REVIEW

Can Water Exercise Improve Motor Function in Parkinson's Disease More Than Land Exercise? A Systematic Review and Meta-Analysis

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ABSTRACT

Background and Purpose: Research findings on the effects of land-based and water-based exercises on motor performance in people with Parkinson's disease (PD) are conflicting, and despite the known beneficial effects of exercise in these individuals, it is unclear which of these exercise protocols is more beneficial. Therefore, this study aimed to systematically evaluate the effects of exercise on land and water on the performance of people with PD.

Methods: Randomized controlled clinical trials related to the motor performance of people with PD were identified by searching the Science Direct, PubMed, Scopus, and Google Scholar databases and analyzed using CMA v4 software. Of 94 studies based on the inclusion and exclusion criteria, eight English articles were included in the comprehensive review.

Results: The meta-analysis revealed a significant difference in the motor performance of people with PD between the land- and water-based exercise groups (CI 95%, −0.135 to −0.649; MD = −0.392).

Discussion: Water-based exercises may offer greater improvements in motor performance compared to land-based exercises in individuals with PD. Therefore, in addition to conventional exercises, exercising in water could help enhance the motor function of these people, and therapists can incorporate it into their exercise programs.

1 | Introduction

Among neurodegenerative disorders, Parkinson's disease (PD) ranks as the second most prevalent, manifesting primarily as a movement disorder. In the elderly population, it is surpassed in frequency only by Alzheimer's disease (Magrinelli et al. 2016). PD is a long-term degenerative illness that causes movement problems such as tremors, slow movement, stiffness, balance changes, and postural instability (Brusse et al. 2005). It is well established that approximately 10 million elderly people worldwide suffer from PD, and given the aging population, this number is expected to increase to more than 40 million (Giroux 2007). This disease is not curable, but symptoms can be alleviated, for example, with medication or surgery. Researchers have consistently explored non-pharmacological approaches and exercise-based therapies to manage this disease. Numerous studies provide strong support for the beneficial effects of physical activity in mitigating the complications and challenges associated with this condition (Giroux 2007; Morris 2000; Williani et al. 1999). Physical rehabilitation interventions, such as conservative treatments, can help people with PD. Research indicates that land-based exercise is effective for treating PD symptoms. However, the optimal exercise training program for people with PD is still being debated (Abbruzzese et al. 2016; Reynolds et al. 2016).

Among older adults, PD is a prevalent condition and ranks as one of the leading causes of disability during this stage of life (Morris 2000). With increasing age and decreasing physical activity, the abilities and performance of people with PD increase (Dibble et al. 2006). Such individuals experience a more rapid decline in their physical capabilities, accompanied by a noticeable reduction in their confidence and coordination (Argue 2000). With the progression of severe clinical stages, functional capacity decreases (Papapetropoulos et al. 2006). However, some studies have shown that depression decreases motor function and increases disability following disease progression (Leonardi et al. 2012). Reduced physical activity, confidence, and movement slowness lead people with PD to become dependent on others for their tasks, resulting in social isolation due to limited activities and decreased motor function (Hirsch et al. 2003). Generally, the goal of treating this disease is to maintain patient independence and improve quality of life (Pallone 2007). Approximately two-thirds of Parkinson's people with PD experience falls at least once a year, which can lead to injuries—fractures and head injuries—that ultimately result in hospitalization or future mobility limitations (Wulf et al. 2009). As PD can be considered a multidimensional disease with effects that spread across various aspects of life, efforts to control its resulting complications are also based on multidimensional approaches, which include not only conventional medical treatments but also exercise as a complementary therapeutic intervention (Giroux 2007). Scientific research has shown that the use of therapeutic movement exercises as a complementary treatment method has a positive role in controlling some complications of this disease, and with movement therapy approaches, the daily functioning of the people can improve (Keus et al. 2007). People with PD may improve with conservative therapies such as physical rehabilitation.

