefits for mobility that still require stronger evidence.

Clinically, the findings of this study suggest that hydrotherapy can be integrated into physical therapy rehabilitation programs to support functional independence in post-stroke patients. A safe and supportive aquatic environment can also enhance patients' motivation and self-confidence during exercise,

thereby accelerating the rehabilitation process. Furthermore, the development of standardized hydrotherapy protocols and their integration with land-based physical therapy exercises can serve as an optimal strategy to improve rehabilitation outcomes for post-stroke patients.

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