Physical exercise is increasingly recognized as a cornerstone in the management of PD, with a growing body of evidence highlighting its positive impact across different stages of the condition. Numerous studies have reported significant improvements in motor function, endurance, and overall quality of life, underscoring the importance of incorporating structured physical activity into rehabilitation protocols (Abbruzzese et al. 2016; Reynolds et al. 2016; Flach et al. 2017; Alberts and Rosenfeldt 2020; Oguh and Videnovic 2012; Rafferty et al. 2021, 2023; Schenkman et al. 2011). Consequently, the development of safe, effective exercise environments has become a key focus of therapeutic strategies. Both aquatic and land-based exercise modalities are commonly employed within individualized treatment plans. However, despite their widespread application, the comparative effectiveness of aquatic versus land-based exercise remains inconclusive, with current evidence insufficient to establish the superiority of one approach over the other in individuals with PD. While water-based exercise has been explored as a potential intervention for people with PD, the literature presents conflicting findings regarding its impact on motor function (Kurt et al. 2018; Palamara et al. 2017; Pérez-de la Cruz 2018; Vivas et al. 2011; Volpe et al. 2014, 2017; Yi-zhao et al. 2017). Despite its recognized benefits, the optimal exercise protocol for people with PD remains uncertain. To address this knowledge gap, a systematic review is needed to evaluate the comparative efficacy of water-based and land-based exercises on motor performance in people with PD. By synthesizing existing evidence, this review aims to provide clinicians and people with PD with valuable insights into the potential differences between these modalities and inform the development of evidence-based treatment plans.

2 | Methods

2.1 | Protocol and Registration

This systematic review, registered with PROSPERO (CRD 42023447388), followed the PRISMA[1] guidelines (Moher et al. 2009) (Figure 1).

2.2 | Eligibility Criteria

This systematic review included studies that met the following criteria: (a) Participants: Individuals diagnosed with Parkinson's disease (PD). (b) Study Design: Only randomized controlled trials (RCTs) were included to ensure methodological rigor and reduce selection and performance bias. (c) Intervention Comparison: Studies that compared water-based exercises with land-based exercises. (d) Outcome Measure: Studies that utilized the Timed Up and Go (TUG) test, as it offers a standardized, validated, and widely used metric, facilitating cross-study comparability. (e) Language: Articles published in English. Studies were excluded if: (a) Participants had conditions other than PD, or (b) The publication type was a review, letter, conference abstract, or case report without original data.

2.3 | Search Strategy

After a comprehensive database search, all relevant articles were imported into EndNote (version X9 for Windows). Duplicate records, arising from multiple database sources, were subsequently removed. After that, all titles and abstracts were reviewed to find relevant articles related to the research topic. The ScienceDirect, PubMed, Scopus, and Google Scholar databases were searched independently by two researchers. The search time frame ended in October 2022. Searches were conducted using subject terms and free terms. Additionally, references cited in relevant works were traced to identify further sources. The search terms used were "water training," "aquatic exercise," "water exercise therapy," "water therapy," "aquatic exercise therapy," "aquatic therapy," "water-based exercise," "hydrotherapy," "hydrotherapies," "hydrotherapeutics," "Parkinson's disease," "Parkinson's syndrome," "Parkinson's syndrome" and "primary parkinsonism."

Two authors reviewed the excluded articles. In cases of disagreement, the group supervisor made the final decision.

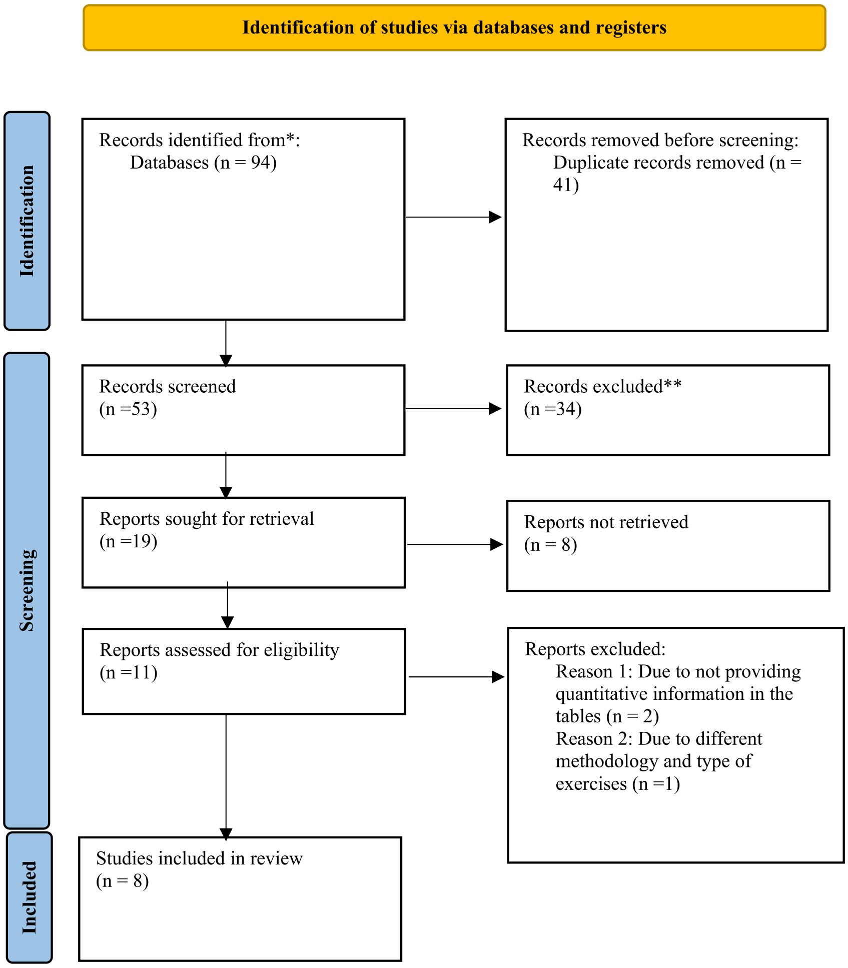

FIGURE 1 | PRISMA flow diagram illustrating the study selection process.

2.4 | Risk of Bias

To evaluate the methodological quality of the included studies, we employed the Cochrane Manual for Systematic Reviews of Interventions (version 5.1.0) (Higgins et al. 2019) as our reference standard. This manual evaluates seven types of bias, including selection bias, performance bias, detection bias, attrition bias, reporting bias, and any other bias. The risk of bias in each study was categorized as low, unclear, or high. Any disagreements among the authors were resolved through discussion with a third party until consensus was reached.

2.5 | Data Collection Process

The necessary information was extracted from the tables of the identified relevant articles. Information such as title, first author, publication year, sample size, intervention, intervention time, frequency, and outcome indicators was extracted from the retrieved studies.

2.6 | Quality Evaluation

The methodological quality of the included studies was assessed using the PEDro[2] scale by MS and HA (Table 1). The motor performance of individuals with PD who participated in aquatic exercise was compared with those who engaged in land-based exercise.

2.7 | Synthesis of Results

Meta-analysis of the data was conducted using CMA[3] software version 4 to assess standardized mean differences (SMDs) as effect sizes. Statistical significance was determined by a *p*-value threshold of 0.05. The 95% confidence intervals (CIs) for both random- and fixed-effects models were computed. When heterogeneity, measured by I^2, was less than 40%, the fixed-effects model was employed for analysis; otherwise, the random-effects model was utilized (Maher et al. 2003). To ensure the reliability of the data, Egger's test was conducted to assess publication bias in the analyzed articles.

3 | Results

Of 94 articles found in the databases based on keywords, 8 studies were included in the comprehensive review (Kurt et al. 2018; Palamara et al. 2017; Pérez-de la Cruz 2018; Vivas et al. 2011; Volpe et al. 2014, 2017; Yi-zhao et al. 2017; da Silva and Israel 2019). The selected studies were thoroughly analyzed,

TABLE 1 | Characteristics of the included studies in the meta-analysis.

Trial country	Participants	Intervention		Outcome measures
		Experimental	Control	
Vivas	$n = 12$	Aquatic exercise	Land-based exercise 45 min, 2/weeks, 4 weeks	UPDRS total score
Spain	Mean age (y) = 67	45 min, 2/weeks, 4 weeks		TUG
	Gender = 8 M, 4 F	Water temp (°C) = 32		5-M WT with gait analysis (turn time, velocity, cadence and step amplitude)
	PD duration (y) ≈ 6	Depth (m) = 1.30		Baseline, postintervention, and 17 days later
	H and Y = 2 to 3			
	Phase = off			
Volpe	$n = 34$	Aquatic exercise	Land-based exercise 60 min, 5/weeks, 8 weeks	UPDRS-II and III
Italy	Mean age (y) = 67	60 min, 5/weeks, 8 weeks		TUG
	Gender = NR	Water temp = NR		Baseline and postintervention
	PD duration (y) ≈ 7.5	Depth = NR		
	H and Y = 2.5 to 3			
	Phase = on			
Volpe	$n = 30$	Aquatic exercise	Land-based exercise 60 min, 5/weeks, 8 weeks	UPDRS-III
Italy	Mean age (y) = 70	60 min, 5/weeks, 8 weeks		TUG
	Gender = 19 M, 11 F	Water temp = NR		Baseline, postintervention and 8 weeks later
	PD duration (y) ≈ 9.2	Depth = NR		
	H and Y ≤ 3			
	Phase = on			
Pérez de la Cruz	$n = 30$	Aquatic exercise with aquatic Ai Chi component	Land-based exercise 45 min, 2/weeks, 10 weeks	UPDRS-I, II, III, IV and total
Spain	Mean age (y) = 67	45 min, 2/weeks, 10 weeks		TUG
	Gender = 14 M, 16 F	Water temp (°C) = 30		Baseline, postintervention, and 1 month later
	PD duration (y) ≈ 6.5\	Depth (m) = 1.10 to 1.45		
	H and Y = 1 to 3			
	Phase = off			
Kurt	$n = 40$	Aquatic exercise with aquatic Ai Chi component	Land-based exercise 60 min, 5/weeks, 5 weeks	UPDRS-III
Turkey	Mean age (y) = 63	60 min, 5/weeks, 5 weeks		TUG
	Gender = 24 M, 16 F	Water temp (°C) = 32		Baseline, postintervention
	PD duration (y) ≈ NR	Depth (m) = 1.20		
	H and Y = 2 to 3			
	Phase = on			
Silva et al.	$n = 25$	Dual-task aquatic exercises		UPDRS - III

(Continues)

TABLE 1 | (Continued)

Trial country	Participants	Intervention: Experimental	Intervention: Control	Outcome measures
Brazil	Mean age (y) = 63 Gender = 11 M, 14 F PD duration (y) ≈ NR H and Y = 3 Phase = off	60 min, 2/weeks, 10 weeks Water temp (°C) = 33 Depth (m) = NR	Dual-task aquatic exercises 60 min, 2/weeks, 10 weeks	TUG (seconds) RCT with a 3-month follow-up
Yi-zhao et al. China	n = 40 Mean age (y) = 63 Gender = 26 M, 14 F PD duration (y) ≈ 4–6 NR H and Y = 1–3 Phase =	Water-based exercise 50 min, 5/weeks, 8 weeks Water temp (°C) = 37 Depth (m) = 1.3–1.4	Land-based exercise 50 min, 5/weeks, 8 weeks	UPDRS-III TUG RCT
Palamara et al. Italy	n = 34 Mean age (y) = 70 Gender = 20 M, 14 F PD duration (y) ≈ NR H and Y = 3 Phase = off	Aquatic therapy (MIRT-AT) 60 min, 6/weeks, 4 weeks Water temp (°C) = depth (m) =	Multidisciplinary-intensive-rehabilitation-treatment (MIRT) 60 min, 6/weeks, 4 weeks	UPDRS-II UPDRS-III TUG (s) RCT with 6-month follow-up

Abbreviations: TUG, timed up and go test; UPDRS, unified Parkinson's disease rating scale.

and the data were extracted by two authors. A total of 205 individuals with PD participated in studies that utilized the TUG test to assess motor performance, with 100 participants assigned to the land-based exercise group and 105 to the aquatic exercise group. The participants' ages ranged from 45 to 69 years. Land-based exercise protocols included resistance training, gait training, and balance exercises, conducted 2–5 times per week for 4–10 weeks, typically lasting 45–60 min per session. Water-based exercises included Ai Chi, aerobic conditioning, and functional movement tasks in warm water (30°C–33°C), and the duration of the programs varied from 4 to 10 weeks. The parameters used in most studies included a session duration ranging from 45 to 60 min and a session frequency ranging from 2 to 5 times per week. Both modalities were supervised and tailored to PD functional levels. The characteristics of the studies that entered the meta-analysis phase are presented in Table 1.

3.1 | Quality Assessment of the Studies

For the assessment of the methodological quality of the studies, the 11-point PEDro scale was used. This scale ranged from 6 to 8 for the reviewed studies, with an average quality score of 7.12 for the reviewed studies. Additionally, 50% of the reviewed studies were of high quality (score of 8) (Table 2).

3.2 | Motor Performance in Aquatic Exercise Compared to Land-Based Exercises

According to the meta-analysis of data collected from 8 studies (205 participants) on motor performance (TUG), land-based exercise had greater effects (0.135–0.649, 95% CI, MD = 0.392) (Kurt et al. 2018; Palamara et al. 2017; Pérez-de la Cruz 2018; Vivas et al. 2011; Volpe et al. 2014, 2017; Yi-zhao et al. 2017; da Silva and Israel 2019) (Figure 2). Due to an I^2 value of 52.875%, a random-effects model was used for the effect size (Figure 3). Publication bias was assessed using a funnel plot, which showed no evidence of publication bias, as the plot was approximately symmetrical (Figure 4).

4 | Discussion

This study aimed to systematically review and meta-analyze the literature to evaluate the effects of water-based exercises on motor performance compared with those of land-based exercises in people with PD. A comprehensive review of 94 studies across eight articles examined the motor performance of people with PD. The synthesized data showed that water-based exercises were associated with improved motor performance compared with land-based exercises.

TABLE 2 | PEDro scale scores for the included studies.

Authors	1	2	3	4	5	6	7	8	9	10	11	Total score
Kurt et al. (2018)	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	8
Vivas et al. (2011)	Y	Y	N	Y	N	N	N	Y	N	Y	Y	6
Volpe et al. (2014)	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	8
Volpe et al. (2017)	Y	Y	N	Y	N	N	Y	N	N	Y	Y	6
Yi-zhao et al. (2017)	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	7
da Silva (2019)	Y	Y	Y	Y	Y	N	N	N	Y	Y	Y	8
Palamara et al. (2017)	Y	Y	Y	Y	N	N	Y	Y	N	Y	Y	8
Pérez-de la Cruz (2018)	Y	Y	N	Y	N	N	Y	N	N	Y	Y	6
Mean												7.12

Abbreviations: 1, eligibility; 2, random allocation; 3, concealed allocation; 4, baseline comparability; 5, blind subjects; 6, blind therapists; 7, blind assessors; 8, adequate follow-up; 9, intention-to-treat analysis; 10, between-group comparisons; 11, point estimates and variability; N, no. Y, yes;

Study	Statistics for each study						
	Std diff in means	Standard error	Variance	Lower Limit	Upper Limit	Z-Value	P-Value
Kurt et al 2018	0.145	0.317	0.100	-0.476	0.766	0.458	0.647
Vivas et al 2011	0.383	0.583	0.339	-0.759	1.525	0.658	0.510
da Silva et al 2019	-0.617	0.412	0.170	-1.425	0.191	-1.497	0.134
Volpe et al 2014	-0.241	0.344	0.119	-0.916	0.434	-0.700	0.484
Volpe et al 2017	-0.046	0.385	0.133	-0.762	0.669	-0.127	0.899
Yi-zhao et al 2017	-1.358	0.351	0.123	-2.046	-0.671	-3.872	0.000
Peres da Cruz et al 2018	-0.808	0.380	0.144	-1.552	-0.064	-2.127	0.033
Palamara et al 2017	-0.327	0.345	0.119	-1.004	0.350	-0.948	0.343
	-0.392	0.131	0.017	-0.649	-0.135	-2.991	0.003

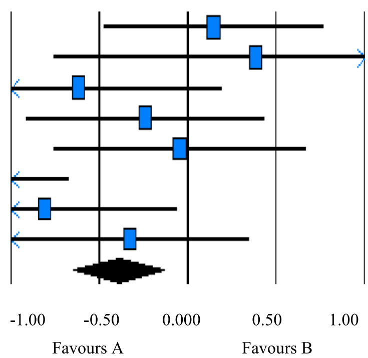

FIGURE 2 | Forest plot and meta-analysis of motor performance in the water-based and land-based exercise groups.

Model		Effect size and 95% confidence interval					Test of null (2- Tail)		Hetrogenity				Tau- Squard			
Model	Number Studies	Point estimate	Standard error	Variance	Lower Limit	Upper Limit	Z-value	P-value	Q-value	Df (Q)	P-value	I-squared	Tau Squared	Standard Error	Variance	Tau
Fixed	8	-0.392	0.131	0.017	-0.649	-0.135	-2.991	0.003	14.854	7.000	0.038	52.875	0.156	0.159	0.025	0.395
Random	8	-0.388	0.194	0.038	-0.768	-0.008	-2.003	0.045								

FIGURE 3 | Effect size and heterogeneity.

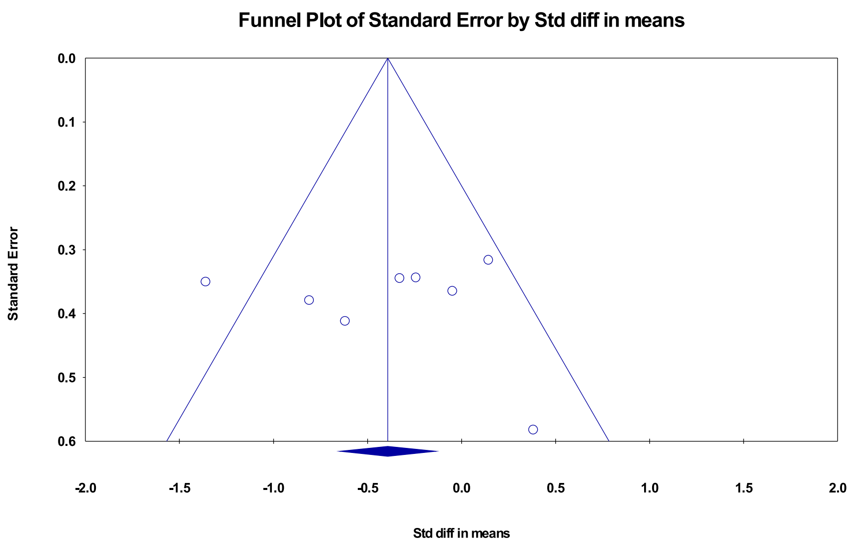

FIGURE 4 | Funnel plot of publication bias in studies.

Vivas et al. (2011), Volpe et al. (2014), Palamara et al. (2017), Kurt et al. (2018), Yi-zhao et al. (2017), Volpe et al. (2017), and da Silva et al. (2019) did not report a significant difference in motor performance between aquatic and land-based exercises (Kurt et al. 2018; Palamara et al. 2017; Vivas et al. 2011; Volpe et al. 2014, 2017; Yi-zhao et al. 2017; da Silva and Israel 2019), but Pérez-de la Cruz (2018) observed a significant difference in motor performance between water- and land-based exercises (Pérez-de la Cruz 2018). Yi-zhao et al. (2017) conducted a study on the effects of 8 weeks of water-based exercise on motor performance, balance, and walking ability in people with PD. They randomly divided 40 early-stage people with PD into a land-based exercise group (20 participants) and a water-based exercise group (20 participants). The results showed that both groups had a significant reduction in TUG scores after exercise but experienced a significant improvement in balance. Both land-based and aquatic exercises improved motor function, balance, and gait in people with PD. However, aquatic exercise demonstrated a more pronounced positive effect on motor function and balance compared with land-based exercise (Yi-zhao et al. 2017). Palamara et al. (2017) conducted a study comparing land-based treatment with water-based exercise alone to treat balance disorders in people with PD. They followed up on the effects of these exercises after 6 months. Both groups showed improvement in the TUG test score compared with that at the beginning of the treatment. They concluded that aquatic therapy combined with land-based rehabilitation could help treat balance disorders in people with PD in the intermediate stage of the disease and may contribute to long-term balance improvement (Palamara et al. 2017). Da Silva et al. (2019) conducted a study to examine the impact of water-based exercises on functional mobility, balance, and gait in people with PD. The study involved 28 participants who were randomly assigned to either an experimental or control group. The experimental group participated in a 10-week aquatic exercise program, consisting of two 40-min sessions per week. The results of the study indicated that the aquatic exercise program was effective in improving functional mobility, balance, and gait in people with PD, with the positive effects persisting for at least 3 months post-intervention (da Silva and Israel 2019). Cugusi and colleagues (2019) systematically reviewed the literature to assess the efficacy of aquatic exercise in improving motor function in people with PD. Their findings indicate that aquatic exercise can significantly enhance motor function in people with PD, often demonstrating comparable or superior outcomes to traditional land-based exercise interventions. Notably, aquatic exercise has been shown to yield substantial improvements in balance, reduced fear of falling, and enhanced health-related quality of life compared with land-based exercise. However, it is important to note that some studies have reported similar benefits between aquatic and land-based exercise (Cugusi et al. 2019).

The findings of this meta-analysis suggest that aquatic exercise may offer distinct advantages over land-based exercise in improving motor function in individuals with PD. While individual studies may not always show a statistically significant difference, the pooled analysis across multiple trials indicates a potentially meaningful benefit of water-based interventions. These results may suggest that the unique properties of water, such as buoyancy and hydrostatic pressure, create an environment conducive to improved balance, gait, and overall motor control in this population. Aquatic exercise is generally regarded as a safe and potentially beneficial rehabilitation modality for older adults and individuals with neurological conditions (Plecash and Leavitt 2014; Zotz et al. 2013). The buoyancy provided by water can reduce joint loading, which may facilitate earlier and more comfortable engagement in exercise, particularly for individuals with limited weight-bearing capacity on land (Harrison and Bulstrode 1987). If individuals with PD prefer aquatic environments and have access to appropriate facilities, such as hydrotherapy pools, water-based rehabilitation protocols may be easier for them to perform (Cugusi et al. 2019). The findings of this meta-analysis indicate that aquatic exercise programs may offer advantages over land-based interventions, especially in addressing movement difficulties such as shuffling gait, freezing of gait, festination, and challenges with turning, which are associated with a higher risk of falls during land-based activities. However, these potential benefits should be weighed against the logistical and financial considerations associated with aquatic therapy. Further high-quality randomized controlled trials are warranted to strengthen the evidence base and clarify the relative efficacy of aquatic exercise, helping to guide more definitive clinical recommendations for its use in PD rehabilitation.

5 | Implications on Physiotherapy Practice

The findings from this meta-analysis may support the inclusion of aquatic exercise as a component of rehabilitation programs for individuals with PD. Given the observed trends suggesting improved motor function, physiotherapists might consider incorporating aquatic modalities into personalized treatment plans, particularly for individuals who experience a fear of falling or face substantial mobility challenges.

Aquatic environments offer unique properties, such as reduced weight-bearing and increased support, which may allow individuals to participate in exercise with lower perceived risk and discomfort. This environment can be especially beneficial for those who are hesitant or unable to fully engage in land-based activities.

To maximize the potential benefits, physiotherapists should be trained in the development and delivery of structured aquatic exercise programs. Protocols aligned with those identified in the literature—typically 45-min sessions, twice a week, for a minimum of 10 sessions—may serve as a useful starting point for clinical practice.

Additionally, aquatic exercise may help promote adherence and motivation, as the supportive and dynamic nature of water-based movement could enhance the overall exercise experience. This, in turn, might contribute to improved motor outcomes, as well as enhanced quality of life, confidence, and functional independence.

In summary, while aquatic exercise appears to be a promising modality for individuals with PD, its integration into physiotherapy practice should be guided by individual patient needs, preferences, and available resources. Continued research is necessary to establish optimal protocols and assess the long-term effects of aquatic interventions, ensuring that rehabilitation strategies remain both evidence-based and patient-centered.

Author Contributions

M.S. and H.A. performed the database searches, data extraction, and initial interpretation of the results. M.S., H.A., and A.E.A. provided advice throughout the interpretation of the data and manuscript drafting. M.S. was responsible for the initial drafting of the article, which was reviewed and edited with assistance from H.A., A.E.A., M.S. and M.S. All authors were involved in the conception, design, and interpretation of the data. All the authors have read and reviewed the manuscript critically for important content and approved the final version for submission. All the authors have read and approved the final manuscript.

Acknowledgments

The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Endnotes

[1] Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

[2] Physiotherapy Evidence Database.

[3] Comprehensive Meta-Analysis.

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